ASOCIACION COLOMBIANA DE MEDICOS VETERINARIOS Y ZOOTECNISTAS

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ACOVEZ

Memorias
IX CURSO
TEORICO PRACTICO
DE
REPRODUCCION BOVINA
Santafé de Bogotá, D.C.
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IX CURSO TEORICO PRACTICO

DE REPRODUCCION BOVINA

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BASES FARMACOLOGICAS PARA EL USO RACIONAL DE LOS FARMACOS ENDOCRINOS

N.R.

DR. NELSON RUEDA ALEJO

FARMACOLOGIA ENDOCRINA DE LA REPRODUCCION

Las hormonas de acuerdo con el sitio de producción y el de su posterior acción se clasifican en autacoides, autocrinas, paracrinas, neurocrinas y hormonas sistémicas o endocrinas.

Los autacoides son hormonas locales que se elaboran y desencadenan su acción en el mismo lugar o cerca a la célula donde se produce. Ej: **PROSTAGLANDINAS.**

Las hormonas sistémicas o generales son aquellas que elaboradas en células endocrinas y neuroendocrinas, se transportan por vía sanguínea para ejercer su acción en un lugar diferente al de su biosíntesis, Ej: **BETA-ESTRADIOL.**

Farmacológicamente hablando en la mañana de hoy nos apartaremos de la clasificación fisiológica de las hormonas basadas en su acción, y es así como se estudiarán iniciando por el hipotálamo con los RH conocidos como hormonas de liberación, para continuar con las hormonas gonadotrópicas, hipofisiarias y placentarias, las oxitócicas y agentes tocolíticos, luego con las prostaglandinas análogas de la F2 Alfa.

HORMONAS LIBERADORAS.

A. DEFINICION:

Las hormonas liberadoras o RH, también conocidas como factores hipotalámicos de liberación (RF) son sustancias proteicas capaces de desencadenar la actividad de la secreción hormonal en la adenohipófisis.

Endógenamente son elaboradas en el hipotálamo a nivel del núcleo arcuato. En la pubertad la acción sinérgica de las betaendorfinas y el neuropeptido y facilitan la iniciación de la cinética folicular.

La hormona liberadora para el LH y FSH es una sola, que se conoce con el nombre de GnRH ó Gonadoliberinas, o también con el de FSH-LH o sea hormona desencadenante en la producción de gonadotropinas hipofisiarias. Las gonadoliberinas presentan varios sinónimos como el LH/FSH.RF, LH-FSH.RH.

Los factores y hormonas inhibitorias desencadenan su acción al bloquear la producción de otra hormona a nivel hipotalámico o adenohipofisiario.

B. CLASIFICACION:

1. HORMONAS DESENCADENANTES: Corresponden a la gonadoliberinas o GnRH y sus análogos sintéticos.

2. HORMONAS INHIBIDORAS (IH): Relacionados con el bloqueo de la producción hormonal adenohipofisiaria. De importancia en veterinaria lo es el inhibidor de prolactina PIF.

HORMONAS LIBERADORAS DE GONADOTROPINAS GnRH

A. ORIGEN Y QUIMICA:

La GnRH decapeptido, de la que se conoce su acción clínica corresponde a la endógena pero no se utiliza en la clínica veterinaria.

Por síntesis el hombre ha desarrollado GnRH como polipeptidos mas exactamente decapeptidos como la buserelina, gonadoliberina, cistorrelina, fertirelinas; luliberinas, que en conjunto conforman los análogos. El GnRH fue el segundo peptido hipotalamico al cual se le diferenció su estructura química.

La GnRH endógena se secreta a nivel hipotalámico y es transportada a la adenohipófisis por medio del sistema portal hipotalámico-hipofisiario donde estimula la secreción de hormona FSH y LH, aunque también de TSH.

Su producción se ve afectada por factores exogenos como la intensidad lumínica, stress, y estados emocionales.

La función de la GnRH es la de estimular la secreción de Gonadotropinas Hipofisiarias las cuales posteriormente estimularán el crecimiento gonadal y la gametogénesis ovárica así como la actividad testicular. En el ovario la FSH a nivel folicular provocará su maduración y la generación de receptores para LH lo cual favorece la ovulación y la formación de un cuerpo lúteo productor de progesterona, que a nivel uterino lo preparará para la gestación o en su defecto para el inicio de un nuevo ciclo.

En el testículo la FSH promueve el crecimiento y la LH la espermatogénesis. En útero, ovario y testículo se generan receptores para FSH y LH. La GnRH se produce a los 14 días postparto.

B. ACCION FARMACOLOGICA DE GnRH ANALOGOS

Los análogos incitan a la producción y liberación del GnRH endógenos y en la adenohipófisis estos GnRH análogos desencadenan el efecto fisiológico para estimular la producción y liberación de LH y FSH, gonadotropinas que vía sanguínea llegan al ovario y estimulan la producción de esteroides estrogénicos la maduración del folículo, la ovulación y posterior luteinización del ovario. La GnRH induce a una liberación extra del LH que promueve en el cuerpo lúteo la elaboración de progesterona. En vacas y en ovejas inducen la ovulación, pero esto no ocurre en yeguas en estro. Las Gonadotropinas hipofisiarias endógenas aparecen 48 horas postadministración de los análogos sintéticos.

En machos puede eventualmente desencadenar los efectos propios de FSH y de ICSH en el testículo.

Los análogos de la GnRH son mas potentes en acción y es así como el acetato de fertirelina es 7 veces mas potente que la GnRH endógena.

C. SITIO DE ACCION:

Hipotálamo con respuesta excitatoria y productoras en la adenohipófisis de FSH y LH, a veces con mas efecto LH.

D. ACCIONES COLATERALES:

No se conocen, pues parece que no provocan la liberación de otras hormonas adenohipofisiarias, dada su especificidad para la producción de FSH y LH. No causa efectos de sensibilización como las gonadotropinas placentarias tipo HCG y PMS.

E. MECANISMO DE ACCION:

No del todo aclarado como desencadenan la liberación de las hormonas adenohipofisiarias, pero se cree que para la activación celular se requiere la presencia de Oxígeno y AMP ciclico. Se estimula entonces la adenililciclasa presente en la membrana celular, la cual transforma el ATP en AMP ciclico necesario para dar la energía requerida para la síntesis proteica mediante la proteín G.

F. FARMACOCINETICA:

Con los análogos sintéticos marcados mediante radiosótopos se demuestra que la prolongación del efecto respecto a la GnRH natural se debe a un retardo en la degradación enzimática del nonapéptido. El acetato de fertirelina se absorbe rápidamente, en 2 minutos se halla en la sangre luego de su administración IM.

El t/2 está entre 12 y 30 minutos. Luego de su aplicación IV. se elimina rápidamente del plasma. Los análogos del GnRH se distribuyen rápidamente en el LEC.

El acetato de fertirelina rápidamente se distribuye por la hipófisis, útero, glándulas salivares, pulmón, tiroides, páncreas y piel, indicando así un amplia difusión.

El péptido previamente marcado rápidamente se acumula en el hígado,, riñón, o hipófisis. Al cabo de 60 minutos se halla una fuerte acumulación en el tejido hipofisiario. No existe ninguna correlación entre el nivel plasmático y la liberación de FSH y LH por cuanto la eliminación a partir del plasma se produce con rapidez mientras que la acción hormonal persiste durante varias horas. La acción del GnRH es en oleadas o picos de producción.

La acción de la fertirelina se mantiene por sus enlaces con receptores específicos de la hipófisis, particularmente con los de FSH y LH.

En el tubo digestivo se degrada por la acción de las enzimas digestivas. En el organismo los análogos son alterados enzimáticamente por las enzimas que catabolizan al GnRH endógeno.

Después del tratamiento con fertirelina se han identificado 3 metabolitos inactivos. No aparece en la leche, se excretan en 24 horas (42% en orina, 52% vía `pulmonar y 1% en las heces). No requieren tiempo de retiro.

La administración repetida o dosis muy elevadas no desencadena desviaciones morfológicas o funcionales y si lo provocan estas son reversibles. Sin embargo, debe pensarse en efecto antiGnRH.

Presenta el acetato de fertirelina un amplio margen de seguridad, pudiéndose aplicar hasta 500 veces su dosis sin causar problema al paciente.

G. APLICACIONES CLINICAS:

En trastornos de la fertilidad de origen ovárico, quistes foliculares o luteinizados por deficiencia de GnRH, para inducción de la ovulación y aumento de porcentaje de preñez en vacas y yeguas. En vacas con quistes foliculares, para provocar la ruptura del folículo, inducir ovulación y luteinización del folículo maduro.

La aplicación de GnRH y PGF2 alfa en el secto o séptimo día del ciclo proporciona un método eficaz para sincronizar ovulaciones.

Después de 15 a 18 días de aplicar el GnRH el quiste estará luteinizado y se presentará posteriormente destrucción del quiste por acción luteolítica de la PGF2 ALFA.

En vacas para el mejoramiento en la eficiencia reproductiva en hembras postparto. GnRH (Fertirelina) y PGF2 ALFA empleados secuencialmente con intervalos de 10 a 12 días han disminuído el número de días abiertos en la vaca.

GnRH en el día 14 postparto adelanta la primera ovulación lo cual genera un efecto terapéutico sobre el útero así como también favorece la involución uterina. Buenos resultados se han obtenido al tratar vacas con quistes foliculares con y sin síntomas de ninfomanía. El empleo de GnRH P4 y PGF2 ALFA proporcionan un desarrollo folicular programado y una subsecuente ovulación en vacas con quistes foliculares.

En aciclia, ovulación retardada y atresia folicular ha mostrado excelentes resultados, mejora el porcentaje de preñez en la I.A. y luego de la sincronización del celo. Aumenta la fertilidad en vacas repetidoras. Para la reducción de los días abiertos entre partor, para incrementar el número de ovulaciones luego de lostres primeros meses postparto. En vacas aumenta el nivel de gestaciones.

Aplicada en el día 12 postinseminación artificial o postransferencia de embriones activa la función de C.L. de la preñez. La presencia del C.L. es necesaria para el mantenimiento de la preñez en la vaca, si el animal no se halla preñado se libera PGF2 Alfa del endometrio en respuesta a la Oxitocina, la cual genera nuevos receptores para la F2 Alfa y se provoca una luteolisis. El embrión produce el ALFA2 Interferon que inhibe los receptores Oxitocinicos endometriales y entonces se previene la luteolisis. El Estradiol de los folículos en crecimiento en la segunda mitad de la fase`luteal es quien estimula el desarrollo y la respuesta de los receptores de Oxitocina en el endometrio, por lo que se incrementa la liberación de PGF2 Alfa y la consiguiente luteolisis. El tratamiento con GnRH análogo entre el día 11-13 de la fase luteal reduce la secreción de Estradiol y el proceso anterior no se decreta, sobreviviendo el embrión y previniéndose la muerte embrionaria.

Cabe anotar que el GnRH es capaz también de provocar por su acción LH la luteinización de otros folículos y este nivel de P4 se elevará impidiendo por doble vía la muerte embrionaria.

YEGUA: Alteraciones quísticas de los ovarios con o sin celo prolongado o permanente, aciclia, inducción de la ovulación, determinación del momento de la ovulación y cubrimiento, mejora el porcentaje de preñez. En Europa se emplea para inducción del ciclo estral, presenta una respuesta pobre si se compara con un programa de luz artificial. Se puede aplicar 10 a 12 horas antes de la ovulación.

Recientemente se ha utilizado GnRH unido a un dispositivo intravaginal de progesterona donde el GnRH aumenta la concentración de Estradiol induciendo a la ovulación y la progesterona provocará la formación de un nuevo cuerpo lúteo. La PGF2 Alfa provoca luteolisis para el desarrollo de un nuevo folículo.

En machos: En caso de oligospermia y criptorquidea.

En deficiencias de Testosterona para favorecer el desarrollo de caracteres sexuales diferenciales se aplica GnRH para el incremento de LH (ICSH) que actúa en las células de Leydig para producir Testosterona. Adelantar la pubertad en caso de retraso.

En gatas: Como terapia alternada de FSH o HCG para la inducción del estro luego de anestro prolongado. Como control hormonal en edad avanzada.

En hembras con edad avanzada que presentan períodos de anestro prolongado y deficiencia en la fertilidad cursan con elevaciones de FSH y LH en forma desordenada. Al aplicar GnRH se sincronizan las oleadas para mantener el ciclo ovárico y reducir los efectos del climaterio tal como ocurre en medicina humana.

G. ADMINISTRACION, DOSIS Y PREPARADOS:

Vía IV,IM,SC. Es preferible usar la vía IM.

BUSERELINA: Dosis: 10 a 20 mcg. en vacas y yeguas (4 a 10 ml) (2 x 5 ml a intervalos de 24 horas).

ACETATO DE FERTIRELINA: Vacas 100 mcg por animal Uso IM una sola administración.

No debe emplearse GnRH análogo en ganado de carne que esté subalimentado, en clima caliente hostil, en vacas de 60 días postparto que estén amamantando, porque puede provocar anestro funcional en ausencia de una cinética folicular estable.

DOSIS:

Perros: Esteroidogenesis testicular 125 a 250 ng/kg, descenso testicular 50 a 100 mcg, si no hay respuesta repetir al mes.

Gatas: Estipulación de la ovulación luego del apareamiento 25 mcg IM.

Vaca: Quistes ováricos 100 mcg/IM o IV

Oveja-Cabra: 100 mcg día x 4 a 5 días

GNRH ANALOGOS O SINTETICOS EN VETERINARIA

NOMBRE COMERCIAL	PRINCIPIO ACTIVO	VIA ADMINISTRACION	PRESENTACION
OVALYSE Unipharma	Acetato de Fertirelina	IM	Amp x 2 ml
CONCEPTAL	Buserelina 0.004 mg/ml	IM	Fcos x 10 ml
OVARELIN	Cistorelina	IM	Fco Amp 2ml

HORMONAS GONADOTROPICAS

Hay dos tipos de hormonas gonadotropicas:

a. Las conocidas como adenohipofisiarias FSH y LH que actúan sobre las gónadas desencadenando en ellas la producción de hormonas sexuales.

b. Las placentarias que producen algunas especies animales como la yegua y la mujer, pero que también son capaces de inducir la producción de hormonas sexuales cuando se aplican en animales no preñados.

A. HORMONAS GONADOTROPICAS ADENOHIPOSIFIARIAS

1- La hormona FSH se elabora en la adenohipófisis por acción directa del GnRH el cual es común para FSH y LH.

A ORIGEN Y QUIMICA:

La natural es una glicoproteína, la comercial se obtiene a partir de extractos hipofisiario, pero no siempre se consigue un extracto en forma de por demás pura. Un producto liofilizado de alto poder se conoce como FSH-P el cual puede contener pequeñas cantidades de LH.

B. ACCION FARMACOLOGICA:

Fundamentalmente provoca desarrollo del folículo y con ello desencadena la cinética folicular. Logra el que a un mismo tiempo varios folículos inicien su cinética, razón por la cual una vez administrada, en un ovario se pueden encontrar varios de ellos en distintos estados de evolución.

Los receptores para FSH y LH se acoplan a la adenilato ciclasa mediante la proteín Gs tanto en la hembra como en el macho.

En el macho provoca desarrolo de los túbulos seminiferos facilitando así la maduración de los geminales primarios y la espermatogénesis.

C. APLICACIONES CLINICAS

Este fármaco debe aplicarse cuando hay comprobada deficiencia de FSH. La FSH se utiliza para provocar superovulación, necesaria para la transferencia de embriones.

Se emplea al igual que otras hormonas en la terapia sustitutiva, en este caso por deficiencia de FSH. Tanto en vacas, ovejas, perros, yeguas, etc.

Se ha intentado producir ovulación en vacas con anestro, pero infortunadamente muchas de ellas no responden al tratamiento.

Junto con progestágenos se utilizan para el tratamiento del anestro.

El empleo de FSH puede provocar gestaciones gemelares lo cual induce a los partos distócicos y/o retención placentaria.

Vacas anéstricas tratadas con FSH pueden desarrollar cuerpos lúteos deficientes.

No debe utilizarse en pacientes con tendencia a hiperplasia endometrial o quistes foliculares.

D. VIAS DE ADMINISTRACION Y DOSIS

Se aplican IV, IM ó SC. Existen varios esquemas para su utilización, el cual debe administrarse cada 12 horas durante 4 ó 5 días, hacia el día 15 óo 16 del ciclo estral, finalizando hacia el 20. Para provocar la superovulación en vacas, dosis total de 25 a 50 mg repartidos cada 12 horas 5 mg y en novillas en dosis decrecientes.

PREPARADOS

FSH-P liofilisada, fraco por 10 ml con reconstituyente. Cada ml contiene 5mg de FSH 1 ml/5mg de FSH

1 mg de FSH-P es igual a 1 unidad Armour, la que a su vez equivale de 9.4 a 14.2 U.I. de FSH.

DOSIS

Perra: Inducción del celo 20 UI/Kg x 10 días

El proestro se presenta entre los 7 y 10 días y puede durar de 2 a 3 días. Se puede aplicar HCG a los días 10 y 11 para efecto LH.

Gato: 2mg I.M.

Caballo: 10-50 mg IV. IM o Sc

Cerda: 5 a 25 mg IV, IM o Sc

HORMONA LUTEINIZANTE LH

Provoca la ovulación, la formación y el mantenimiento del cuerpo lúteo, presentando acciones similares a la GnRH.

La LH estructuralmente es un péptido más grande que el GnRH lo que ocasiona respuestas inmunológicas.

Actualmente en nuestro medio no contamos con preparados veterinarios a base de LH, por cuanto han sido desplazados en su actividad farmacológica por los análogos de GnRH y las Prostaglandinas.

La LH comercial se encuentra en forma más pura que la FSH.

B. GONADOTROPINAS PLACENTARIAS

1. Gonadotropina Corionica Humana (hCG):

Conocida también como CG, hCG o PV. Se elabora en las células del trofoblasto de la placenta fetal humana, su acción predominante es la de actuar como hormona LH por cuanto tiene acciones similares y ocupa los mismos receptores. Este polipéptido secretado por la placenta se absorbe de la orina de la mujer embarazada. Como ya se anotó en nuestro país no contamos con presentación veterinaria de hCG, pero la línea humana cuenta con PRIMOGONYL (Schering) amp, por 2 ml x 1000 y 5000 U.I:/ml. Esta hCG se emplea en terapia hormonal sustitutiva de LH.

Se acepta que una U. Internacional es igual a 1 unidad USP. Se hallan 1500 USP por miligramo. Igualmente en humanos existe un inhibidor gonadotropico a base de DANAZOL (Ladogal cápsulas po4 50,100,200 mg) indicado para el tratamiento de la endometriosis al transformar el endometrio en inactivo y atrófico.

La hCG presenta un marcado efecto FSH.

En machos induce a la producción de andrógenos testiculares y el descenso testicular. En hembras estimula el cuerpo lúteo para la producción de progesterona y la inducción de la ovulación. En perras la hCG induce a la secreción de estrógenos.

FARMACOCINETICA

La hCG es destruída en el TGI después de su administración vía oral razón por la cual se medica vía parenteral. Luego de su administración IM los niveles plasmáticos más altos se obtienen a las 6 horas. La hCG se distribuye inicialmente en los ovarios de las hembras y en los testículos de los machos, aunque también se puede distribuír en los tubulos proximales y en la corteza renal. La hCG se elimina de la sangre de manera bifásica. La eliminación primaria se realiza cerca a las 11 horas y la fase terminal a las 23 horas.

USOS CLINICOS

Ninformanía por quistes foliculares, infertilidad en perras debidas a fallas en la ovulación, inducción a la ovulación, criptorquismo. Luego de la inseminación artificial se puede aplicar hCG. En amenaza de aborto, en aborto habitual, en impotencia y astenia sexual masculina.

DOSIS

Perros: Criptorquismo 500 UI. vía IM 2 veces x semana x 4 a 6 semanas.

Perras: Luteinización de quiste folicular persistente 500 UI vía IM. Perras infértiles ciclando normalmente con bajos niveles de progesterona 500 UI Sc días 10 a 11 del calor.

Gatas: 100 a 500 UI.

Vacas: 10.000 UI vía IM o 2500 UI vía IV. Si es necesario se repite el tratamiento a los 14 días.

Caballos: Criptorquismo: 100 UI 2 días por semana por 4 a 6 semanas.

Yeguas: Ovulación 2000 a 3000 UI vía IV.

Ovejas: 250 A 1000 UL vía IM o Sc, la ovulación se presenta a las 48 horas.

En superovulación la dosis de las distintas especies.

Vacas: Para crecimiento folicular se aplican en el día 15-16 del ciclo 1500-3000 UI de Gonadotropina Humana Postmenopausica (hMG)

Presenta actividad LH y FSH se extrae de la orina de mujer menopausica y dado su pero molecular no presenta riesgos de producción de anticuerpos que bloquean sus efectos terapéuticos.

Se utiliza para el tratamiento de la esterilidad masculina, en criptorquidia y esterilidad femenina.

En nuestro medio el producto **PERGONAL** 500 amp provee 75 UI de FSH y 75 UI de LH.

2. Gonadotropina Placentaria PMS (o PMSG) También eCG:

Significa suero de yegua preñada. Es una proteína que elabora la yegua en el primero tercio de su gestación y como se sabe es la base para la determinación del diagnóstico precoz de gestación.

En forma comercial se obtiene del suero de las yeguas preñadas. Su acción farmacológica es similar a la desarrollada por la adenohipofisiaria FSH, pero como quiera que presenta una vida medida (t/2) más larga se le puede administrar a períodos más espaciados o a veces una sola dosis logra desencadenar respuesta terapéutica.

En el país no se cuenta en la actualidad con preparados veterinarios a base de PMS, pero en el mercado no legalizado se encuentra FOLLIGON (Intervet), el cual se emplea para el tratamiento de anestros, para provocar superovulación para la transferencia de embriones, y en el macho para combatir desviaciones en el cuadro espermático.

GONADOTROPINAS

1. ADENOHIPOFISIARIAS

NOMBRE COMERCIAL	PRINCIPIO ACTIVO	VIA ADMINISTRACION	PRESENTACION
FSH-P Schering	Hormonas FSH de Porcino 5mg/ml	V. IM. SC	Fco 10 ml/50 mg

2. PLACENTARIAS

NOMBRE COMERCIAL	PRINCIPIO ACTIVO	VIA ADMINISTRACION	PRESENTACION
PRIMOGONYL Schering	hCG 100 y 5000 UI	IM, IV	Amp x 2 ml
PROFASI Farma	hCG 1000,2000 y 5000 UI	IM	Caja x 2 amp

HORMONOTERAPIA DEL UTERO

a. **DEFINICION:** Los medicamentos que estimulan la contracción uterina se llaman oxitocicos. El término ecbólico es sinónimo de oxitócico.

b. **CLASIFICACION:**
Oxitocina o extractos hipotalámicos
Alcaloides del cornezuelo de Centeno (en desuso)
Prostaglandinas F2 alfa y E2

OXITOCINA

A. ORIGEN Y QUIMICA:

La oxitocina endógena se elabora en el núcleo paraventricular del hipotálamo. La oxitocina fue el primer polipéptido hormonal que se sintetizó.

Es una polipéptido ciclico, de 9 aa PM 1000. Contiene unión disulfuro y es muy similar en su estructura a la vasopresina ADH.

Un extracto acuoso estéril de la neurohipófisis de cerdos y vacas, se estandariza originando 10 unidades por ml, de Oxitocina (1 unidad internacional equivale a 2 mcg de hormona pura).

Los análogos de la Oxitocina se obtienen por sustitución de varios grupos y los cambios en la actividad farmacológica se deben a sus modificacines estructurales.

Los preparados comerciales de oxitocina están exentos de efectos ADH o actividad vasopresora cuando se administran a dosis usuales.

Preparados comerciales de oxitocina tienen su pH ajustado con ácido acético a 2.5- 4.5. y viales con multidosis pueden contener clorobufanol al 0.05 % como preservativo.

B. ACCION FARMACOLOGICA

La actividad de la oxitocina en el útero se pone de manifiesto mediante previa sensibilización estrogénica, por lo que actúa en el estro, al inicio y al final de la preñez, desendadenando miocontracción de la fibra muscular lisa uterina.

La oxitocina normalmente actúa hasta 6 días post parto por lo cual debe confirmarse previa a su administración la dilatación del cervix para evitar de ésta manera ruptura del útero.

Glándula Mamaria: Provoca contracción de las células nioepiteliales del alvéolo lácteo, desencadenando la eyección de leche así como también la oxitocina está involucrada en una mayor producción de PRL postordeño. Cabe anotar que la Oxitocina no tiene propiedades o efectos galactopoyéticos.

Debido a que la oxitocina tiene mínimas propiedades antidiuréticas puede ocurrir intoxicación hidrica si se administra a una velocidad muy alta o grandes volúmenes intravenosos de fluídos sin electrolitos.

Recientemente se ha comprobado que ejerce efecto luteolítico en la fase temprana de la luteinización.

FARMACOCINETICA

La oxitocina se destruye en el TGI por lo que debe administrarse por vía parenteral, luego de la administración intravenosa la respuesta uterina se presenta inmediatamente. Cuando se aplica por vía intramuscular la respuesta se presenta en 3-5 minutos. La duración del efecto en perras después de la administración IV, IM, SC es de aproximadamente 13 20 minutos. La administración de Oxitocina puede hacerse por vía intranasal, pero la absorción puede ser errática. La Oxitocina se distribuye en el LEC. Pequeñas cantidades de Oxitocina pueden atravesar la placenta y entrar en la circulación fetal. La vida media en el plasma es de 3 - 5 minutos. En cabras cerca de 2 minutos. La Oxitocina se metaboliza rápidamente en el hígado y riñon y la enzima circulante oxitocinasa destruye la hormona. Pequeñas cantidades de Oxitocina son excretadas en la orina.

ACCIONES COLATERALES:

En humanos tiene efecto insulinoide. Puede tener efecto antidiurético dada su similitud en la estructura química con la ADH. La oxitocina natural es más uterotónoca que antidiurética.

C. SITIO DE ACCION:

Fibra muscular lisa del útero y en las células mioepiteliales del alvéolo lácteo.

D. MECANISMO DE ACCION:

Aumenta el componente cálcico necesario al momento de la iniciación del potencial de acción.

Elevados niveles de Mg,K y Ca están involucrados en la hipercinética uterina. La Oxitocina tiene gran afinidad por los receptores uterinos que son en ocasiones verdaderos marcapasos:

Fisiológicamente la oxitocina se conoce como Neurofisina I y la Vasopresina ADH como Neurofisina II.

La Oxitocina incrementa la permeabilidad en las miofibrillas uterinas, al sodio facilitando su contracción.

E. FARMACOCINETICA:

La Oxitocina natural que elabora el animal preñado es destruída por la oxitocinasa y es destruída en el TGI. Se emplea parenteralmente vía IM, respuesta a los 3 a 5 minutos. IV es inmediata. Duración del efecto de 13 a 20 minutos.

La Oxitocina se metaboliza en el hígado y en el riñon y en la circulación por la oxitocinasa, pequeñas cantidades se pueden eliminar por la orina.

Pequeñas cantidades pueden atravesar la placenta y penetrar al feto.

F. APLICACIONES CLINICAS:

Util en el caso de distocias en perras, gatas y cerdas, donde la palpación es dificil. En la expulsión de placentas retenidas, aunque hoy en día lo hacen mejor las prostaglandinas tipo F2 Alfa.

Para activar úteros atónicos al momento del parto.

En casos de cesárea la administración intrauterina facilitará la rápida involución, así como también evitará hemoragias uterinas.

En prolapso uterino la administración directa provocará reducción de su tamaño y facilitará el manipuleo del mismo.

Debe administrarse oxitocina con el cervix dilatado.

Facilita la evacuación de leche lo cual es útil en cerdas agalácticas, síndrome MMA y en casos de mastitis en vacas para expulsar leche y posteriormente poder aplicar una quimioterapia adecuada.

Para combatir hemorragias postparto. La Oxitocina puede actuar como luteolítico hacia el final de la preñez. La sintética por su característica no presenta vasopresinico y su acción es constante.

Contraindicada en partos distócicos, desproporción fetopélvica, en severa toxemia.

G. ADMINISTRACION, DOSIS Y PREPARADOS:

La administración IV, debe hacerse en forma lenta y diluída en suero fisiológico.

La administración IM, debe hacerse lo más profundo posible, pues cuando se aplica superficialmente podrá causar estafelación en el sitio de inyección.

Se aconseja administrar pequeñas dosis y repetir cuantas veces sea necesario.

Puede presentarse intoxicación acuosa si se emplea grandes dosis para largos períodos, si se da conjuntamente con soluciones no electrolíticas debida al efecto ADH. Puede provocar hipertensión si se administra simultáneamente con simpaticomiméticos.

Las PG potencializan el efecto de la oxitocina.

La administración intranasal puede presentar absorción errática.

DOSIS EN U I	OBSTETRICIA U I	EYECCION DE LECHE U I
Gata	5-10	1-10
IM Perra	5-25	2-10
Cerda	30-50	5-20
Oveja	30-50	5-20
Vaca	75-100	10-20
Yegua1	75-100	10-20

Cuando se administra IV, estas dosis se pueden reducir a la mitad. También se recomienda Sc pero no es muy aconsejable.

Preparados humanos: PITOCIN Y SYNTOCINON. Ampolla x 1ml de 5 UI ó 10 UI.

En Medicina Humanam, en caso de embarazo prolongado, desnutrición intrauterina, ruptura prematura de membranas, aborto frustrado, etc. Se utiliza la oxitocina como inductor para conseguir contracciones cada tres minutos de 30 45 segundos.

Alcaloides del Cornezuelo de Centeno: Actúan por cuanto estimulan los receptores uterinos. No hay presentaciones comerciales para uso veterinario y poco se emplean. En humanos se emplea en casos de atonía o hemorragia uternina asociada a cesárea el producto METHERGIN (Metilergobasina), ampollas por 0.2 mg/ml, grageas 0.125 mg.

D OXITOCINA SINTETICAS VETERINARIAS

NOMBRE COMERCIAL	PRINCIPIO ACTIVO	VIA ADMINISTRACION	PRESENTACION
HORMOFISINA Vicar	Oxitocina sintética 50 UI x ampolla	IM SC.	Caja 3 amp x 5 ml
ORASTINA Hoechst Colombiana	Oxitocina sintética 10 UI x ml	IM SC	Fco x 5 y 10 ml
OXITOCINA CALIER-Boehringer Ingelheim	Oxitocina sintética 10 UI x 5 cm.	IM IV	Faco x 10 ml
OXITOCINA SINTETICA Vecol	Oxitocina sintética 10UI x ml	IM SC IV en 100 ml Suero Fisiológico	Caja 12 Fcos x 10 ml
PITUIFRAL Boehringer Ingelheim	Oxitocina sintética 10 UI po ml	IM SC	Fco x 10 ml
VETUCIN Lab Wyeth	Oxitocina Sintética	IM SC IV Lenta	Fco x 10 ml x 100 UI Faco x 20 ml x 200 UI
LACTOPART Lab Erma	Oxitocina Sintética	IM SC IV Lenta	Fco x 10 ml

U.I. UNIDADES INTERNACIONALES

NOTA: los diferentes laboratorios la recomiendan para estimulantes de las contracciones uterinas, hemorragias postpartum, retención de placenta, coadyuvante en el tratamiento de la mastitis, descenso de la leche. **JAMAS** para atonía intestinal.

B. AGENTES TOCOLITICOS: Aquellos fármacos que provocan inhibición de la contracción uterina al momento del parto (antiespasmódicos) se conocen con el nombre de tocolíticos ó uteroinhibidores. Se puede ejercer con ellos una farmacovigilancia al momento del parto.

CLASIFICACION: Los agentes tocolíticos fundamentalmente son aminas simpaticomiméticas o agentes adrenérgicos beta 2 meméticos.

A. ORIGEN Y QUIMICA: Compuestos sintéticos análogos a la adrenalina que endégenamente se biosintetizan en la adrenal y el terminal nervioso autónomo simpático.

B. ACCION FARMACOLOGICA: Inhiben las contracciones del útero al momento del parto. Colateralmente pueden provocar aceleración cardíaca, broncodilatación y vasodilatación. No interrumpe la cinética hormonal concomitante con la labor del parto. Indirectamente promueven una acción uterosedante.

C. SITIO DE ACCION: La fibra muscular lisa uterina.

D. MECANISMO DE ACCION: El útero posee receptores alfa y beta 2, llamados adrenoreceptores. Los tocolíticos actúan sobre los receptores beta 2 uterinos que durante el parto y al término de la preñez, generando una activación de los adrenoreceptores, betamiméticos o simpaticomiméticos beta 2, lo que finalmente se traduce en miorrelajación uterina. Hay concomitantemente un aumento del AMPc a partir del ATP mediado por acción de la proteína Gs localizada en la cara interna de la membrana celular. A nivel bronquial los beta 2 pueden ser activados provocando una broncodilatación por cuanto ejerce acción sobre el mastocito previniendo la deghranulación de sustancias bronccontrictoras, acelera los movimientos mucociliares. Poco afecta los receptores beta 1 por lo que sus efectos cardíacos son limitados.

E. FARMACOCINETICA: Se absorben por vía oral y parenteral. Se elimina por la orina aunque pequeñas cantidades lo hacen por la leche y heces. Su efecto dura aproximadamente 6 horas.

TOXICOLOGIA: DL 50 20 a 30 mg/kg IV .
oral 176 mg/kg

F. APLICACIONES CLINICAS: Permite el manejo del parto distócico, evitando la muerte de las madres y los fetos, por cuanto bloquea las contracciones uterinas, aliviando al feto de la presión del parto. Igualmente facilita el paso del feto por el canal uterovaginal.

Facilita la programación de los partos, evitándose los partos nocturnos.

En cabalos de hipódromo evita la hemorragia por sobre esfuerzo luego del ejercicio de las carreras.

No afecta el posterior proceso de expulsión de la placenta y sus secundinas. Facilita el manejo del útero para reponerlo en su sitio en casos de prolapso, en espasmos del cervix, en posición incorrecta del feto y en la preparación quirúrgica de la cesárea.

NO DEBE ADMINISTRARSE JUNTO CON SIMPATICOMETICOS U OTROS VASODILATADORES.

Se puede prolongar el parto por 6 a 8 horas.

- Recientemente se han reportado que animales tratados con beta 2 miméticos presentan capa de grasa uniforme en sus carnes. Por efecto de B3 miméticos.

También se pueden emplear con beta 2 miméticos fármacos de uso humano como AUPENT (Orciprenalina), BRYCANIL (Terbutalina), VENTILAN (Salbutamol), BEROTEC (Fenoterol), SPIROPENT (Clenbutero) jarabe.

G. DOSIS, PREPARADOS:

E. TOCOLITICOS

PLANIPART B.I.S.A.	**Cienburterenol 0.03 mg/ml. Simpaticomimético**	**IM IV Lenta**	**Fcos x 50 ml**

Vaca dosos 0.06 mcg/kg ó 0.03 dosis total.

Ovinos 0.20 a 0.25 mg dosis total

Eventualmente también pueden provocar afecto uteroinhibidor los analgésicos no esteroidales como la aspirina y la indometacina por bloqueo de la síntesis de PG F2 alfa. El efecto es sostenido aunque su acción no es tan manifiesta y de rápida presentación como con los beta 2 miméticos.

PROSTAGLANDINAS

Centenares de artículos refieren la historia de las prostaglandinas y es así cimo el nombre de KURZROK y LIEB están ligados al inicio de su estudio, pues ellos observaron en 1930 que tiras de útero recientemente colectado generaban actividad cuando se les adicionaba en el tubo de Fletis semen humano también recientemente colectado.

Goldbatt en Inglaterra y Von Euler en Suecia, informaron de hallazgos similares. En 1936, Euler lo identificó como ácido liposoluble y dado que esta sustancia se encontraba en el semen del cual hace parte el fluído prostático, lo bautizó como Prostaglandina.

Hoy en día sabemos que se ha encontrado en todos los tejidos y líquidos corporales, tiene entonces obicuidad en el organismo, aunque las PG son utilizadas muchas de las veces por los órganos que las sintetizan por lo que se ha acuñado un término que denota esta característica y es el de **AUTOCOIDE.**

Pequeñas cantidades provocan variados efectos biológicos, activan o inactivan la adenililciclasa en muchas células y se explica que el mecanismo de acción de muchos fármacos que actúan a nivel cardiovascular o los que actúan en los procesos inflamatorios así como gran variedad de compuestos deben su acción a la síntesis o inhibición de las prostaglandinas.

Las primeras prostaglandinas fueron aisladas en 1957 por Bergstrom y Sjoval, obteniendo las E1 y F2 alfa.

Entre 1962 y el 65 se obtuvo la dilucidación de sus estructuras. En el 63 la sustancia presente en la médula renal del conejo inicialmente conocida como Medulina se identificó como una PGA2 y 2 años más tarde se aisló de la médula renal la PGE 2.

Inicialmente las PG de las series E y F fueron llamadas primarias y consideradas como las más importantes. Hoy en día se piensa que ellas constituyen solo una fracción de los productos fisiológicamente activos. Se han identificado endoperóxidos cíclicos (PGG2 y PGH2).

Recientemente se han encontrado los tromboxanos y las prostaciclinas. Se debe hablar no de prostaglandina sino del sistema prostaglandínico que incluye una gran variedad de las mismas, con múltiples efectos en el organismo tanto humano como de los animales.

Desde hace ya unos años se discuten las aplicaciones de mediadores prostaglandínicos en la patología del dolor y la inflamación. Son numerosas las acciones que desencadenan las prostaglandinas y como tal, también es grande la expectativa en el desarrollo de nuevos fármacos.

CARACTERISTICAS QUIMICAS:

Químicamente son ácidos grasos insaturados con 20 átomos de C y un anillo ciclopentano. Las prostaglandinas cuya abreviación es P.G. son análogas de un compuesto hipotético, el ácido prostanoico, que se divide en varios grupos designados por letras A-B-C-D-E-F-G-H-12-Tx, los cuales se diferencian por las características del anillo ciclopentano. E y F son las llamadas primarias. Las clases principales se subdividen a su ven según el número de dobles enlaces en las cadenas laterales.

Las prostaglandinas con subíndices 3 son muy raras en la naturaleza. De las E se obtienen las A,B y C por deshidratación e isomerización. La estereoquímica determina las posiciones de los grupos radicales en los carbonos asimétricos. En la F2 alfa existen cinco carbonos asimétricos (8.9,11,12,15).

La síntesis de PG primarias se logra por un mecanismo enzimático microsomal llamado prostaglandinsintetasa. En vivo las PG se originan a partir de ácido linoléico que se ingiere como cinstituyente de la carne de bovino para construír la base del ácido araquidónico fundamental en la llamada "cascada" de la síntesis de las distintas prostaglandinas.

El ácido araquidónico se libera de los fosfolípidos de la membrana celular por acción de la fosfolipasa A2. Esta enzima es activada por varios tipos de mecanismos hormonales, químicos, mecánicos, tóxicos, lumínicos, etc. La activación de la enzima fosfolipasa limita la producción del precursor y siendo las prostaglandinas hormonas de acción rápida y en la mayoría de los casos local, la disponibilidad de ellos está determinada por la actividad y presencia de la enzima.

La vida media de las prostaglandinas PGF2 alfa estable en solución acuosa a 37 grados centígrados, endoperóxidos cíclicos PGG2 y PGH2 30-40 segundos, prostaciclina desaparece en 10 minutos.

El ácido araquidónico que es el precursor debe llegar a los microsomas y cerca de la membrana nuclear, dinde la enzima prostadinsintetasa determina la cascada de síntesis de PG.

Las prostaglandinas actúan sobre receptores situados cerca del lugar d síntesis, transformándose rápidamented en metabolitos menos activos desde el punto de vista fisiológico.

Inhibidores en la formación de PG por impedir la formación del ácido araquidónico son los glucocorticoides o por inhibición de la ruta cicloocigenasa para formar los endoperóxidos que determinan la formación de varias prostaglandinas. Entre ellas están, la aspirina y los agentes antiinflamatorios no esteroidales. N.S.A.I..

Ahora bien el 95 % de postaglandina E2 se inactiva en el pulmón en los lechos vasculares. El pulmón actúa como un filtro esta depuración previene al sistema cardiovascular y a otros órganos de sus efectos prolongados. El catabolismo puede ser rápido por la acción de enzimas específicas para las prostaglandinas o lento su catabolismo pues deben ser oxidados y luego aparecerán en la orina.

Laz enzimas que catabolizan la degradación de PG tienen amplia distribución en el organismo y se hallan en el bazo, riñon, tejido adiposo, intestino delgado, hígado, testículo, pulmón.

Una PG muy importante en Medicina Veterinaria es la F2 alfa. Es inactivada a nivel pulmonar, pero este problema se obvia cuando se administran los análogos sintéticos de las prostaglandinas y cuando se aplican vía intravaginal o intravulvular.

INHIBIDORES DE LAS PROSTAGLANDINAS

Los fármacos antiinflamatorios provocan bloqueo del sistema prostaglandínico a través de la inactivación de la ciclooxigenasa como en el caso de los fármacos antiflogísticos no esteroidales NSAIA y la aspirina, o también a través de la disponibilidad reducida del sustrato tal como ocurre con los fármacos antiflogísticos esteroidales.

Estos fármacos no esteroidales provocan formación reducida de PG, en el foco de la inflamación y en otras partes como ocurre en el hipotálamo que cuando se produce fiebre debida a la producción de PG pero su bloqueo por parte de la aspirina reducirá entonces el efecto pirético.

El mecanismo de acción de la aspirina se explica por el bloqueo de la síntesis y liberación de PG. El mismo mecanismo de acción lo tiene la INDOMETACINA por inhibición de la ciclooxigenasa. La ciclooxigenasa es una enzima suicida la cual irreversiblemente se autodestruye durante la oxidación del ácido araquidónico. A partir de 1971 se han estudiado las acciones farmacológicas de los inhibidores de la síntesis del ácido araquidónico y en especial de la ciclooxigenasa (COX).

Recientemente se han identificado dos isoenzimas COX1 y COX2. La activación de la COX1 que se considera la enzima constitutiva originan prostaglandinas con efecto antitrombogénico y de acción citoprotectora sobre a mucosa gástrica. La COX2 se induce por efecto de los estímulos que conducen a la inflamación- Hoy en día la investigación está orientada a la búsqueda de fármacos, si bien antiinflamatorios, que bloquean la COX pero no a la COX1.

Se explica que la aspirina ejerce efecto antiinflamatorios por inhibición de la COX2 y los efectos secundarios indeseables como toxicidad renal e irritación de la mucosa gástrica son debod a la simultánea inhibición de la enzima constitutiva COX 1.

PROSTAGLANDINAS EN REPRODUCCION ANIMAL

QUIMICA

Los análogos más importantes son dinoprost, trometamina, tiaprost, clorprosterenol sódico, fluorprosterenol, fenprostaleno que es un ester metil sintético análogo a la F2 alfa.

ACCION FARMACOLOGICA

En Medicina Veterinaria la F2 alfa y sus análogos como el DINOPROST, TIAPROST, CLORPROSTERENOL provocan efectos luteolíticos. La F2 alfa endógena junto con las bradiquininas, kininas, histamina y otras citocínicas están involucradas en el proceso de la ovulación.

Por su efecto luteolítico provocan aborto, inducción del parto, efecto de apertura del orificio cérvico uterino, expulsión de contenidos uterinos purulentos, expulsión de membranas fetales, expulsión de fetos momificados, sincronización del estro, inducción de la ovulación, inhibición de la esteroidogénesis por parte del cuerpo lúteo, también provocan relajación del cervix.

La PGF2 Alfa endógena de origen uterino mediante un sistema de contracorriente llega al cuerpo lúteo donde provoca regresión del mismo, de esta manera se comportan sus análogos.

FARMACOCINETICA:

Poco se conoce pero se sabe que el dinoprost se distribuye rápidamente y que la vida media es muy corta. En la leche aparecen niveles muy bajos.

El Tiaprost en Bovinos la concentración máxima es de 2 ng/ml a las 0.5 horas de aplicación, la vida media en el plasma es de 1.2 horas y concentraciones comprobables hasta 7 horas en el plasma después de su aplicación.

El Fenprostalene se absorbe y se elimina mas lentamente que otras PG. No se le encuentra en la leche después de 48 horas de su administración.

No se dispone de información sobre el fluorprosterenol.

USOS CLINICOS:

Dado que los análogos de las PGF2 alfa presentan el mismo mecanismo de acción y los mismos efectos se consideran en bloque los usos clínicos de los distintos tipos comerciales de prostaglandinas.

En Veterinaria se han utilizado para sincronizar el celo, inducir el aborto, inducir el parto y junto con corticoesteroides como la Dexametasona inducen la presentación del parto pero provocan retención de placenbta, expulsión de fetos momificados, para expulsar piómetras, lo cual ha dado excelente resultados en perras y vacas. Vacas resistentes a antibióticos dan buena respuesta con PGF2 alfa en la expulsión de piometras y en mastitis.

Para efecto profilático una dosis postparto vía intravulvar reduce el riesgo de piómetras.

En Porcinos la PG es sensible, su cuerpo lúteo después del día 13 del ciclo. Los cuerpos lúteos de la preñez son muy susceptibles luego del día 12 de la preñez. Inducen el aborto 48 horas luego de su administración. Induce y sincroniza el parto a los 111,112,113 días de gestación provocando el parto a las 40 horas postaplicación. El tiempo para emplear PG en sincronización del celo en cerdas es muy corto.

Las yeguas son muy sensibles al efecto de la PG sobre la musculatura lisa del TGI lo cual provoca cólicos, sudoración ,diarrea y a nivel vascular hipotensión.

Dado el atlo costo de la PG se utilizan vía intravulvar, IV o intravaginal y es mejor utilizarla previa palpación rectal a fin de establecer un cuerpo lúteo funcional donde es efectiva la PGF2 alfa.

En bovinos la sincronización de celos y la administración conjunta de PMS favorece y asegura la transferencia de embriones.

El DINOPROST es la prostaglandina natural de la F2alfa que se encuentra en el mercado veterinario y el TIAPROST es su análogo en el mercado colombiano junto con el clorprosterenol.

DOSIS VIAS DE ADMINISTRACION

En trabajos realizados en la Facultad de Medicina Veterinaria y de Zootecnia de la Universidad Nacional de Colombia, se llegó a la conclusión de que en la vaca las PG se pueden emplear por vía intravenosa (3cc) vía intracervical pero con alto riesgo de infección y la intravulvar (IV) a menor dosis y con menor riesgo de infección, la PG se administra penetrando externamente por labios vulvares a la dosis de 2.5-3.0 cc para las PG naturales y sintéticas, aprovechando el que estos análogos también siguen el sistema de contracorriente para llegar al ovario y causar luteolisis.

EN PERRAS

Piómetra: 0.25 mg/kg Sc día 2 5 días conjuntamente con antibióticos. No se recomienda en animales mayores de 8 años.

También 0.025 a 0.25 mg/kg cada 12 horas hasta lograr efecto abortivo, después del día 25 de gestación 60 mcg/kg IM divididos en 2 0 3 tratamientos x 5 días.

EN GATOS

Piómetra: 0.1 mg/kg Sc día x 5 días con antibióticos.

Abortivo: Día 40 de gestación 0.5 a 1.0 mg Sc x 2 días. El aborto se presenta 8 24 horas postadministración.

También en perras con piometra se aplica vía IM a la dosis de 1cc (5 mg Dinoprost) durante 5 días consecutivos. Vía Sc dosis 0.10 - 0.25 -0.50 mg/kg una vez día por tres días.

En general se recomienda no utilizarla en animales preñados. Los veterinarios deben tener cuidado en el manejo de las PG máxime si sufre de asma o problemas respiratorios o si las colegas están en período de embarazo.

Varios fármacos tienen como mecanismo de acción el bloquear la síntesis de PG tal como ocurre con los analgésicos NSAI, prototipo aspirina, glucocorticoides, por lo que para ellos se ha acuñado el término ANTIPROSTALANDINICO.

VIAS DE ADMINISTRACION DOSIS Y PREPARADOS

Universalmente se recomienda la vía I.M. a las siguientes dosis totales:

Tiaprost 5 mg/ml	VACA 0.750mg 5cc	YEGUA 0.450 mg 3cc	CERDA 0.600 mg 4cc	OVEJA 0.225 mg 1.5cc
Dinoprost 5 mg/ml	25 mg 5cc	5mg 1cc	10mg 1cc	15mcg
Clorprosterenol	500 mcg	100 mcg	175 mcg	100 mcg

De los preparados comerciales se recomienda administrarlos 2 x 5 veces a intervalo de 10-12 días para vacas y novillas cuando no se presenta el celo 48-72 horas postratamiento, sin embargo, al efectuar previamente la palpación rectal, o establecer niveles de P4 (ng/ml) mediante la técnica del RIA se puede reducir a una sola dosis el tratamiento.

Las PG (endógena y sintética) son inefectivas cuando se administran como una sola dosis 5 días después del celo, por cuanto aún no hay receptores en el ovario para la PGF2 alfa, pero en cambio en este período actúa la oxitocina.

A PROSTAGLANDINAS TIPO F2ALFA (ANALOGOS)

NOMBRE COMERCIAL	PRINCIPIO ACTIVO	VIA ADMINISTRACION	PRESENTACION
LUTALYSE Tuco	Dinoprost 5mg/ml PG Natural	IM 5ml IVv 2ml	Fco x 10 ml
ILIREN Hoechst Colombiana	Tiaprost 0.150 m/ml análogo F2 Alfa	IM 5ml Vv 2ml IVv 3ml	Fco x 10 ml
PROSTIN E2 Upjohn en humanos	Dinoprostona Tabletas x 0.5 mg	Oral	Tabletas
ESTRUMATE	Clorprostenol	MI	Fco x 10 ml

FARMACOS HORMONALES

OXITOCINA	DISTOCIN HORMOFISINA ORASTINA OXITOCINA SINTETICA VETUCIN
PROSTAGLANDINAS F2 ALFA	ESTRUMATE ILIREN LUTALYSE
FSH	FSH.P
GnRH	CONCEPTAL OVALYSE OVARELIN

HORMONAS ESTEROIDEAS

ESTROGENOS 1- Alfa Estradiol 2- Beta Estradiol 3- Benzoato de Estradiol 4- Valeriato Estradiol 5- Trembolona	 ESTRO -ZOO COMPUDOSE 200 Elanco COMPUDOSE 200 Purina COMPUSODE 400 Elanco COMPUDOSE 400 Purina REVALOR GANAMAX H GRAFOLEON N.F. SMB SYNCROMATE REVALOR
PROGESTAGENOS 1- Progesterona	 GESTAVEC 25 PROGESTERONA GANAMAX -M
ABANICOS 1- Andrógenos a- Boldenona 2. Estrogénicos 3. Mixtos	 GANABOL 50 BOLDENOL GANABOL EQUIPOISE COMPUDOSE 200 Y 400 REVALOR RALGRO REVALOR GANAMAX H GANAMAX M

ANABOLICOS VETERINARIOS

NOMBRE COMERCIAL	PRINCIPIO ACTIVO	V. ADMINIST	PRESENTACION
COMPUDOSE 200 - LAB ELANCO	17 Beta Estradiol 24 mg/implante	SC OREJA	Implante proveedor x implantes
COMPUDOSE 200 ESTRADIOL	Estradiol 24 mg/implante	SC OREJA	Estuche x 10 implante
COMPUDOSE 400 Lab Elanco	17 Beta estra diol 45 mg	SC OREJA	Proveedor x 10 implantes
EQUIPOISE Iny Squibb BOLDENOL Prodiva GANABOL	Boldenona Undecilinato 25 ML	I.M.	Fcos x 10 ml x 50 ml
FINAPLIX Hoechst	Acetato trembolona	SC OREJA	Pelets cartucho x 10
GANAMAX Squibb	Benzoato estra diol 20 mg Testosterona 200 mg	SC OREJA	Comprimidos caja x 20 dosis
GANAMAX M Squibb	Benzoato estra diol 20 mg progesterona 200 mg	SC OREJA	Comprimidos Caja x 20 dosis
RALGRO Hoechst	Zerarol No Hormonal	SC OREJA	Implante, Pelet Discos x 24 dosis

PROGESTERONAS VETERINARIAS

NOMBRE COMERCIAL	PRINCIPIO ACTIVO	V. ADMINIST	PRESENTACION
PROGESTERONA Erma	Progesterona 25mg/mg	I.M.	Fco x 20 ml Caja x 12 fcos
GESTAVEC 25 Vecol	Progesterona 25mg/ml	I.M.	Fco x 10 ml Caja x 20 fcos
SINESTROL Pharmavet	Progesterona 50 mg/tab	Oral	Caja x 22 tab de 55 mg
SYNCRO-MATEB Comandina	Norgestomet 6 mg Implante + inyectable 3 mg. Norgestomet 5 mg valerato de estra diol. Estronos sintéticos	Administrar implante mas inyectable al 9 día retirar el implante	

ESTROGENOS NO HORMONALES DIETILESTILBESTROL D.E.S.

NOMBRE COMERCIAL	PRINCIPIO ACTIVO	VIA ADMINISTRAC	PRESENTACION
DIETILBOESTROL Ifsa	Dietil Stilboestrol 0.05g x amp oleoso	IM	Fco ampolla x 10 ml
ESTILBESTROL Vecol	Dietil estilbestrol 4 mg por ml oleoso	IM	Fco de 20 ml x 1 x 12
ESTO - ZOO ZOO	Alfa estradil (DES) Oleoso	IM	Fco x 20 ml
FOLIESTROL Probyala	Estibestrol 4%	IM	Fco x 20 ml
GRAFOLEON NF Life	Benzoato de Estradiol	IM	Fco x 10 y 50 ml

TRATAMIENTOS SUPEROVULATORIOS EN YEGUAS

	TRATAMIENTO DE GONADOTROPINA		TRATAMIENTO INTERVALO ESTIMADO
	PARA INDUCIR TRATAMIENTO FOLICULAR	PARA INDUCIR OVULACION	
Yeguas anovulatorias estacionales	Gonadotropinas hipofisiarias equinas crudas, inyectadas en forma subcutánea 2 veces al día durante 14 días para una dosis total de 13.2 mg/kg de peso corporal durante el período de 14 días	hCG 2000 UI administradas por inyección intramuscular en el día 14	Algunas yeguas estaban en estro en el momento del tratamiento, la ovulación se presentó en los días 14 ó 15
Yeguas cíclicas	Preparación de gonadotropina hipofisiaria equina 750 unidades Fevold Hisaw de rata, inyectada en forma subcutánea diariamente durante site días desde el día 14 has ta el día 20 posovulación	hCG 4000 UI por inyección subcutánea en el día 20 posovulación.	La ovulación se presentó en la mayor parte de las yeguas en el día de las inyecciones de hCG (Día 20)

TRATAMIENTOS SUPEROVULATORIOS PARA CERDAS MADURAS Y CERDAS JOVENES POSPUBERAS

TRATAMIENTO DE GONADOTROPINA		DIAS DESDE EL TRATAMIENTO AL ESTRO
PARA INDUCIR CRECIMIENTO FOLICULAR	PARA INDUCIR OVULACION	
PMSG: 1000-1500 UI en una sola inyección intramuscular en el día 15 del ciclo estrual.	Ninguno	3-4 después de PMSG
PMSG: 1500 UI en una sola inyección intramuscular 24 horas después de PCF en cerdas sincronizadas al provocarles gestación o seudogestación.	hCG: 500 UI tres días después de PMSG	3-4 después de PMSG

Datos de Betteridge K.J. Embryo Transfer in Farm Animals. Departamento de Agricultura de Canadá. Monografía 16 1977 p 41: Martín P.A.: Embryo Transfer in Swine en: Current Therapy in Theriogenology 2 1985 p 56 Primer día del estro

TRATAMIENTOS SUPEROVULATORIOS PARA GATAS EN ANESTRO

GONADOTROPINA		
PARA INDUCIR CRECIMIENTO FOLICULAR	PARA INDUCIR OVULACION	DIAS DESDE EL TRATAMIENTO AL ESTRO
FSH: 2.0 mg diario, inyecciones intramusculares hasta el inicio del estro PMSG: 200 ó 400 UI única inyección	HcG: 250 UI inyecciones intramusculares en los días 1 y 2 del estro hCG: 200 UI en el día 2 del estro	4 a 5 después del primer tratamiento de FSH 3 a 6 después de PMSG

Datos de Wildt D.E. et al: Lab Anim Sci 28 301 1978 Bowen R.A. Inédito.
FSH porcina, Armour-Baldwin Laboratories.

METODOS PARA SINCRONIZACION DEL ESTRO EN ANIMALES DE GRANJA

ESPECIE	TRATAMIENTOS	INTERVALO AL ESTRO
Ganado Bovino	20-30 mg PGF por inyección intramuscular en cualquier día del 5 al 16 del ciclo estrual. 5mg PGF por infusión intrauterina en cualquier día del 5 al 16 del ciclo estrual. 30 mg PGF por inyección intramuscular dos veces, separadas por 10 días, sin importar la etapa del ciclo. Implante subcutáneo que contiene 6 mg SC2 1009 combinado con una inyección intramuscular de 3 mg SC2 1009 más 5 mg de valerato de estradiol, implante retirado en 9 14 días.	2-4 días después de PGF 2-3 días después de PGF 2-4 días después de la segunda iunyección de PGF. 24-52 horas después del retiro de pregestina.
Ovejas y Cabras	12.5 mg de progesterona en aceite diariamente durante 16 días por inyección intramuscular. 10-15 mg PGF por inyección intramuscular en cualquier día del 5 al 14 del ciclo estrual. Esponja con 20 mg de acetato de flurogestona colocada en la vagina durante 16 a 20 días, inyección intramuscular de 500 UI PMSG y 500 UI hCG en el momento de retirar la esponja.	1-3 días después de la última inyección de progesterona. 1-3 días después de PGF 1-2 días después de retirar la esponja
Cerdas	100 mg de metalliburo oral en alimento diariamente durante 20 días. 100 mg de metalliburo oral diariamente durante 16 a 25 días: 1000-1500 UI PMSG en el día después del último alimento de metalliburo, seguido en 96 horas por 500-1000 UI hCG	2-4 días después del cese de alimento de progestina. 1-2 días después de hCG

ALGUNOS METODOS PRACTICOS PARA LA SINCRONIZACION DE ESTRO EN LOS ANIMALES DOMESTICOS

Especie	Método	Tratamiento	Respuesta
Bovino	Progestágeno a largo plabo	Progestágeno bucal o implantado durante 14 a 21 días.	La sincronización del estro es buena pero la fertilidad es baja.
	Prostaglandina	Una dosis luteolítica de PGF o su análogo a animales entre los días 5 y 18 del ciclo estral.	La mayoría entra en estro de 2 a 5 días después del tratamiento, la fertilidad es buena.
		Dos dosis luteolíticas de PGF o su análogo dadas con 11 a 12 dís de diferencia a un grupo de animales.	La mayoría entra en estro 2 a 5 días después del tratamiento. La festilidad es aceptable.
	Estrógeno más progestágeno a largo plazo.	5 mg de estradiol día 1: Progestágeno implante durante 9 a 12 días comenzando en el día 1.	La mayoría entra en estro 2 a 4 días después de retirar el implante, la fertilidad es buena.
	Progestágeno más prostaglandina	Progestágeno (implante bucal) durante 5 a 7 días, dosis luteolíticas de PGF o sus análogos dados en el último día del tratamiento progestágeno.	La mayoría entra en estro de 2 a 5 días después la fertilidad es buena.
Borrega	Progestágeno GSYP	Pesarios de progestágeno durante 12 a 14 días GSYP 500 750 UI dados en el momento de retirar el pesario	El estro se sincroniza en hembras acíclicas y cíclicas,la fertilidad es buena siempre y cuando los carneros se manejen adecuadamente.
Cabra	Progestágeno GSYP	Progestágeno durante 18 a 21 días, GSYP 400 - 800 UI dados uno a dos días antes del fin del tratamiento de progesterona.	La sincronización del estro, la fertilidad es buena.
Cerda	Progestágeno	Progestágeno bucal durante 18 días	La sincronización del estro y la fertilidad son buenas, siempre y cuando la dosis de progesterona sea suficientemente elevada para prevenir formación de quistes ováricos.
Yegua	Prostaglandina	Una dosis luteolítica de PGF o sus análogos a yeguas en diestro.	El estro comienza de 2 a 5 días después y la fertilidad es buena.

METODOS PARA LA SINCRONIZACION DEL ESTRO

ESPECIE	METODO	REGIMEN DEL TRATAMIENTO	RESPUESTA
Bovino	Prostaglandina PGF2 Alfa	Detectar el estro en IA por 5-6 días, dar PGF al resto de los animales en el 6 7 e IA al estro.	La mayor parte se aparea una vez en un período de 10 a 12 días.
		Dar PGF al día 1 e IA a los animales en estro durante los siguientes 5 días, dar a los animales sin cría PGF al día 11 a 12 e IA al estro o IA a tiempo fijo.	La mayor parte se aparea una vez durante los 2 períodos de 3 a 5 días-
		Dos inyecciones de PGF a intervalos de 11 a 12 días e IA al estro o por tiempo fijo después de la segunda PGF.	La mayor parte se aparea dentro de un período de 3 a 5 días, los ciclos repetidos están sincronizados.
	Estrógeno + Progesterona	La inyección del estrógeno + el progestágeno en el día 1 con implante de progestágeno por 9 días, iniciando el día 1, IA en el estro o por tiempo fijo.	La mayor parte se aparea dentro de un período de 3 a 5 días, los ciclos repetidos son sincronizados.
	Progesterona + Prostaglandina	Progestágeno por 7 días con PGF administrada el día 6 IA al estro o por tiempo fijo.	La mayor parte se aparea en un período de 2 a 3 días, los ciclos repetidos están sincronizados.

Oveja	Progestágeno +PMSG	Progestágeno por 12 a 14 días, PMSG administrado al retiro del progestágeno, aparear en el estro o IA doble.	La mayor parte se aparea dentro de 2 días.
	Prostaglandina	Dar dos inyecciones PGF con 9 días de intervalo, aparear en el estro a IA doble.	La mayor parte se aparea en un período de 2 a 3 días.
Cabra	Progestágeno +PMSG	Progestágeno por 18 a 21 días, PMSG al momento del retiro del progestágemp. aparear en estro a IA doble.	La mayor parte se aparea en un período de 2 a 3 días.
	Prostaglandina	Dar dos inyecciones a intervalos de 11 a 12 días. Aparear en estro o IA doble	La mayor parte se aparea en un período de 2 a 3 días
Cerda	Progestágena	Progestágeno por 14 a 18 días, aparear al estro.	La mayor parte se aparea en un período de 4 a 7 días-
Yeguas	Progestágeno	Progestágeno por 15 días aparear al estro.	La mayor parte se aparea en un período de 4 a 7 días.
	Prostaglandina	Una dosis a las yeguas es diestro, aparear al estro.	La mayor parte se aparea en un período de 3 a 5 días.
	Prostaglandina + HCG	PGF al día 1 HCG al día 7 u 8, PGF al día 15 HCG al día 21 o 22	La mayor parte se aparea en un período de 2 a 4 días -

HORMONOTERAPIA PARA LA INDUCCION Y SINCRONIZACION DE LA OVULACION

TIPO DE HORMONA	VIA DE ADMINISTRACION	ACCION FARMACOLOGICA
Gonadotropina sérica de Yegua preñada (PHSG)	I.M.	Semeja a la FSH y estimula el crecimiento folicular
Gonadotropina Coriónica humana	I.M.	Semeja a la LH e induce ovulación
PMSG +hCG	I.M.	Combina la acción de FSH y LH
Hormona liberadora de gonadotropinas FSH-LH (GnRH) (Buserelina)	Inyección I.M. ó I.V.	Induce liberación de LH y FSH de la hipófisis anterior.
Progesterona	Inyección, implante, pesario	Semeja la acción del cuerpo lúteo.
Progestágenos sintéticos	Inyección, implante, pesario, oral	Semeja la acción del cuerpo lúteo
Conjugados de estradiol (estrógenos)	Inyección, implante	Induce la regresión prematura del CL y aumenta la respuesta a los progestágenos
Prostaglandina F ó análogos de PGF2	Inyección	Induce la regresión del CL durante las fases de respuesta.

Los ejemplos incluyen: Norgestomet, aedroxiacetato (MAP). Acetato de melengestrol (MGA, acetato de fluogestona). (FGA, Cronolona) y Altrenogest.

+Los ejemplos incluyen: Valerato de estradiol, benzoato de estradil y cipionato de estradiol.

METODOS PARA INDUCIR EL ESTRO Y OVULACION

ESPECIES	TRATAMIENTO	RESPUESTA
Vacas prepúberes o en postparto.	Estrógeno en el día 1 seguido por 7 a 12 días de progestágeno, PMSG en el último día (opcional)	La mayor parte presenta estro en los 5 días después del tratamiento.
Vacas lactantes en postparto	GnRH en el día 14 del postparto.	La mayor parte ovula 1 día después del tratamiento.
Ovejas y Cabras. Anestro prepuber o estacional	Progestágeno por 12 a 21 días con PMSG cerca del final del tratamiento con progestágenos.	La mayor parte presenta estro de 2 a 4 días después del tratamiento. Se requiere de la PMSG para una buena respuesta.
Cerdos. Anestro prepucer ó postparto.	PMSG sola. PMSG el día 1 con hCG de 48 a 96 horas después. PSMG + hCG en el día 1	La mayor parte presenta calor de 3 a 5 días después del tratamiento.
Equinos. Anestro estacional	Alargamiento del fotoperíodo por 4 horas por día.	La mayor parte cicla de 4 a 6 semanas antes de lo normal.
Equinos. Anestro tardío	Progestágenos por 15 días	La mayor parte cicla dentro de 1 semana después del tratamiento.

Reg 27696

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PRINCIPALES FACTORES

QUE

AFECTAN LA REPRODUCCION

V. J.
Dr. Víctor Cotrino B.adillo

Santafé de Bogotá, D.C.
13 al 17 de Julio de 1998

PRINCIPALES ENFERMEDADES INFECCIOSAS QUE AFECTAN LA REPRODUCCION

TIPO DE PROBLEMAS REPRODUCTIVOS

SINTOMA	POSIBLES CAUSAS
1. ANESTRO	Nutrición Minerales Energía Proteínas Bloqueo hormonal
2. INFERTILIDAD	
a. Con celos regulares	Semen-Toro-Inseminaciones
b. Celos 30 45 días	No detección de calores Muerte embrionaria temprana Stress Hormonal Enfermedad infecciosas IBR
c. Celos 45 90 días	Enfermedad infecciosa Trichomoniasis Campylobacteriosis IBR
3. ABORTOS	
a. De 3 a 5 meses	IBR Diarrea Viral Leptospira
b. De 5 a 7 meses	Leptospira: Campylobacter Brucella Novillas
c. Mayores de 7 meses	Brucella Leptospira Toxicológicos Deficiencias minerales
4. RETENCION DE PLACENTA	
a. Nutricionales	Baja energía Fósforo
b. Infecciosos	Brucella
c. Funcionales	Parto prolongado

LEPTOSPIROSIS

BOVINOS
ORINA ROEDORES
PERROS
OTROS

AGUA
ALIMENTOS
PASTOS

INGESTION

CONTAMINACION

1-2 Semanas

BACTERMINA

AGUDO Fiebre

Hemoglobin

CRONICO
RIÑON

ABORTO

MUERTE

AGUDO
Hepatitis
Neumonía
Nefritis
Bajo peso

FETO

Placenta

UTERO

ORINA

BRUCELLOSIS

FETO
PLACENTA
LIQUIDOS UTERINOS

BACTERIAS

SUELOS
PASTOS
LECHE
AGUAS

INDIGESTION

LECHE

HOMBRE

CONTAMINACION

GENITAL
MUCOSA OCUL
INSEMINAC

2-4 Sem

ABORTO FETO PLACENTA UTERO

BACTEREMIA

RETENCION PLACENTA
PARTO PREMATURO
MUERTE PERINATAL
METRITIS

GANGLIOS LINFATICOS
Tiempo variable

UTERO

GESTACION

CLASIFICACION DE LAS REACCIONES SEROLOGICAS EN EL DIAGNOSTICO DE BRUCELOSIS

	TIPO DE ANTIGENO				ANTICUERPO		
	I.P.S.		HN	PROT	Ig G1	IgG2	IgM
PRUEBA	CC	P					
ARP	X				X	X	X
ST	X					X	X
RB	X				X		X
FC	X	X			X		X
IFI	X				X	X	
IDD		X		X	X		
ELISA RIA		X			X		
IH		X			X		
IDR			X		X		
CIEF			X		X	X	
A.2-ME	X				X	X	
A RIV	X				X	X	

TRICHOMONIASIS CAMPYLOBACTERIOSIS

TORO INFECTADO

1er Servicio

COITO VACA SANA CONTAMINACION ENDOMETRITIS

FECUNDACION 28 30

VACA INFECTADA

ANIDACION

TORO PERMANECE INFECTADO

MUERTE EMBRIONAR

15-25

3er Servicio 2o Servicio

NUEVA OVULACION

LIMPIA CARGADA Repite ciclo anterior

CALOR IRREGULAR

45 60 DIAS

OCASIONALMENTE Repetir otro ciclo

CARGADA?

DIARREA VIRAL

VIRUS CITOPATICO — ANTIGENICAMENTE IGUALES — NO I.P.
VIRUS NO CITOPATICO — POSIBLE MUTACION — I.P.

ELISA Ac 115 SUEROS 35%

I.M.V.

ELISA Ag 35 PRUEBAS 5 I.P.

0-45 DIAS % DE FECUNDACION
PRE INSEMINACION 79% CONTROLES Vs 44%
POST INSEMINACION 69% DE FECUNDIDAD
67% DE ABORTOS A // DIAS
Vs 21% EN CONTROLES

45-125 DIAS PERIODO MAS CRITICO
DE 15 ANIMALES INOCULADOS A LOS 100 DIAS
6 ABORTARON 36 54 DIAS
7 Ac NEGATIVOS VIRUS POSITIVO
2 Ac POSITIVO VIRUS NEGATIVO

125-174 DIAS PERIODO FETAL INMUNOCOMPETENTE
LOS BIOTIPOS CITOPATICOS PARECEN MAS PATOGENICOS QUE LOS NO CITOPATICOS
ABORTO RETARDO CRECIMIENTO. EFECTOS TERATOGENICOS
HIPERPLASIA CEREBELOSA. MICROCEFALIA. HIDROCEFALIA
CATARATAS. DEGENERACION DE LA RETINA. APLASIA DEL TIMO

SOBRE 175 DIAS: NO OFRECEN MAYOR RIESGO.

RINOTRAQUEITIS BOVINA INFECCIOSA IBR

IPV VULVOVAGINITIS PUSTULAR
IPB BALANOPOSTITIS PUSTULAR
IBR RINOTRAQUEITIS BOVINA

IBR HERPESBIRUS-LATENCIA

FORMAS CLINICAS

RESPIRATORIA	NERVIOSA		REPRODUCTIVA
AEROSOL			
	MENINGOENCEFALITIS		COITO INSEMINACION
2 3 SEMANAS			AEROSOL?
FIEBRE	TERNEROS	FETOS	
NARIZ ROJA	CONVULSIONES		2 - 3 DIAS
SECRECION NASAL	TREMOR	60-90 DIAS	VULVOVAGINITIS PUSTUL
SECRECION OCULAR	EXITACION		
TRAQUEITIS	INCOORDINAC	6 8 MESES	10 14 DIAS
NEUMONIA	DEPRESION		
	MUERTE		SECRECION VAGINAL
			UTERINA

PROTOZOARIOS

TOXOPLASMA BAJO EN BOVINO
1979 FINCA COTA MORFOLOGIA H.I.

NEOSPORA 1987 NUEVO MEXICO
1991 PRIMER AISLAMIENTO
1994 CALIFORNIA 10% DE TODOS LOS ABORTOS
E.U.-CANADA- MEXICO- GRAN BRETAÑA- HOLANDA
AUSTRALIA - NUEVA ZELANDIA - JAPON

PATOGENESIS CONFIRMADA POR INOCULACION

CICLO POR DEFINIR. POSIBLEMENTE SIMILAR A TOXOPLASMA

SINTOMAS ABORTO 3 7 MESES (78% $ & meses) SIN RETENCIN
AUTOLISADOS FLUIDO SERO SANGUINOLENTO
EN CAVIDADES

DIAGNOSTICO LESIONES EN FETO, ENCEFALITIS NO PURULENTA MIOCARDITIS-
MIOSITIS NECROSIS HEPATICA
I.F.A.

SARGOCYSTOSIS ABORTO??

CG2: Secreción mucopurulenta.

CG3: Secreción francamente purulenta.

PIOMETRA: El contenido purulento dentro del útero que tiene dos condiciones adicionales: en primer lugar cuello cerrado y en segundo lugar la presencia de cuerpo luteo. Estas dos condiciones son irremplazables porque sino cae en las otras clasificaciones de catarro genital.

La patofisiología de las metritis y de la piometra es que en el periódo puerperal las poblaciones bacteriales aumentan y disminuyen así como la involución uterina progresa. En condiciones favorables, el C pyogenes, Fusobacterium y Bacteroides se establecen. Los coliformes se establecen sobre todo cuando hay infecciones persistentes con C Pyogenes y gram negativos anaeróbicos Estos coliformes no significan infertilidad crónica pero en estados tempranos del puerperio pueden estar asociados con meteritis séptica o tóxica. Esto es en el periódo inicial del puerperio. En el periodo intermedio, las bacterias anómalas son expulsadas en vacas normales. En vacas con fluidos anormales, las bacterias permanecen hasta la primera ovulación conllevando esto a una subinvolución uterina y por ende la metritis persiste. El periodo postovulatorio, la metritis crónica persiste inclusive si la bacteria causante es eliminada. La infertilidad severa es producida por C. Pyogenes, Fusobacterium, Bacteroides Etc... Las bacterias estimulan la exudación de un gran número de leucocitos por ende aparece el exudado purulento. Si la ovulación ocurre antes de que el útero expulse el contenido y hay subinviloción, aparece un cuerpo lúteo retenido y por consiguiente puede aparecer la piometra.

Control y tratamiento

Es difícil divisar una rutina de tratamiento para el postparto debido a la variación en la severidad de la enfermedad y la capacidad individual de resistir a la infección. En condiciones normales las metritis leves tienden a curar por si solas. Lo más importante es la atención individual haciendo énfasis en la historia del animal, el apetito, enfermedades peripartales que se presenten , examen físico y condición física haciendo énfasis en el tamaño uterino, volumen del contenido, consistencia y tipo de descarga además de ausencia o presencia de retención de placenta. En cuanto a la efectividad del tratamiento teniendo en cuenta la fertilidad futura del animal hay varios factores a analizar como la respuesta inmune, ganar concentraciones antimicrobiales en sangre como en el lumen uterino dependiendo del agente y de la farmacocinética; hay fármacos que dan concentraciones altas en el lumen uterino y bajas en sangre y *viceversa por ende en estos casos se necesita de ambos. Las infusiones con antibióticos tienden a alterar la respuesta inmune local debido a que inhiben la fagocitosis o la migración de leucocitos, pero dependiendo del caso es necesario utilizarla . En general en el puerperio se recomienda el uso de sustancias antimicrobiales de rápida distribución, absorción total, que en algunos casos sirvan de buffer y que no se inactiven metabólicamente. En general dosis bajas de antimicrobiano para tratamiento local son inadecuadas en los periódos puerperales.*

En el periodo inicial del puerperio esta el inicio de este con o sin remoción de la placenta retenida. Hoy en día se recomienda remover hasta donde se logre en forma fácil y sin mucho manipuleo, cortando la placenta a nivel de la vulva. se ha demostrado que la fertilidad en estos casos es buena en cambio la remoción brusca causa generalmente daños a nivel local, además de afectar la fagocitosis. El uso de las tetraciclinas de ser necesario en dosis de 2 a 6 gramos diarios hasta la expulsión de la placenta retenida. En caso de manifestaciones sistémicas el uso de antibióticos vía parenteral com penicilina a dosis de 10 a 20.000 UI por kilo de peso. En resumen dependiendo de la reacción inmunológica del animal se aplicaran los tratamientos, si esta en riesgo la salud y la vida del animal se recomienda tanto el tratamiento local en primera instancia y luego el parenteral

En el periodo intermedio cuando hay la presencia de una descarga purulenta, 1 gramo tetraciclina en 50 a 100 cc de agua destilada dependiendo del tipo de catárro genital depende la duración del tratamiento.

En el periodo post ovulatorio se recomienda el uso de la prostaglandina con la combinación de antibióticos ya sea por vía local o parenteral.

El uso de las hormónas en el periodo postparto es de cierto cuidado y criterio. Se habla de la utilización de la GnRH 12 a 18 dias post parto ya que se induce la ovulación pero se ha demostrado que el tratamiento incrementa la formación de piometras.

El uso de estrogenos especialmente en problemas sépticos y tóxicos trae el riesgo de la diseminación de la enfermedad a otras partes del cuerpo especialmente hígado, pulmón, riñón y articulaciones; además en el tracto genital fomenta el piosalpinx y en algunos casos peritonitis.

El uso de prostaglandinas únicamente restringidas y de valor terapéutico cuando hay cuerpo luteo presente (periodo post-ovulatorio).

Las terapias locales con antimicrobianos se han impuesto en nuestro medio versus las parenterales debido a los costos ya que la local es más económica que la parenteral.

La terapia de las metritis con respecto a los residuos de antibióticos en leche y carne hoy en día se busca racionalizar el uso de estos ya que se controla cada vez en carne *y leche buscando así un uso más racional y por parte de un médico veterinario y no de cualquier persona.*

Otras prácticas inconvenientes son las manipulaciones vigorosas del aparato reproductivo ya que esto tiende a predisponer a problemas de perimetritis y adherencias del útero con las estructuras circundantes.

Los obstetras que causan heridas, abcesos, perimetritis etc. por malos manipuleos obstétricos durante el parto.

La aplicación de sustancias irritantes que causan una reacción local en el tejido lacerado y aumentan los problemas de infertilidad.

La remoción traumática de la placenta que causa abcesos, adherencias etc. que van en contra de la fertilidad futura.

La irrigación líquida (sifonages) que pueden causar daño a nivel de los oviductos, salpingitis y bursitis.

El exiro de la terapia antimicribial depende de la sensibilidad del microorganismo al antimicrobial escogido, la dosis, la longitud del tratamiento, la ruta de administración, el tiempo de inicio del tratamiento, la presencia de otras enfermedades, de la edad, del estado nutricional, del stress , del manejo, de la presencia de resistencias que en el caso tal hay que cambiar de sustancia.

Hay drogas que por vía local alteran el ciclo estral como es el caso del lugol, la oxitetraciclina y los nitrofuranos.

No todos los antibióticos ni desinfectantes se pueden utilizar.

Las fallas en la terapia puden ser debidas a inefectividad de la droga, dosis inadecuada o presencia de resistencias bacteriales.

Como alternativa a la terápia uterina antimicrobial se pueden utilizar promotores de a contractibilidad uterina en el postparto como oxitocina, prostaglandoinma, ergonovina y estrógenos y en segundo lugar promotores de los mecanismos de defensa como los estrogenos, la GnRH y los desinfectantes

Las infecciones uterinas en animales que ciclen son debidas a cierto tipo de enfermedaes trasmisibles por el coito o el semen o por efectos de sanitación o infecciones crónicas resistentes anteriores o a hongos y levaduras. El tratamiento de elcción son las sustancias irritantes para alterar el ciclo estral y necrosar el endotelio por 24 horas para que este se regenere. Se utiliza desde el punto de vista hormonal las prostaglandinas. El uso de antibióticos esta recomendado en el caso que los hongos y levaduras no sean los causantes de la lesión.

Para terminar es importante trabajar con dosis terapéuticas indicadas, con una longitud de tratamiento ideal para el control de las infecciones uterinas. Otro factor importante es conocer los sinergismos y antagonismos de los fármacos que se utilizan *en la terapia además de estar consciente de las resistencias a los antibióticos que puedan estar presentes.*

EL COMPLEJO METRITIS - PIOMETRA

DR. Eduardo A. Stasiukynas M.V.: M.Sc.

Las infecciones uterinas son una de las causas de perdidas economicas en la industria ganadera ya sea porque las perdidas son a corto plazo las cuales ocasionan elevación de temperatura, perdida de peso, baja de la producción láctea o de carne, menos consumo de pienso etc.. como es el caso de la metritis séptica o tóxica o gangrenosa o las enfermedades sistemicas ocasionadas en el puerperio; las pérdidas a largo termino son las relacionadas con la menor eficacia reproductiva como son mayor número de dias abiertos, servicios por concepción, aumento de descartes de hembras por mala eficacia reproductiva lo cual conlleva perdidas en la producción láctea, mayor número de inseminaciones, mayores costos de reposición de hembras, reducción del progreso genetico entre otros.

La incidencia de las infecciones uterinas esta influenciada por el manejo sanitario, la sanidad del animal o del hato; organismos patogenos; factores endocrinos; la lactancia; la nutricón y los factores estresantes del medio ambiente.

I-) FACTORES QUE INCIDEN EN LA PRESENTACIÓN DE LA ENFERMEDAD UTERINA

1-) BACTERIOLOGICO

El utero es un medio más anaerobico que aerobico. El A. pyogenes, Fusobacterium y Bacteroides son sinergicos entre si. Hay otras bacterias que " protejen " los patogenos(los que producen penicilinasa). El A. pyogenes es el más patogeno en el periodo intermedio y post-ovulatorio del puerperio.

2-) PRECARIAS CONDICIONES SANITARIAS EN EL PARTO

Sitios con polvo, barro, materia fecal etc.. tienen un mayor contenido bacteriologico. El stress del parto asi como la inmunosupresión existente se encarga de bajar las defensas del organismo por ende hay menos resistencia a las infecciones y al control de la población bacteriana. Hay bacterias como el A. pyogenes, Anaerobocos Gram(-) y Clostridium sp se introduzacan al tracto genital en las areas de intervención del parto. Esto es más frecuente en ganado de leche que de carne.

3-) ENFERMEDADES ALREDEDOR DEL PARTO.

Dentro de estas la principal es la retención de placenta ya que la incidencia de las metritis sube desde un 50% hasta un 90%. Todo lo que provoque un aumento en la retención de placenta aumenta la metritis. Dentro de estos factores podemos considerar los siguientes: aumento excesivo del peso en el periodo seco; periodo seco corto; gestación gemelar; stress de calor; acortamiento de la gestación; abortos; partos prematuros; distocia; edad; alta producción de leche; enfermedades metabolicas (hipocalcemia) y la inducción del parto. Todos estos factores ocasionan una subinvolución uterina asociada con un incremento de infección uterina y la incapacidad de eliminar la infección del utero por parte de la vaca.

4-) FACTORES ENDOCRINOS

La combinacion de progesterona baja y estrogenos altos en el pre y postparto se asocia con aumento de la retención de placenta. La progesterona alta en el postparto hace igual efecto que en el caso anterior. Bajos niveles de prostaglandina ocasionan lo mismo. En el parto las hormonas disminuyen hasta que la pituitaria se vuelve sensible al GNRH y esto ocurre a los 7 a 14 dias postparto. Las vacas con factor mamogenico la pituitaria responde después de los 14 dias postparto y por eso el primer celo postparto es muy tardio y además porque la LH necesaria para estimular la primera ovulación se deprime.

En el ganado de leche se presenta más metritis aunque ovulan más temprano es debido a que el utero no esta en capacadad de deshacerse de la infección.

5-) MECANISMOS DE DEFENSA

La fagocitosis comienza al segundo día postparto, en partos dificiles o en condiciones patologicas como el ternero muerto en el utero, la fagocitosis aparece hasta varios dias o semanas postparto. La fagocitosis es inhibida por mecanismos como la remoción de placenta, partos distosicos, por antibioticos locales.

La leucocitosis es estimulada por los estrogenos pero inhihida por la progesterona y es por eso que no hay una buena leucositosis en el periodo folicular y por eso la infecciones no se eliminan del todo.

6-) MALOS TRATAMIENTOS UTERINOS

Los antibioticos y los irritantes bajan los mecanismod de defensa. Los irritantes en el periodo temprano del puerperio pueden ocasionar severas lesiones en el utero (parametritis) asi como lesione sen el oviducto. La irritación y el stress prolongan la enfermedad genital.

7-) MANIPULACIÓN FÍSICA

Per rectum o per vagina debe de ser abolida ya que el utero enfermo es friable y esta sujeto a trasudación y a adherencias. La maanipulación vaginal con excelente desinfección además de una excelente lubricacion oara reducir el daño en el epitelio uterino.

8-) NUTRICIÓN

las deficiencias de vitaminas com la A en especial, minerales etc.. ocasionan etos problemas. Ojala tener siempre a la vaca con una alimentación balanceada y devacuerdo a su estado de producción.

II-) PATOFISIOLOGÍA DE LA METRITIS Y LA PIOMETRA

1-) PERIODO PUERPERAL

Las bacterias más comunes aquí son: A.pyogenes, Fusobacterium necrophorum, Bacteroides sp. Gram(-) anaerobicos; los coliformes crecen y decrecen su población. Una bacteria ocasional puede ser el clostridium ya que en este periodo aparecen metritis toxicas, septicas o gangrenosas. El A. pyogenes más los anarobicos Gram (-) conducen a una metritis crónica.

2-) PERIODO INTERMEDIO

La población bacteriana esta reducida pero en vacas con fluidos anormales hay un aumento de bacterias hasta la primera ovulación. Si las bacterias y los liquidos no son expulsados entonces la subinvolucón persiste y la metritis existente se convierte en crónica.

3-) PERIODO POST-OVULATORIO

Si la metritis persiste en este periodo tenemos leucocitosis (puz) y además como bacterias frecuentes al A. pyogenes, Fusobacterium necrophorus y Bacteroides sp.

Si la ovulación aparece antes de expulsarlos líquidos purulentos tenemos una piometra, el ciclo estral se interumpe y la piometra se puede perpetuar por periodos prolongados de tiempo.

III-)DIAGNOSTICO DE LA METRITIS Y DE LA PIOMETRA.

CG1: Anillo de Burdi positivo, secreción mucosa o serosa con poco material purulento.
CG2: Anillo de Burdi positivo y una secreción más mucosa que purulenta.
CG3:Cuello abierto (como es posible en las otras) secreción más purulenta que mucosa o francamente purulenta.
PIOMETRA: Cuello cerrado con contenido purulento dentro del utero además de la presencia de un cuerpo lúteo en uno de los ovarios.

El diagnóstico puede realizarse ya sea por via rectal mediante una palpación rectal que conlleve a palpar las alteraciones del utero o mediante el uso del especulo vaginal lo cual permite observar las alteraciones en el cervix además de las secreciones que salen atrvés de él o que estan localizadas en la vagina.

IV-) TRATAMIENTO Y CONTROL DE LA INFECCIÓN UTERINA

Es dificil diseñar una rutina para el tratamiento de la vaca postparto con metritis debido a la variación en severidad de la enfermedad y la habilidad individual de diferentes vacas para resistir a la infección. Es mejor trabajar en forma individual el tratamiento de estos animales para así obtener una respuesta eficaz.
Los anamnesicos siempre consultados son la fecha del parto,, si fue normal o no, hubo retención de placenta, estuvo enferma, si estuvo su tratamiento. Se necesita por eso de un examen fisico del animal además del examen del tracto genital el cual incluye tamaño del tracto, tipo de loquios o secreciones del tracto y si hay no placenta retenida.
Los tratamientos en forma general bajan la fertilidad. Las vacas con metritis leve generalmente no necesitan de tratamiento. Cuando se necesita de un tratamiento

debemos tener en cuenta la concentración del farmaco a aplicar, su vía de aplicación ya sea local o parenteral y su farmacocinética. En general los tratamientos locales a más alta concentración más dura su efecto no siempre siendo esto cierto en los tratramientos parenterales. A veces es necesario usar la via parenteral y local en casos de que esten comprometidos el oviducto, los ovarios o la salud general del animal. Los irritantes en el puerperio no son recomendables.

La terapia hormonal ayuda a evitar las resistencias bacterianas, los residuos en leche y carne(ocasionados por los antibioticos) asi como no altera los mecanismos de defensa del organismo.

Como alternativa la terapia hormonal como son los estrogenos no muy recomendados ya que pueden las infecciones y las toxinas atravesar la barrera uterina y complicar la salud general del animal con problemas como artritis sépticas, abcesos hepaticos, pneumonias etc. De por sí los estrogenos aumentan los dias abiertos. Otro de los efectos de los estrogenos es que drena el utero y aumenta la fagocitosis. La Oxitocina solo estimula las contracciones uterinas y por eso drena los contenidos uterinos; hoy se usa en dosis de 20UI 3 veces al día en los primeros 3 dias después del parto.El uso de la GnRH también es limitado por la posibilidad del aumento de la incidencia en las piometras. La prostaglandina F 2 alfa es la hormona de elección para el tratamiento de la piometra ya que la prostaglandina solo es útil en presencia de cuerpo lúteo maduro. Es la hormona de elección para tratar metritis leves o como ayuda en tratamientos con antibioticos locales ya que reduce el número de tratamientos en forma significativa siempre que haya un cuerpo lúteo maduro en uno de los ovarios.

V-) EFECTOS ADVERSOS DE UN MAL TRATAMIENTO UTERINO

1-) Manipulaciones vigorosas puede conllevar a parametritis.
2-) Remoción manual de la placenta conlleva aabcesos .
3-) Procesos obstetricos mal efectuados.
4-) Excesoi de liquidos en el utero conlleva a una ruptura o siino a salpingitis, bursitis,etc..
5-)Sustancias irritantes en uteros traumatizados o lacerados conlleva ainfertilidad.
6-)los cateteres a heridas.
7-)Antibioticos versus resistencias bacterianas.

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Res 27698

DIAGNOSTICO Y TRATAMIENTO DE LA METRITIS

DR. EDUARDO A. STASIUKYNAS M.V. M.Sc.

Sobre el diagnóstico de las metritis y su control hay demasiada literatura a disposición del interesado y variedad de criterios asi mismo.
Para el diagnóstico de las metritis básicamente se utilizan 2 métodos ya sea uno o la combinación de los dos que es la palpación rectal y la utilización del especulo vaginal. Mediante la palpación rectal es posible palpar las paredes del útero, su consistencia, la presencia de liquidos y la formación de anomalias dentro o fuera del útero como es el caso de abscesos, parametritis, adherencias etc.. La palpación para el diagnóstico de catarros genitales de grado 1 necesita de una experiencia muy amplia para su correcto diagnóstico. A veces por la palpación rectal es posible también observar secreción que permiten identificar el tipo de secreción presente aunque no siempre. En la palpación rectal la asimetria uterina no siempre significa que hay una patologia uterina mientras la consistencia y la contractibilidad si lo son: consistencia semidura es debida por una inflamación aguda (sin edema); consistencia firme es debido a cicatrización o inflamación crónica o neoplasia. La crepitación subserosal es la presencia de gas (clostridium); La motilidad impedida por adherencias. El contenido puede ser fácilmente detectado como moco, sangre, loquios, puz, gas, orina etc.. tomando el útero entre los dedos y pasandolos través de éste, también la presencia de un feto y si este esta vivo o muerto (macerado, momificado etc.)
El examen con el especulo vaginal permite básicamente el diagnóstico de cualquier tipo de metritis ya que por medio de éste se observan las secreciones y la inflamación del anillo de Burdi para el CG1. Por medio de este sistema también se examina la vagina y el vestíbulo, pero este sistema no permite la palpación de adherencias , abcesos o hematomas sobre el útero o patologías que no tengan secreciones a través del cerviz. De cuidado es la desinfección adecuada del especulo entre animal y animal.

La clasificación de los catarros genitales (CG) sería la siguiente.

CG1: Secreción mucosa con escaso contenido purulento. Anillo de Burdi positivo.

Reg 22699

DETECCION DE CELOS EN LOS BOVINOS

Dr. Eduardo A. Stasiukynas M.V.. M.Sc.

Para nosotros la detección de celos y sus sintomas han sido muy importantes par el manejo reproductivo de los hatos. La detección de los celos es un arte no es una ciencia. Para esta charla vamos a tratar las caracteristicas de hatos con una detección de celos deficiente y sus correctivos.

El hato con una detección de celos deficiente se caracteriza por los siguientes parametros:

a-) Pocos celos observados antes del primer servicio.

b-) Muchos dias del parto al primer servicio (a pesar del periodo de espera voluntario).

c-) Exceso de dias entre servicios .

d-) Cuando más del 15% de las vacas de chequeo de preñez salen no preñadas.

e-) Al chequeo genital se confirma que los animales estan ciclando pero no hay detección.

f-) Menos del 50% de las vacas elegibles para el servicio son observadas en celo.

Otro factor a considerar es si verdaderamente la vaca esta en celo cuando es observada es decir cuando hay errores en la detección esto lo podemos sospechar si:

a-) Más del 10% de las vacas tienen periodos interestrales entre 3 a 17 dias.

b-)Más del 10% de los intervalos interestrales estan entre 25 y 25 dias

c-) Más del 5% de las vacas se inseminan 2 veces en 3 dias.

En la practica del campo muchas veces hemos olvidado que existen factores que afectan la conducta del celo y estos son:

a-) El Medio Ambiente: tiene que ver por ejemplo con los pisos, en piso de cemento es menos que en el potrero.

b-) Problemas de las extremidades. Si son problemas estructurales en las extremidades de por sí la actividad es menor. Otros problemas pueden ser como cojeras, laminitis, artritis, desgarros musculares etc.. Si estos problemas aparecen entre los 36 y 70 dias postparto entonces se incrementaran los dias abiertos.

c-) La influencia de la vacada. Se sabe si la mayoria de las vacas estan preñadas entonces la detección de celos es menor. La detección de celos es más efectiva cuando hay un número importante de vacas en proestro o estro que cuando hay muchas de ellas en diestro.

d-) La variación de la actividad de monta durante el día es otro factor. El 70% de las vacas muestran una actividad importante entre las 6pm y las 6am. Otro factor es que las vacas cuando estan muy distraidas durante el día porque les dan pasto, concentrado, el ordeño u otras practicas de manejo se observan menos los celos.

e-) La temperatura ambiente es importante. A más de 30 grados centigrados la actividad de monta disminuye sustancialmente; se mantiene bien en la temperatura de comfort. Entre más frio más actividad pero a temperaturas altas inclusive los signos secundarios del celo se ven disminuídos y por eso también se puede aumentar los errores en la detección de celos.

f-) La nutrición versus el nivel de producción de leche es importante. En la vaca lechera se sabe que el tiempo de aparaición de la primera ovulación es inversamente proporcional al promedio del balance energetico en los primeros 20 días de lactancia. La actividad de monta es menor en vacas que pierden más peso en el periodo seco o en los primeros días postparto. Se observa una menor expresión del celo en vacas de alta producción láctea.

Como hasta ahora hemos visto las fallas y los factores negativos que inciden en la detección de celos vamos a describir los metodos para mejorar la eficacia de la detección de celos.

a-) Identificar apropiadamente los animales ya sea con marcas frias o calientes, placas metalicas, tatuajes etc..

b-)Separar en lo posible las vacas no preñadas entre si o con un animal recelador.

c-)Nutrición y salud: Tener buena condición corporal, pocos problemas en las extremidades de las vacas, controlar peso en periodo seco e inicio de la lactancia.

d-) Buenas condiciones del piso.

e-) Llevar buenos registros individuales de las vacas.

f-) Responsabilizar a los hateros de la observación de celos.

g-) Un programa agresivo de observación de celos como es al amanecer, al atardecer y al medio día.

h-) Utilizar si es necesario programas de sincrinización de celos ya sea con Prostaglandina F 2 Alfa o progestagenos ya que estos programas ayudan a que el manejo sea más conciente, el celo se puede anticipar y es más fácil de observar y si hay más animales en celo estos lo manifiestan mejor.

Existen sistemas sistemas que ayudan a detectar los celos. es conveniente siempre insistir en la observación visual pero a veces es necesario de esta ayuda. Estas ayudas son en primer lugar los detectores K-MAR que son de presión o marcadores en la base de la cola. También se utiliza el Chin-Ball con toros con pene desviado o vasectomizados o hembras androgenizadas. Hay sistemas más sofisticados como el monitoreo de la resistencia electrica de los liquidos vaginales, detectoresd de presión electricos que son chips que van conectados a un computador o medir la podometría ya que los animales en celo caminan más.

SINCRONIZACION DE CELOS EN BOVINOS

DR. EDUARDO A. STASIUKYNAS M.V. M.Sc

El manejo del ciclo estral ha sido de gran interes debido a que es una herramienta de gran importancia para el manejo reproductivo y productivo del hato.

Los programas de sincronización de celos no solo se basan en el uso de ciertas hormonas sino además de ciertos criterios importantes de manejo para que el programa tenga éxito.

Los criterios de manejo son los siguientes:

-Nutrición: El caso de balance energético bajo, perdida de peso, plagas, anestro, aparición retardada del estro hacen pensar en una baja de las gonadotropinas en la pituitaria. La vacas deben ingerir una dieta que les permita no desgastarse demasiado y aumentar de peso a medida que transcurre la lactáncia. El balance energético positivo favorece la sobreviviencia espermática y del embrión. El efecto de una dieta de proteína baja no es tan grave como el de la energía.

- Ciclicidad del rebaño: normalmente si el ganado esta sin gestar el 4.5% de las vacas ciclen en 1 día y el 24% en 5 dias. Se pueden hacer la detección de celo en forma visual, RIA o Elisa .

-Intervalo entre parto: de 12 a 13 meses. Las novillas de 1 y 2 parto tienen tendencia a demorarse un poco más (60 dias) ya que estas necesitan más energía en la dieta que las vacas.

-Sanidad del Hato: Más problemas sanitarios más baja la concepción.

_Semen- Excelente calidad.

-Técnico: Excelente

-Concepción al 1 servicio: Debe ser superior al 40%.

Las consideraciones de tipo endocrinológico tambien han de tenerse en cuenta: Las vacas que se inyectan con prostaglandina entre el 9 día y la mitad del ciclo estral entran 10 a 12 horas antes que las que se les aplica prostaglandina después de la mitad del ciclo estral. Por consiguiente hay variaciones en el grado de sincronia con respecto al día del ciclo estral. También existe una variabilidad de aparición de celo de las vacas versus la novillas: vacas 2.5-3 a 5 dias y la novillas de 2 a 4 dias postinyección.

Las hormonas a utilizar son dos: La prostaglandina F 2 alfa y los progestagenos (norgestomet etc...)

Reg 27701

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USO DE LAS HORMONAS EN LA REPRODUCCIÓN DE LOS BOVINOS

Dr. Eduardo A. Stasiukynas M.V.. M.Sc.

El uso de las hormonas de la reproducción esta muy bien definido en la literatura medica. Es importante tener en cuenta qyue la terapia hormonal cuando es aplicada de acuerdo a un buen diagnóstico debera tener exito. Las terapias hormonales aplicadas sin un diagnóstico exacto son frustantes, costosas y perjudiciales al animal. En esta charla hablaremos de dichas hormonas y de sus usos correctos en la terapia bovina.

LH

Hay hormonas que tiene efecto LH como son la HCG (gonadotropina coriónica humana) y la PMSG (suero de yegua preñada). La LH se obtiene generalmente de estractos pituitarios de oveja y cerdo. La LH su función es desarrollar tejido luteinizante y por eso se utiliza para el tratamiento de quistes foliculares y el ciclo estral normal se desarrolla entre 20 y 30 días post-inyección.

Dosis: 5.000UI IV o IM

10.000UI IM

PLH 25mg IM

Puede presentar problemas anafilacticos.

FSH

Hormona foliculo estimulante. Se utiliza para tratamientos de poliovulación a dosis de 50mg dosis total aplicada en 5 dias ya sea en dosis iguales 2 veces al día o en dosis ascendentes y desnedentes. Se aplica después del noveno día después del celo. Otra hormona con efecto FSH es la PMSG la cual se aplica al noveno día post celo a dosis única de 2000 a 2500 UI.

La FSH también puede ser utilizada para la inducción de celos pero con sus limitantes.

GnRH

La GnRH actúa sobre la pituitaria y hace que se libere LH endogena principalmente. Su dosis es de 100 microgramos por vaca para la luteinización de quistes. Otra dosis es la de 0.5 a 1.5 mg para la luteinización pero a veces se luteinizan los foliculos existentes. Los animales entran en celo a los 18 a 23 dias. Otra aplicación es la inducción de la primera ovulación postparto practica no muy recomendable debido al aumento de la incidencia de piometras.
Otro uso es la combinación de GnRH y prostaglandina F 2 alfa para el tratamiento de quistes foliculares y se aplicaría GnRH se considera día cero y a los 9 días la prostaglandina y entran en celo al día 12. Esto permite reducir el tiempo del tratamiento.
Otra aplicación de la GnRH es el del control de la ovulacón. Se aplica a la mitad de su dosis terapeutica indicada para los quistes ya sea varias horas antes del servicio o al servicio ya sea via IM o IV.

PROGESTERONA

Se utiliza para reestablecer la ciclicidad en vacas con quistes ovaricos. Dosis 50-100mg por 14 dias.
Otro de los usos es en implantes a dosis de 750 a 1000mg (Synchromate o crestar). El implante se coloca en la oreja por 9 días después de los cuales es necesario retirarlo y el animal entra en celo entre 48 a 72 horas y ovula aproximadamente a las 56 horas. El implante trae una sustancia luteolica que es un estrogeno (valereato de estradiol) el cual limpia los ovarios de remanentes de tejido luteo. Otro sistema son los pesarios vaginales (Eazi-Breed-cidr) el cual se colocan en la vagina por 7 dias y un día antes de retirar el implante se le aplica prostaglandina y los animales entran en celo a las 72 horas o se insemina a ciegas a las 50 horas.
Estos implantes se pueden aplicar a cualquier momento del ciclo estral ; otra función de estos implantes es la de inducir al celo vacas en anestro.
La progesterona es una de las hormonas utilizadas en el proceso de lactoinducción.

PROSTAGLANDINA F 2 ALFA (PGF)

Se utiliza para la sincronización de celos, tratamiento del celo silente , inducción del

parto, como tratamiento para los quistes luteinicos o luteinizados , la piometra y como coadyuvante para el tratamiento de las metritis.
Lutalyse 25mg IM (prostaglandina natural)
Estrumate 250microgramos IM
La respuesta a la prostaglandina puede ser inconsistente y variable por eso se necesita de: en primer lugar un cuerpo lúteo suceptible a la luteolisis; en segundo lugar los mecanismos fisiologicos que conllevan al celo deben de estar normales; en tercer lugar los animales deben de presentar celo y el humano debe estar presente para la observación del celo.
Existen varios sistemas de sincronización del celo:
a-) Palpar las hembras para servicio en busca de determinar un cuerpo lúteo funcional y aplicarles prostaglandina e inseminar al celo
B-) Colocar prostaglandina a todas las hembras vacias y que se sabe que estan ciclando, inseminar aquellas que entren en celo, a los 12 dias después de la inyección de prostaglandina se aplica otra y se insemina al celo y/o a las 80 horas y/o a las 72 y 96 horas post inyección.
C-)Observar las hembras clicantes por 5 dias e inseminar las hembrass que entren en celo, pasado el quinto día se repite el programa como en el caso B.
Para la inducción del parto se aplica la dosis terapeutica y entre 72 a 96 horas aparece el parto normal.
Para el estro silente se aplica la prostaglandina una vez se determine que el animal esta ciclando normalmente mediante palpación rectal y se insemina ya sea a las 72 y 96 horas post inyección o a las 80 horas después de la inyección de prostaglandina.

ESTROGENOS

Se utilizan como agentes luteoliticos y como sustancias que promueven la motilidad uterina postparto y ayuda a elevar la fagositosis asi como a la evacuación de líquidos uterinos. Para inducir celos no es recomendable ya que produce celos anovulatorios e induce a la quistosis ovarica. En los implantes con progesterona su función es de agente luteolitico. El tratamiento en el postparto con procesos septicos uterinos fuertes puede conllevar al paso de toxinas y bacterias através de la barrera uterina al organismos en general y diseminar un proceso toxico obacterialen diferentes organos de la vaca.

OXITOCINA

Se utiliaz en dosis de 100Ui para el bovino. Sus recomendaciones son basicamente para dilatar el cuello uterino, expulsión de secundinas, fomentar las contracciones uterinas asi como la hormona para el descenso de la leche. Sus aplicaciones varian desde la dosis total hasta variaciones como 20UI tres veces al día por 3 días. En el caso del tracto genital es una hormona dependiente de los estrogenos. Otra aplicación es en combinación con los estrogenos para la expulsión de fetos muertos o momificados dentro del utero, cuando estos no han sido expulsados con la prostaglandina.

SOMATOTROPINA

Unicamente estimula el crecimieento folicular lo que hace que los foliculos sean ligeramente diferentes a los normales. Con la progesterona es indispensable para que esta se mantenga normal es un balance energetico de la dieta. No hay cambios en FSH y LH.

CORTICOSTEROIDES

Los corticoides de acción corta como dexametasona, flumetasona se utilizan basicamente para la inducción del parto; este aparece a las 72 a 96 horas post-parto pero una de sus secuelas es la elevada incidencia de retención de placenta. Sus otros usos como antiinflamatorio pero hay que tener en cuenta su poder abortibo en la sergunda mitad de la gestación.

La prostaglandina actua únicamente sobre el cuerpo luteo maduro (mayor de 8 días) provocando una luteolisis similar a la que ocurre en el ciclo estral en la naturaleza entando el animal entre los 2 a los 5 días post inyección. Es decir la prostaglandina necesita para el éxito de un cuerpo luteo maduro.

Los progestagenos se puden aplicar en cualquier momento del ciclo estral. Este sistema se caracteriza por un implante o un pesario o una esponja impreganada en un progestageno que dura en general de 6 a 9 días según el progetageno utilizado acompañado de un estrógeno el cual sirve de agente luteolitico en primer lugar y cumple su función además estrogénica. Este sistema se pude aplicar en cualquier día del ciclo estral que con El trabajamos es en base de niveles de progesterona y no con el cuerpo luteo directamente; al quitar el implante los niveles de progesterona descienden abruptamente y desencadenan el ciclo estral.

Con cada hormóna existen diversos sistemas de sincronización . Comenzaremos con los de las prostaglandinas:

Plan A: Palpar y aplicar PGF (prostaglandina) a los que ciclan. Entran el calor y a los 12 dias después aplicar PGF y se pueden recurrir a 3 caminos: el primero es inseminar al calor. El segundo inseminar a ciegas a las 80 horas y el tercero inseminar a las 72 y 96 horas. Este sistema se usa en ganado de leche y carne cuando hay problemas de detección de celos. Se obtiene una mejor sincronía. Se utiliza en vacas y novillas y donde hay o no detección de celos.

PLan B. Palpar y las que tiene cuerpo luteo inyectar PGF. Este sistema se insemina al calor. Existe una variación en los días del calor.Utilizarlo con detección de celos o con toros sueltos.

PLan C. Observar por celo por 5 dias e inseminar esos animales en celo. Los que no entran Aplicar PGF y servir los que entran en calor y al 12 día tratar los que no ciclaron con PGF para que entren en calor y se inseminan al celo.

Progestagenos.

Colocar implante en la oreja y dejarlo por 9 días. El día de colocar el implante se coloca un estrógeno por vía intramuscular. Se retira el implante y el animal entra en calor entre las 48 y 72 horas y tiene tendencia a ovular entre las 56 a 72 horas después de retirado el implante.
Este sistema se usa para Synchromate B y Crestar.

Con el EAZI-BREED se coloca el dispositivo vaginal, al 6 día se inyecta prostaglandina, al séptimo día se retira el dispositivo y entran en celo del 9 a 11 día en vacas de leche y el 12 día en novillas. El dispositivo esta acompañado ya sea de una cápsula o una inyección de estrógenos.
Existe también la combinación progestagenos PGF como lo acabamos de mencionar.
Los progestagenos también funcionan como inductores de celos.
Existen varios tipos de programas que se asocian con varios tipos de necesidades y por lo tanto es de importancia escojer el programa necesario para cada requerimiento.

Reg 27702

CONDICIÓN CORPORAL, ANESTRO Y REPRODUCCION

DR. EDUARDO A. STASIUIYNAS ,. V. M.Sc.

Los veterinarios que ejecutan exámenes reproductivos periódicos, se ven cada vez más interesados en proveer servicios adicionales uno de los cuales es la evaluación de la condición corporal. Este es un método subjetivo, rápido y sin mayor costo para estimar las reservas de energía en el ganado de leche y doble propósito, permitiendo así estimar el estado nutricional al cual los bovinos están sometidos.
El examen se efectúa colocando los dedos en las apófisis espinosas de la 4 a 5 vértebra lumbar y luego el dedo pulgar en las apófisis transversas para determinar el grado de la cubierta de grasa. También se ha de observar la base de la cola y la tuberosidad coxal de las apófisis transversas no se pueden palpar. En la práctica lo ideal es de tener encuentra estos tres puntos de observación para determinar la condición corporal. La calificación de la condición corporal va de 0 a 5 donde 0 = emancipación y 5= obesidad excesiva. Se debe tener en cuenta que existen puntos intermedios determinado asi condiciones corporales intermedias. Existe una relación entre el puntaje de la condición corporal y el peso vivo, la cual en pastoreo es : 1 punto = 60 kilos en vacas adultas y 1 punto = 90 kilos para las novillas.
La condición corporal ideal en el momento del parto es de 3 a 3.5 prefiriéndose este último puntaje.

La condición corporal nos sirve para optimizar la producción y la reproducción en ganado de leche y doble propósito y esto se hace en base a un buen manejo de la energía. El tejido corporal es un depósito de energía cuando los requerimientos de esta por parte del animal son bajos y el consumo es alto. Estos tejidos son depósitos que van a ser utilizados una vez el organismo requiera la movilización de energía lo cual coincide con el inicio de la lactancia. Durante las primeras semanas del post-parto, la ingestión de materia seca no se acompaña con los requerimientos de energía en vacas de alta producción láctea, por lo cual el proceso natural es que las vacas comienzan a movilizar tejido adiposo para compensar la falta en la dieta, creándose así un balance energético negativo. Las vacas gordas son incapaces de incrementar su ingestión de materia seca en el postparto temprano por lo cual se liberan más reservas corporales para sostener la producción láctea. El ejemplo de esto es que las vacas gordas alcanzan su balance positivo energético 2 semanas más tarde que las vacas *con condición corporal ideal. Otro factor es que las vacas gordas pierden más peso que las vacas de condición corporal ideal pero todas deben llegar a una condición corporal de 2.5 alrededor de los 65 a 68 dias postparto.*

La condición corporal del animal lactante tiene un gran impacto en su actividad metabólica para ajustarse metabólicamente para incrementar la producción láctea. La manera de demostrar esto es en los días abiertos; las vacas que pierden 1 punto de condición corporal en las 5 primeras semanas postparto versus las vacas que pierden 0,5 puntos en el mismo periodo tiene más días abiertos a la primera ovulación y al primer servicio así como, la rata de concepción es más baja.

El impacto de un estado extremo de energía negativa en el post-parto tiene influencia sobre la actividad ovárico posterior en la lactancia. Esto se ha determinado por una menor secreción de Progesterona durante el 2 y 3er ciclo. El regreso de la ciclicidad normal es importante para una concepción más rápida. Vacas con balance de energía positivo, la actividad folicular se aumenta y por consiguiente hay mayor ciclicidad.

La perdida de la condición corporal se desacelera a medida que la lactancia progresa

La selección genética para el incremento de la producción láctea produce alteraciones en la fertilidad ya que el nivel nitricional debe ser más alto en vacas con pobre condición corporal y de mayor potencial lechero. Entre mejor condición corporal es el momento de la inseminación la concepción aumenta. La perdida de peso produce las siguientes altraciones: declinación en la producción láctea; pérdida excesiva de peso lo cual produce infertilidad; cetosis; hipocalcemia subclinica y acidosis ruminal.

La pérdida de peso, más un déficit energético más alta producción de leche desarrollan alteraciones uteroováricas que conllevan a un mayor número de inseminaciones y de días abiertos.

Si uno observa el bovino tres semanas antes y tres semanas despúes del parto que es el periodo crítico de la producción y la reproducción ya que en este periódo se producen hechos fundamentales como el desarrollo fetal, el desarrollo de las papilas ruminales, la disminución (ante parto) y luego aumento y déficit (post parto) del consumo de la materia seca, aumento de la producción láctea van en contra de las infecciones y enfermedades metabólicas en el postparto. Uno siempre busca que el parto sea normal, sin injurias físicas, con buena producción de calostro; que no haya enfermedades metabólicas (hipocalcemia, cetosis, laminitis etc.) e infecciosas (metritis y mastitis); que se acelere el consumo de comida; que la leche suba en forma exponencial; que comience la actividad ovárico (ovulación a los 21 días) entonces un objetivo fundamental es con la condición corporal normal, tener menos desordenes, más leche y mejor reproducción.

Podríamos concluir lo siguiente:

- La condición corporal anteparto 3.5 a 3.75; al servicio de 2 a 3 y al secarse cde 3 a 3.5.

- Al minimizar la rata de perdida del peso corporal en la lactancia temprana mejora la reproducción.
-La condición ideal de 3.5 a 3.75 en el anteparto permite reservas suficientes para mantener la producción láctea y estimular los procesos reproductivos.
- La sobrecondición mayor a 4 hay una perdida de condición corporal más rápida al inicio de la lactancia y por eso es más propensa a tener problemas reproductivos.
- Vacas que preñan a los 85 días post parto pierden menos condición corporal en la lactancia temprana que las vacas que preñan más tarde.
- Vacas con pobre condición corporal muestran índices bajos de fertilidad.
- Monitorear la condición corporal en fincas ayuda al diagnóstico y prevención de la ineficiencia productiva y reproductiva.
El anestro postparto es un periódo fisiológico normal y la actividad ovárico reaparece a medida que el útero involuciona. El anestro aparece cuando la duración de este periodo es más largo de lo normal. La duración de este periódo esta influenciado por la edad, raza, factores ambientales y factores genéticos. Se necesita que el eje hipotálamo-pituitaria -gónadas este en buenas condiciones. Después del parto hay picos de FSH que van en aumento lo cual hace un desarrollo folicular palpable a los 9 a 15 días postparto, el estradiol pica similar a la FSH y este sensibiliza los centros endocrinos al influjo de la GNRH entonces depúes de esto, los la LH va en aumento en las primeras dos semanas postparto y entre la segunda y tercera semana se induce la ovulación pero esta ovulación tiene un cuerpo luteo que produce poca progestreona lo cual hace que este cuerpo luteo sea de vida corta; además de esto la ovulación es silenciosa. La aparición del celo puede estar afectada por varios factores:
-efectos lactacionales
-efectos nutricionales.
-enfermedades-
-La combinación de 2 o 3 de los factores.

Las novillas primerisas tiene un anestro más prolongado debido a su crecimiento acompañado de la lactancia.
Las vacas de alta producción de leche (stress lactacional) los corticosteroides bajan la LH y disminuyen la sensibilidad de la glándula pituitaria a la GNRH. Las vacas de más alta producción láctea tiene los niveles de cortisol más alto y más anestro.
El factor mamogénico baja LH alargando asi entre si los picos de LH entre si bloquendose asi la primera ovulación y asi el ciclo estral.
El balance de energía negativo es un indicador del anestro. Con nivel bajo de energía, la LH esta suprimida.

Las disfunciones orgánicas como la involución uterina retardada, hacen que la prostaglandina este alta por más tiempo, la progesterona entonces es más baja y no hay tejido luteo.

El anestro prepubereral se presenta yasea por un aparato reproductivo anormal (freemartin, hermafrodita etc..) por lo cual la ciclicidad esta afectada en animales en especifico en el grupo o por prácticas de manejo que en general retrasan la aparición de la pubertad y por lo cual los animales afectados se muestran la aparición de la ciclicidad alguna vez en su vida al contrario de los primeros.

El anestro post servicio se puede deber a:

-falla en la detección de calores.

-mortalidad embrionaria

-quistes foliculares

-útero unicornio

- tumor de las células de la granulosa.

-leiomiomas.

-mala condición corporal

-mala alimentación

-enfermedades.

La terapia hace énfasis en 2 puntos:

-Prácticas de manejo

- Hormonas

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ALTERNATIVAS EN MANEJO DE LA INFORMACION PARA EVALUACION DEL HATO

N. Completo

Claudia Jimènez MV MsC
Profesor Asistente
Universidad Nacional de Colombia
Facultad de medicina Veterinaria y de zootecnia

Claudia Jiménez E

1. INTRODUCCION

La habilidad de utilizar registros, para la evaluaciòn del hato, debe ser uno de los pilares para lograr determinar la eficiencia productiva y reproductiva del hato. Esta obtenciòn de informaciòn dependerà, en gran parte, de la persona o el profesional que estè a cargo de la explotaciòn. Dicha persona debe ser conciente que la eficiencia reproductiva es uno de los principales limitantes en una explotaciòn pecuaria, pero que ademàs de estudiar los paràmetros reproductivos debe relacionar posibles fallas en manejo y presencia de otras enfermedades para asi analizar de una forma global la informaciòn encontrada en la finca, para encontrar las deficiencias y ejecutar los ajustes necesarios. Esta es una labor que puede realizar el mèdico veterinario, el zootecnista, el administrador o el propietario de la finca si se tiene una asesorìa adecuada.

La INFORMACION es la clave. Para que de ella se puedan obtener mediciones que nos indiquen como estàn "manejàndose" los animales debemos ser sistemàticos, metòdicos y por sobretodo constantes en su recolecciòn.

En muchas fincas la informaciòn es recolectada pero no ANALIZADA. Este punto es tan o mas àlgido que la misma recolecciòn ya que de nada nos sirve tener la informaciòn sin utlizarla. Con el anàlisis de la informaciòn podemos establecer cual es la eficiencia de nuestro hato comparado con metas propuestas, con resultados anteriores, con resultados de otras fincas o aùn con paràmetros ideales provenientes de la literatura.

Es igualmente importante tener presente que el manejo eficiente de la reproducciòn se obtiene de una mezcla de factores de manejo y de medio ambiente. Aspectos como nutriciòn, levante de terneras de reemplazo, control de enfermedades y control de la glàndula mamaria, son factores que nos afectan los resultados reproductivos de las vacas y que se deben tener en cuenta al realizar un balance general de producciòn.

Existen muchos paràmetros para monitorear la eficiencia del hato. Sin embargo, los paràmetros de mas significancia son los que tienen que ver con la eficiencia reproductiva de la finca ya que èsta va a variar si otros paràmetros de producciòn (ie. mortalidad, enfermedades) cambian.

Esta conferencia estarà enfocada a discutir paràmetros a nivel de finca que nos pueda generar informaciòn que se pueda utilizar para establecer ajustes que nos permitan aumentar la eficiencia de producciòn en nuestra finca.

2. EFICIENCIA REPRODUCTIVA

2.1 Intervalo entre partos: Como su nombre lo indica es el intervalo transcurrido entre dos partos. Tiene el problema que excluye novillas de primer parto y animales sacrificados ya que requiere que el animale haya parido dos veces (alrededor de 12 meses). Es un paràmetro dificil de utilizar y se recomendarìa cuando se va a realizar un anàlisis retrospectivo de varios años en una finca determinada.

2.2 Dìas abiertos (DA): Se conoce tambièn como el intervalo que existe entre parto y concepciòn. Es uno de los paràmetros mas importantes para evaluar la eficiencia reproductiva de hato. Su determinaciòn puede ser anual. El inconveniente es que en èl no se incluyen animales que por razones reproductivas se hayan descartado. Es un paràmetro que incialmente muestra deficiencias reproductivas a nivel de finca pero que requiere de otros paràmetros para detectar cual es el real problema de la finca. ie. Mala detecciòn de calores, problemas en la inseminaciòn artificial, repeticiòn de calores, enfermedades infecciosas etc. Es un paàrametro que muestra una informaciòn similar a la del intervalo entre partos, sòlo que en èste caso se requiere de pocos meses para poder calcularlo.

Los dìas abiertos se originan de cuatro fuentes:

2.2.1. Tiempo que tiene establecido la finca para realizar el primer servicio postparto (DPSP): dìas al primer servicio postparto).

2.2.2. Mitad del ciclo de 21 dìas despuès de que la vaca a pasado el lìmite de DPSP (una vaca puede haber tenido el celo un dìa antes de cumplir el tiempo al primer servicio o puede tener celo 20 dìas despuès). En promedio se considera que se deben añadir 10 dìas.

2.2.3. Falla en la detecciòn de calores: Cada celo no detectado implica un incremento de 21 dàs en el perìodo abierto.

2.2.4. Falla en la concepciòn: tambièn incrementa en 21 dìas el periodo abierto si la vaca es detectada en celo. Si esto no ocurre, se nos puede incrementar en 42 o mas dìas.

Con estos puntos es muy comùn que el periodo abierto tenga una duraciòn de 123 dìas:

1.	DPSP:	50 dìas
2.	Mitad del ciclo:	10 dìas
3.	50% detecciòn de calores:	21 dìas (1er celo)
4.	50% de concepciòn:	21 dìas (2do celo no concibe)
5.		<u>21 dìas</u> (3er celo si concibe)
		123 dìas

Es muy comùn que el nùmero de DA sea mayor a 123 dìas y es por esto que posterior a este diagnòstico inicial de dìas abiertos se debe hacer una "disecciòn" de èste paràmetro para detectar cual es el problema que nos incrementalos DA.

2.2.1. El primer punto sobre el cual hay que trabajar es sobre el paràmetro de DPSP. Este es un paràmetro establecido por la finca que por desconocimiento puede ser fijado arbitrariamente. En general, el mìnimo tiempo que debemos servir a una vaca postparto (pp) es 45 dìas debido a que el ùtero tarda este tiempo en recuperarse para permitir una nueva gestaciòn. Es muy comùn que se encuentren fincas que sirven por primera vez a las vacas hasta 100 dìas despuès del parto. En estos casos es muy probable que con el hecho de iniciar los servicios mas temprano (ie. 50 dìas pp) logremos una mejorìa en DA. Se debe tener en cuenta que factores como un prolongado anestro postparto harìa imposible disminuir el periodo de DA.

2.2.2. Los dìez dìas en promedio para lograr detectar un animal en celo, no se pueden evitar a menos que se realicen programas de sincronizaciòn de celos, donde el ciclo estral se ve disminuìdo en su duraciòn.

2.2.3. EL punto de la detecciòn de calores es bastante àlgido en las ganaderìas de nuestro paìs donde la inseminaciòn artificial a desplazado el uso del toro. Es obvio que este no es un problema presente en aquellas ganaderìas donde todavìa el toro es el encargado de realizar la monta. La mala detecciòn de calores es quizàs el principal problema que nos incrementa el paràmetro de dìas abiertos.

Se debe tener en cuenta que la detecciòn de celos puede fallar por dos aspectos: 1. Que el nùmero de celos detectados no coincide con el nùmero de celos esperados (es lo mas comùn) lo cual se conoce con el nombre de intensidad de detecciòn de calores; y 2. Que los celos que se detectan no son realmente celos.

2.2.3.1. Intensidad de la detecciòn de calores: existen varios paràmetros para detectar si èste es el problema a nivel de la finca.

a. Porcentaje de estros detectados: Es el porcentaje de celos detectados de un total de celos esperados provenienes de vacas que estàn listas para ser servidas. Es de anotar que las vacas que estàn òptimas para servicio son vacas que llevan mas de 45 dìas postparto y que no presentan niguna patologìa puerperal. El problema de èste paràmetro es que no detecta si los celos observados fueron realmente celos.

b. Vacas confirmadas preñadas al momento del chequeo genital. Este paràmetro puede ser muy utilizado por el profesional que realiza el chequeo reproductivo pero puede dar resultados falsos si no se tiene una adecuada detecciòn de celos en la finca o si hay fallas en concepciòn. Los problemas de fallas en la concepciòn se pueden descartar fàcilmente si hay una adecuada detecciòn de calores pues en estos casos la vaca repite celo a los 21 dìas; es decir antes de ser chequeada para diagnòstico de preñez. Por el contrario, si el celo no es detectado, es una vaca que va a ser chequeada para preñez y va a resultar vacìa.

c. Ensayo de detecciòn de calores por 24 dìas. Este procedimiento da una apreciaciòn directa de la eficiencia en detecciòn de calores. Durante este procedimiento es importante que la persona encargada de la detecciòn no se entere que este experimento se èstà llevando a cabo ya que si lo sabe es muy probable que intensifique la detecciòn durante este periodo. La otra posibilidad es la de utilizar 24 dìas retropectivamente y hacer el analisis en este tiempo. Esta mediciòn se va a ver afectada si se utilizan sistemas de sincronizaciòn de celo.

d. Promedio de la duraciòn entre celos: En teorìa cada celo en un animal que no concibe se presenta cada 19 a 23 dìas. Al hacer un anàlisis de los animales listos para servicio, cada celo se debe presenar en mùltiplos de alrededor de 21 dìas. Este paràmetro nos ayuda a detectar celos que se han escapado (ie. una vaca con un periodo interestro de 42 dìas muy seguramente no se le ha detectado un celo).

Un aspecto importante de mencionar es que una vez la vaca a reiniciado su actividad ovarica, es decir a comenzado a mostrar celos,no es frecuente que manifieste un celo, el siguiente no y el tercero si. Este patròn es muy comùn encontrarlos en fincas con mala detecciòn de calores.

2.2.3.2. Precisiòn en la detecciòn de calores. Es muy comùn que una vaca se registre con varios celos en un periodo de tiempo menor al que deberìa (mùltiplo de 21 dìas) e inclusive se insemine en estos falsos celos. Tambièn es importante anotar que alrededor de un 5% de las vacas gestantes

2.2.4. La tasa de concepciòn es otro paràmetro muy utilizado que nos indica el costo (en semen) que representa obtener una preñez. El ideal es que al animal apto para ser servido que se le detecte calor, se le insemine y como resultado se obtenga una preñez (es decir un servicio por concepciòn). Esta es una meta dificil de lograr la cual puede verse incrementada por varios razones:

a. Problemas en la inseminaciòn
b. Patologìas puerperales
c. Estrès

Sobre este punto es importante tener en cuenta que las fallas en la concepciòn no son fisiològicamente frecuentes, es decir, que una vez detectado que una finca tiene 3 o mas servicios por concepciòn debemos analizar los factores anteriormente descritos, antes de atribuir el problema a la falla en la concepciòn.

3. Enfermedades reproductivas: El monitoreo de enfermedades reproductivas nos permite detectar varios problemas: la presencia de enfermedades venèreas transmisibles por parte del toro, un

problema infeccioso, problemas de nutriciòn, problemas de limpieza durante el priparto. Las enfermedades reproductivas que mas se deben monitorear son: Aborto, retenciòn de placenta, distocias, metritis, mortinatos, quistes ovàricos. Se considera que porcentajes de estas patologias superiores a un 10% nos deben alertar sobre la existencia de condiciones patològicas o de manejo inadecuado en el hato.

Una de las patologias que mas nos interesan es la presencia de aborto. La presencia de aborto en varios animales en un periòdo corto de tiempo generalmente llama la atenciòn al genadero e inmediatamente se toman medidas para detectar y controlar su causa. Los abortos esporàdicos en cambio, frecuentemente pasan desapercibidos hasta que no se vuelvan agudos. Si nosotros analizamos anualmente la incidencia de abortos, podemos detectar el problema antes de que ocurran "tormenas de abortos" y asi lograr tomar medidas correctivas antes de que la pèrdida econòmica sea mucho mayor.

Algo importante de mencionar es ¿Què es un aborto?. Se considera que una repeticiòn de calores antes del dia 45 es una mortalidad embrionaria y no se cuenta como aborto. Del dia 45 al 260 de la gestaciòn se considera como aborto y del dia 260 hasta tèrmino se considera como parto prematuro. Si la pèrdida gestacional està incrementada en cualquiera de estas etapas, de todas formas nos està indicando que hay un problema que debemos solucionar. Como regla general se considera que la tasa de pèrdidas gestacionales superiores a un 10% son tomadas como problema en un hato a pesar de que el ideal es que esta tasa no sea superior a un 2-5%.

Tasa de sacrificio por razones reproductivas: Este es un parametro que no debe ser superior al 8% anual. Cuando este paràmetro està incrementado nos indica que hay un inadecuado manejo reproductivo. En estos casos es importante determinar las razones por las cuales un animal es sacrificado, es decir que las desiciones de sacrificio generalmente se toman de forma individual y en muchos caso es inevitable. Son muy frecuentes los sacrificios de vacas en el priodo posparto donde la vaca sufre enfermedades puerperales como enfermedades metabòlicas, problemas neumònicos, problemas de patas etc, que finalmente ocasionan un incremento indeseable en los DA si dichos animales se mantienen en el hato. La determinaciòn de los causales de sacrificio, a pesar de ser generalmente inevitables, nos indican si ciertas patologias se estàn incrementando y nos llama la atenciòn sobre algùn problema de manejo del hato.

PARAMETROS Y METAS UTILIZADAS EN EL MONITOREO REPRODUCTIVO EN UN HATO DE LECHE

Intervalo parto-concepciòn (DA)	85-120 dìas
Intervalo parto al primer servicio	60-70 dìas
Porcentaje de detecciòn de calores	50-70%
Tasa de concepciòn al primer servicio	50-60%
Tasa de concepciòn general	45-55%
Servicios por concepciòn	1.7-2.2
Edad al primer servicio	13-15 meses
Edad al primer parto	22-25 meses
Tasa de sacrificio por razones reproductivas	< 8%
Porcentaje de abortos (vacas confirmadas preñadas que abortan)	<5%
Porcentaje de retenciòn de placenta	<10%

COMO TRABAJAR LOS FACTORES QUE AFECTAN LOS DIAS ABIERTOS EN EL HATO

El paràmetro de dìas abiertos, en general, tiende a ser superior a 120 dìas (paràmetro ideal). Una vez determinado que tan lejos estamos del ideal debemos determinar con la ayuda de los demas paràmetros cual es el principal problema que nos està incrementando los dìas abiertos. Los siguientes son las posibles alternativas que nos permitiràn de alguna forma reducir el intervalo parto concepciòn.

DPSP: Dìas hasta el primer servicio postparto (voluntario)
Educaciòn y evaluaciòn sobre cual es el periodo mìnimo preestablecído fisiològicamene y cual es el periodo mìnimo para una finca en particular.

Eficiencia en la detecciòn de calores
- Mejora del manejo de la detecciòn de celos
- Establecer la detecciòn de celos como una funciòn especìfica a nivel de finca
- Mejorar el manejo de registros
- Utilizaciòn de detectores de celo
- Nutriciòn
- Control de las enfermedades puerperales
- Control de otras enfermedades (cojeras, neumonias etc).
- Controlar de forma mas cercana las vacas que deben ser detectadas en calor.

Precisiòn en los calores detectados
- Educaciòn sobre los sìntomas de celo
- Tener en cuenta sìntomas de celo secundarios
- Tener en cuenta que el intervalo entre celos debe ser de alrededor de 21 dìas.
- Ayudas con detectores de celo

Eficiencia en tasa de concepciòn
- Vacas fèrtiles
  - Calidad del semen
  - Tècnicas de inseminaciòn artificial
  - Mejorar la precisiòn de los calores detectados
- vacas infèrtiles
  - Enfermedades infecciosas
  - Toxinas
  - Nutriciòn
  - Medio ambiente
  - Control de enfermedades pueperales
  - Control de nutriciòn
  - Control de enfermedades infecciosas
  - Detecciòn de celo

Un adecuado anàlisis de la composiciòn del hato tambièn nos puede señalar problemas y ademàs nos indica sobre què grupo de animales debemos actuar. El siguiente cuadro nos muestra una condiciòn relativamente ideal de una finca. Con esta informaciòn nosotros podemos tomar desiciones para actuar sobre tres grupos de vacas en particular: 1. Aquellas vacas recièn paridas que estàn presentando problemas puerperales; 2. Aquellas vacas que no estàn aptas para servicio a pesar de tener mas de 45 dias de paridas; y 3. Aquellas vacas vacias que tienen mas de 45 dias de parto, las cuales no se han inseminado a pesar de estar aptas.

COMPOSICION DE HATO

1.	Vacas problema	3%
2.	Vacas recièn paridas (< 45 dias pp)	15%
3.	Vacas listas para servicio (>45 dpp)	10%
4.	Vacas servidas sin confirmar	15%
5.	Vacas gestantes y en lactancia	42%
6.	Vacas gestantes y secas	15%

PARAMETROS REPRODUCTIVOS EN DIFERENTES AREAS LECHERAS DE COLOMBIA

Intervalo entre partos	461.4 dìas
Dìas abiertos	181.4 dìas
Edad al primer parto	35 meses
Natalidad	78.2%
Tasa de descarte anual	6.7%
Vacas problema (> 100 dias abiertos)	27.5%
Fincas con problema de detecciòn de calores	88.1%
Nùmero de observaciones	4.159
Nùmero de fincas	113

PARAMETROS REPRODUCTIVOS EN DIFERENTES AREAS DE COLOMBIA

Porcentaje de natalidad	
Lecherias	24%-88%
Doble propòsito	18-83%
Fincas de crìa	15%-80%
Edad al primer parto	
Lecherias	26-54 meses
Doble propòsito	25.8-67 meses
	30-64 meses (Novillas-Còrdoba)
	346-671 dìas (vacas-Còrdoba)
Fincas de crìa	31-63 meses
Cebù	34.6-57.8 meses (Socorro)
	35.8-40.4 meses (Piedemonte)
	35.6-54.4 meses (Urabà)
Intervalo entre partos	
Doble propòsito	326-822 dìas (Còrdoba)
	310-937 dìas (Còrdoba)
	312-717 dìas (Còrdoba)
Cebù	15-25.9 meses (Socorro)
	13.2-26 meses (Piedemonte)
	14.7-20.2 meses (Urabà)
Porcentaje de abortos	
Doble propòsito	8% (novillas-Monteria)
	1.5% (vacas-Monteria)
Porcentaje de mortinatos	
Doble propòsito	8% (novillas-Monteria)
	1.5% (vacas-Monteria)

4. Paràmetros reproductivos en fincas manejadas con toro: En las ganaderias donde el toro es utilizado como reproductor, los paràmetros reproductivos que se utilizan tienden a evaluar la eficiencia reproductiva del toro y al mismo tiempo las de las vacas.

El desempeño reproductivo del toro va a depender inicialmente del nùmero de vacas que se dispongan para cada toro. Se considera que un toro adulto debe manejar un màximo de 30 vacas cuando la monta no se realiza de manera controlada. Si por el contrario, la monta es controlada, un toro es capaz de montar 3-4 vacas por semana indefinidamente, si su estado nutricional se mantiene.

Una vez se tiene el lote de vacas y se exponen al toro se debe tener en cuenta cual es el tiempo que dicha vacada debe estar con el toro para obtener unos porcentajes aceptables de preñez. Se considera que un periodo que comprenda tres celos, es decir alrededor de 60 dias, es suficiente para asegurar un porcentaje de preñez superior al 80%. Este paràmetro ademàs de evaluarnos la fertilidad del toro, nos permite eliminar el grupo de vacas subfèrtiles que no quedaron preñadas en este lapso de tiempo. ie. si el promedio de fertilidad del toro fuè de 85%, el 15% restante son vacas que deben ser consideradas para descarte.

Otra condiciòn que se nos puede presentar es que la fertilidad haya sido menor al 80%. Por ejemplo si el porcentaje de preñeces es de un 60%, debemos entrar a evaluar cuales son las razones para haberse obtenido este porcentaje. Pueden haber razones por parte del toro, pero tambièn se puede presentar el caso de vacas que se encuentran en anestro y que obviamente nos disminuyen este valor.

OTROS PARAMETROS A EVALUAR A NIVEL DE FINCA

Existen otros paràmetros que nos afectan la productividad de la finca y que debemos monitorear, no solo para establecer correctivos, sino tambièn para determinar el perjuicio o beneficio econòmico que ellos nos pueden estar generando:

Peso al destete
Peso o edad al primer servicio
Peso o edad al primer parto
Ganancia de peso

Estos paràmetros nos indica lo eficiente que se està haciendo el levante de los animales, es decir nos està controlando el componente nutricional. Los ideales para estos paràmetros son:

Peso al año	50% del peso adulto
Peso o edad al primer servicio	65% del peso adulto
Peso o edad al primer parto	85% del peso adulto

5. ANOTACIONES FINALES

La siguiente etapa una vez obtenida la informaciòn es la de realizar un diagnòstico de la finca. Una vez hecho el diagnòstico en base a los paràmetros estudiados, debemos buscar dos objetivos primordiales:

1. General: Determinar como se està manejando la explotaciòn anualmente para comparar dicha informaciòn con metas propuestas en años anteriores en la misma finca. Este es un anàlisis que nos arroja resultados a largo plazo y que debe ser implementado anualmente para tomar correctivos. Es importante anotar, que es dificil esperar que una vez se ha realizado el primer diagnòstico de deficiencias en la finca, nosotros vayamos a lograr en un año convertirnos en la finca ideal, por mas correctivos que nosotros pongamos en pràctica. Lo que debemos hacer es tratar de disminuir los paràmetros paulatinamente hasta que nosotros determinemos que ya se ha llegado a un màximo de eficiencia para esta finca.

En cuanto a la toma de desiciones despuès de haber hecho un diagnòstico debemos ser concientes de que como en medicina no hay enfermedades sino enfermos; en el caso de las fincas, la frase serìa que "no existen paràmetros ideales para las fincas, sino que cada finca genera sus paràmetros ideales". Mal hariamos si trataramos de estandarizar los paràmetros para todas las fincas pues cada finca forma parte de un universo. ie. Fincas donde no existe riego, fincas donde el verano dura 6 meses, fincas donde no se suplementa etc.

La recomendaciòn general es que en base a las capacidades econòmicas de la finca nosotros establezcamos los correctivos posibles cuando estos son de tipo urgente. ie. vacunaciones, descartes, tratamientos etc. Ademàs, debemos buscar disminuir los paràmetros en un 5% anual o mas si la finca lo permite. Si al siguiente año las expectativas superan las metas propuestas, entonces al segundo año podemos colocar de meta la reducciòn del paràmetro indeseable en un porcentaje mayor. Lo importante de las metas propuestas es que nos permite detectar si los correctivos que se realizaron durante el año fueron benèficos (se redujo en 5%) o no tuvieron ningùn efecto o inclusive que dichos correctivos hubieran tenido un efecto negativo.

2. Especifico: En estos casos se pueden fijar paràmetros que nos permitan decidir sobre el futuro de un animal particular. Igualmente, estos lìmites deben ser establecidos para cada una de las fincas, sin olvidar que este tipo de desiciones nos va a mejorar a largo plazo los paràmetros generales de la finca. ie. Si una vaca se excede mas de 180 dìas postparto sin quedar gestante es un animal que podemos considerar eliminarlo para asì disminuir el nùmero de vacas problema y el promedio de DA.

Una anotaciòn final muy importante es la de la evaluaciòn reproductiva de las novillas de primer parto. Se ha demostrado que en general la novilla de primer parto tiene en promedio una mayor duraciòn de DA por variadas razones, entre las cuales està el hecho que es un animal que sufre el estrès del parto por primera vez, es un animal que no a terminado de crecer y es un animal que entra a competir nutricionalmente con vacas que ya tienen establecida una jerarquìa en el hato. Por estas razones es importante ser un poco mas "benevolente" con la novilla de primer parto. Si el manejo de la finca lo permite, es importante que las novillas de primer parto sean evaluadas de una manera indepndiente y que para ellas se tracen metas particulares. En muchos casos donde el nùmero de animales y la extensiòn de la finca lo permitan, es ideal que se haga un lote de novillas de primer parto, ya sea solo para el manejo nutricional o inclusive para ser expuestas al toro.

Dìas abiertos en ganado de carne

Cebù	205	Cuba	Martìnez et al., 1987
Brahman	141.8	Cesar	Cely et al., 1988
Brahman	194.8	Santander	Cely et al., 1988

Intervalo entre partos

Brahman	422d	Cesar	Cely et al., 1988
Brahman	456d	Santander	Cely et al., 1988
Brahman	350-450	Còrdoba	Laredo et al., 1986

Edad al primer servicio

Brahman	24.7	Cesar	Cely et al., 1988
Brahman	31.8	Santander	Cely et al., 1988

Peso al primer parto

Brahman	450 Kg	Còrdoba	Laredo et al., 1986

Edad al primer parto

Carne	30m		Laredo et al., 1986
Cebù	37m		Guevara et al., 1988
Brahman	48.7		Grimaldo et al., 1981
Brahman	48.2	Caldas	Duràn, 1986
Brahmam	42.5		Olivera, 1986
Brahman	37m	Cesar	Cely et al., 1988
Brahman	40.2	Santander	Cely et al., 1988

Intervalo entre partos para una mezcla de B. taurus X B. indicus

% B. Taurus	Inetrvalo etre partos India	Inetrvalo etre partos Brasil	Edad primer servicio India	Edad primer servicio Brasil
100	463	538	32	37.3
75	444	529	34	36.4
50	432	467	32	35.2
25	442		37.2	38.3
0	448		42.2	

Ganaderia de carne intervalo parto-primer celo

Raza	Intervalo parto-primer servicio	Fuente	
Nelore	260d		
B. Taurus	82d		
Brahman	49-98d		
Brahman y cruces	49-72d		
Cebù	181d	Cuba	Martinez et al., 1987
1/2 H X Nelore	58dd	Perù	Garcia et al., 1990
1/4 H X Nelore	123d	Perù	Garcia et al., 1990

Paràmetros reproductivos en ganado de doble propòsito en el departamento de Còrdoba (Navarrete, et al., 1993).

Mortalidad	Menores de 12 m	10%
	1-3 años	5%
	Adultos	3%
Natalidad		65.5%
Lactancia		250d
Porcentaje de leche/dìa		4-5 lt
Intervalo entre partos		384-588 (vacas-novillas)
Edad al primer parto		38m

Paràmetros reproductivos de ganaderias de leche en Colombia (Griffiths, 1982).

IEP	461d
DA	181d
Lactancia	202d
Periodo seco	125.4
Edad al primer servicio	26m
Edad al primer parto	35m
% vacas problema	27.5
% Preñez	41.6
Indice de fertilidad	65%
Natalidad	68.2%
Descartes	6.7%
Problemas de detecciòn de celo	83.1%
Servicios por concepciòn	2.37

Otros paràmetros a tener en cuenta

Peso al destete	50-60% adulto
Peso al primer servicio	65% adulto
Edad al primer servicio	13-15 meses
Edad al primer parto	22-24 meses
Natalidad (%)	70 %
Lactancia	305d
Descarte por no preñez	10%
Distocias	10%
Mortinatos	2%
Abortos	<2%
Mortalidad neonatal	
Nacimiento-10d	5%
10-30d	2%
30d-destete	1%
Mortalidad en adultos	2%

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Claudia Jiménez E.

BASIC PRINCIPLES AND TECHNIQUES FOR TRANSRECTAL ULTRASONOGRAPHY IN CATTLE AND HORSES

R.A. Pierson, J.P. Kastelic, and O.J. Ginther

Department of Veterinary Science
1655 Linden Drive
Madison, WI 53706

INTRODUCTION

Diagnostic ultrasound instrumentation has been available to the medical community only since the early 1970's. The development of real-time or dynamic imaging in the late 1970's made this powerful technology adaptable for the study of the internal reproductive tract in large domestic animals via the transrectal route. With an ultrasound scanner, an operator may visualize organs previously accessible only with the tactile sense. Ultrasound scanners therefore have become an important tool in research programs and have been integrated into clinical and commercial programs in the breeding of animals.

The applications of diagnostic ultrasonography to the embryo transfer industry have not been explored extensively. However, evaluation of the follicular population and ovarian response to superstimulation regimens is a complementary step in the procurement of transferable embryos; ultrasonic imaging profoundly increases our capabilities for ovarian evaluation. Additional uses include evaluating the reproductive tract (especially the corpus luteum and uterus) of potential recipients and diagnosing pregnancy and embryonic loss in recipients. It appears, therefore, that incorporation of ultrasonography into an embryo transfer program should be given consideration.

The ultrasonographer is an integral part of each ultrasonic examination on three distinct levels. On the most basic level, the eye-to-hand coordination necessary to locate the organs is relatively easily learned. With experience, locating the structures of interest (e.g., ovaries, uterus) requires only a few seconds in most cases. Difficulties occasionally may arise when structures such as a loop of bowel or fecal material disrupt the image; however, these are easily corrected. Secondly, once the structures of interest are located, the ultrasonic anatomy must be evaluated. This requires a detailed working knowledge of reproductive anatomy and pathology. Finally, the basic principles of diagnostic ultrasound and the biological subject under study must be constantly integrated. Scanning technique, instrument adjustment, anatomic structure, and an understanding of the basic concepts of acoustic physics combine to yield a technically correct and aesthetically pleasing ultrasound image.

Detailed descriptions of the acoustic physics and principles of ultrasonography (1-13) and technical descriptions of the origin and interpretation of artifacts are available (14,15). The purpose of this report is to provide a summary of the principles of diagnostic ultrasonography needed to begin successful application of transrectal ultrasound imaging technology. In addition, interpretation of ultrasound images, commonly encountered artifacts, and examination techniques for imaging

BASIC PRINCIPLES

Ultrasonography uses high frequency sound waves to produce images of soft tissues and internal organs similar to the way sonar is used to map the ocean floor. The origin of waves from an ultrasound transducer is similar to that of audible sound waves from a drum (Figure 1). In the resting state, equilibrium exists between the air molecules on either side of the drumhead (audible sound) or between the molecules of the piezoelectric crystals of the transducer and the tissues with which they are in contact (ultrasound). When the drumhead is struck the air molecules on either side of the drumhead are alternately compressed and rarefacted by the vibrations. Similarly, when a pulsed electric current is applied to the piezoelectric crystals in a transducer, vibrations characteristic of the crystals are produced and result in acoustic pressure (sound) waves in the contiguous tissues. The sound waves are directed through the tissues by moving the transducer or varying the angle of the transducer as desired. Tissues have abilities to either propagate or reflect the sound waves to varying degrees. The proportion of the sound beam that is reflected or echoed is received by the same piezoelectric crystals in the transducer, converted to electrical impulses, and displayed on the ultrasound screen as a series of gray dots. The resulting real-time or moving image is analogous to a movie taken with sound waves in place of light waves.

The characteristics of a tissue determine what proportion of the sound beam will be reflected. The reflected portion is represented on the ultrasound image by shades of gray, extending from black to white. Liquids (follicular fluid, yolk-sac fluid) do not reflect sound waves (i.e., are nonechogenic or anechoic); therefore the image of a liquid-containing structure appears black on the screen. At the other extreme, dense tissues (fetal bone, bovine cervix) reflect much of the sound beam (i.e., are hyperechogenic or hyperechoic) and appear white on the screen. Other tissues are seen in various shades of gray depending upon their echogenicity or ability to reflect sound waves. The gray-scale may be defined as step-wise progression of shades of gray extending from black to white. Some ultrasound instruments are able to display 16 shades of gray and others may display a gray-scale of up to 64 steps. The sound beam which passes through the tissues is quite thin (e.g., 2 mm); therefore the beam acoustically samples a "slice" of the tissues. The two-dimensional image seen on the screen is analogous to a histologic section of the organs, enabling the ultrasonographer to visualize the structures in a detail which approaches grossly viewing a histologic specimen.

As audible sound travels, the wave is weakened or attenuated. An echo of the same frequency and speed as the primary sound wave is produced if the sound wave hits a barrier before it is too weak to be returned (Figure 2). The returning echo may be received by the ear of the individual beating the drum and the distance from the drum to the barrier may be estimated by using the known velocity of sound in air (approximately 330 m/sec). Similarly, ultrasound waves travel through the body (approximately 1540 m/sec) until a tissue reflector is reached. Some of the waves are reflected and return to the crystals; some of the waves continue on to interact with deeper structures. The returning echo compresses the piezoelectric crystals which, in turn, produce electrical energy which is transmitted to a receiver. The time delay between the propogation of the wave and reception of the returning echo is used to calculate the distance from the crystals to the tissue reflector.

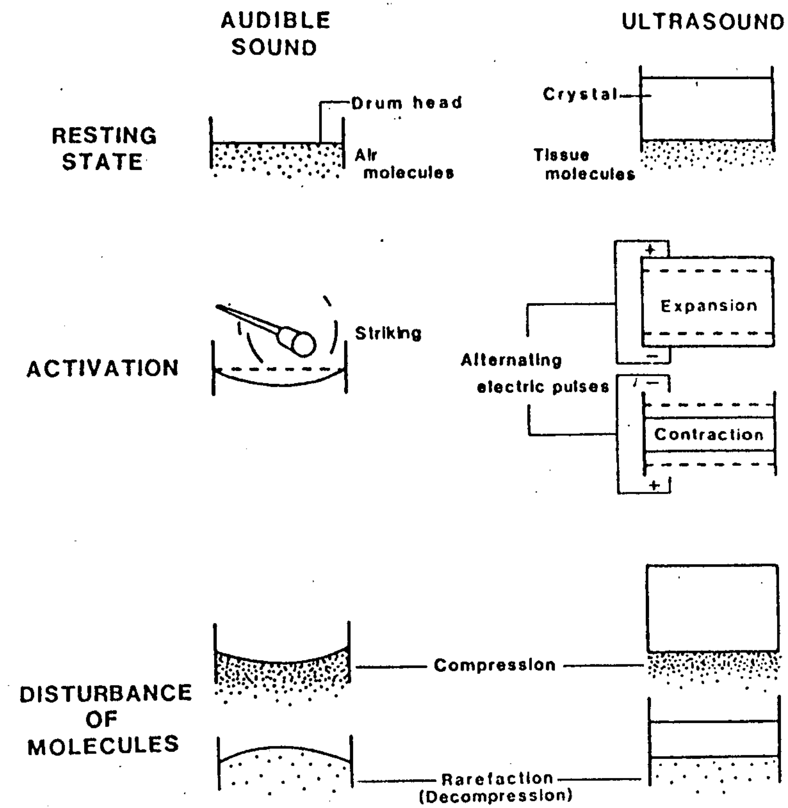

Figure 1. Comparison between the origin of audible sound waves and the origin of ultrasound waves. From (3).

The body is composed of many layers of tissues. A tissue interface occurs whenever tissues of different densities or acoustic impedence are in contact. Acoustic impedence is a measure of the resistance of the tissue to propogation of the ultrasound waves. Very slight differences in tissue density may result in an interface. The density and organization of a tissue also result in a characteristic ultrasonic pattern, or echotexture, which allows the identification of many of the internal organs (Figure 3). In addition, the echotexture of reproductive organs may vary depending on reproductive status (estrus, diestrus, or anestrus). For example,

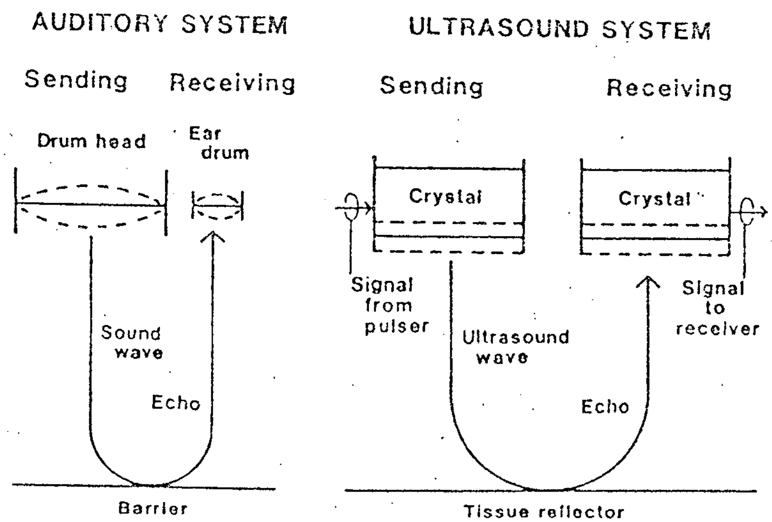

Figure 2. Comparison of the reception of echoes from audible sound and diagnostic ultrasound. From (3).

morphologic changes occur in the uterus in response to changes in the pattern of secretion of the ovarian hormones. These morphologic changes are reflected in the echotexture of the uterus. The uterine echotexture of a mare or cow in estrus is easily differentiated from that of diestrus (16,17).

EQUIPMENT

The resolving power of the equipment is dependent on the frequency of the sound waves. Frequency refers to the number of vibrations of the acoustic source per second. High frequency provides greater detail, whereas lower frequency provides greater tissue penetration. Ultrasound frequencies are measured in megahertz (MHz; 1 MHz = 1,000,000 sound waves per second). The frequencies of the various transducers are analogous to the various powers of the objectives of light microscopes. With a low frequency transducer or low power objective, a larger area is viewed, but with less detail. With a high frequency transducer or high power objective, a smaller area is viewed, but with more detail. The lower frequency transducers (e.g., 3.0-3.5 MHz) are suited for viewing larger structures at a greater distance from the transducer (e.g., imaging a large fetus). The higher frequency transducers (e.g., 5.0-7.5 MHz) are intended for detailed study of structures close to the transducer (for example, evaluating the ovaries and uterus) and are preferred for intrarectal examinations of the reproductive tracts of horses and cattle.

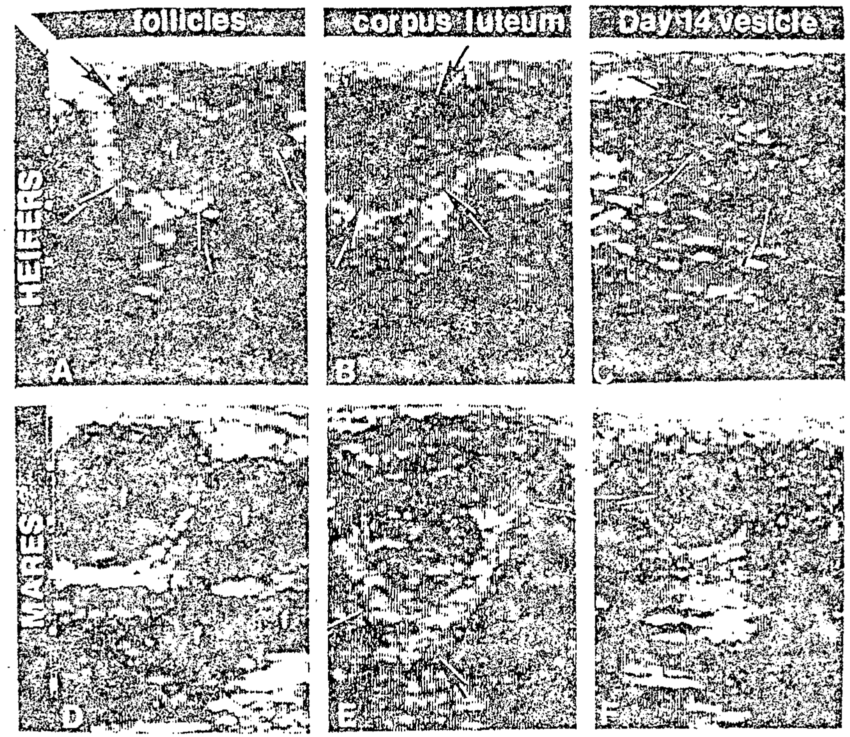

Figure 3. Ultrasound images showing echotextures from the reproductive tracts of heifers (A-C) and mares (D-E). Images A and D represent ovaries with follicles of various sizes (f). Follicles are fluid-filled and appear black on the ultrasound image. Compare the follicle with the echotexture of the surrounding ovarian stroma. Boundaries of the bovine ovary are demarcated by arrows. Images B and E represent corpora lutea. The luteal gland is distinguished from stroma by a distinct border and echotexture differing from that of stroma. Boundaries of the luteal glands are indicated by arrows. Note that in the specimen of the luteal gland of the mare (E) approximately 40% of the gland, the peripheral portion, represents the wall of luteinized tissue. The remaining 60% of the gland, the central portion, is a centrally located organized blood clot. The blood clot forms after approximately [illegible]% of ovulations in mares. Images C and F represent the Day 14 embryonic vesicles (arrows). The vesicle of the heifer (C) is elongated and difficult to visualize while the vesicle of the mare (F) is spherical and is easily distinguished from the surrounding uterine tissue. Scales in the left panels are in centimeters.

Ultrasound instruments used for examination of the reproductive tracts of horses and cattle are B-mode, real-time scanners. B-mode refers to brightness modality, wherein the ultrasonic imaging is a two-dimensional display of dots. The brightness of the dots is proportional to the amplitude of the returning echoes. Real-time imaging refers to the "live" or moving display in which the echoes are recorded and refreshed continuously. There are two basic types of real-time, B-mode ultrasound instruments available on the veterinary market: linear-array scanners and sector scanners. In linear-array scanners, the sound waves are emitted perpendicular to the transducer along the row of crystals. The waves produced by each crystal travel parallel to those produced by neighboring crystals in a linear array. Therefore the resulting image is rectangular; the width of the image corresponds to the length of the active portion of the transducer. The images of tissues closest to the transducer are at the top of the screen. The section is generally in the sagittal plane with respect to the body. The images of tissues at the tip of the transducer may be displayed at the right or left side of the video monitor depending on the design of the scanner. Some scanners are equipped with an image inversion feature that allows display of echoes from the tip of the transducer to be placed on either the right or the left of the monitor at the option of the operator. For ease of orientation and consistency with other imaging modalities, the preferred display is with the cranial aspect of the animal to the left side of the ultrasound image. For intrarectal reproductive examination of large animals, it is important to select a machine with a durable, atraumatic probe that was specifically designed for intrarectal insertion. Sector scanners produce a "slice of pie" shaped image and are taken directly from the human medical market for veterinary use. Typical uses of sector scanners in the veterinary field are imaging the tendons in the legs of horses and imaging thoracic and abdominal structures in small animals.

PRODUCTION OF IMAGES

The technically correct, useful ultrasound images sought in examinations of the reproductive tract are the product of many electronic components which must work in harmony to produce the image. Diagrammatically, the basic components of a linear-array ultrasound scanner are shown (Figure 4). The transducer is in intimate contact with the tissues and is connected to the console by a cable comprised of many wires connecting individual crystals to both the pulser and receiver. The pulser sends electronic signals to groups of the piezoelectric crystals at a predetermined rate which causes the formation of the ultrasound wave. The pulse rate is calculated so that the image which is displayed on the screen appears continuous. A complete sweep of all of the crystals in the elements of the array produces one image or frame. Typical frame-rates are 20 to 30 frames per second. Thus real-time images are produced. The images move as the structures change locations (e.g., beating of a fetal heart) or as the transducer itself is moved over the tissues.

Echoes returning from the tissues are electronically captured by the receiver where the signal is amplified and compensation is made for the loss of intensity due to attenuation. The degree of amplification is called gain. The gain controls are under the direct control of the ultrasonographer and are important in creating a proper ultrasound image. Adjustment of the gain controls is a method of equalizing the strength of the echoes returning from different depths within the tissues. For example, echoes from similar tissue reflectors located at 10 mm depth and 40 mm depth should be of similar echogenicity; however, the echo from the 40 mm deep

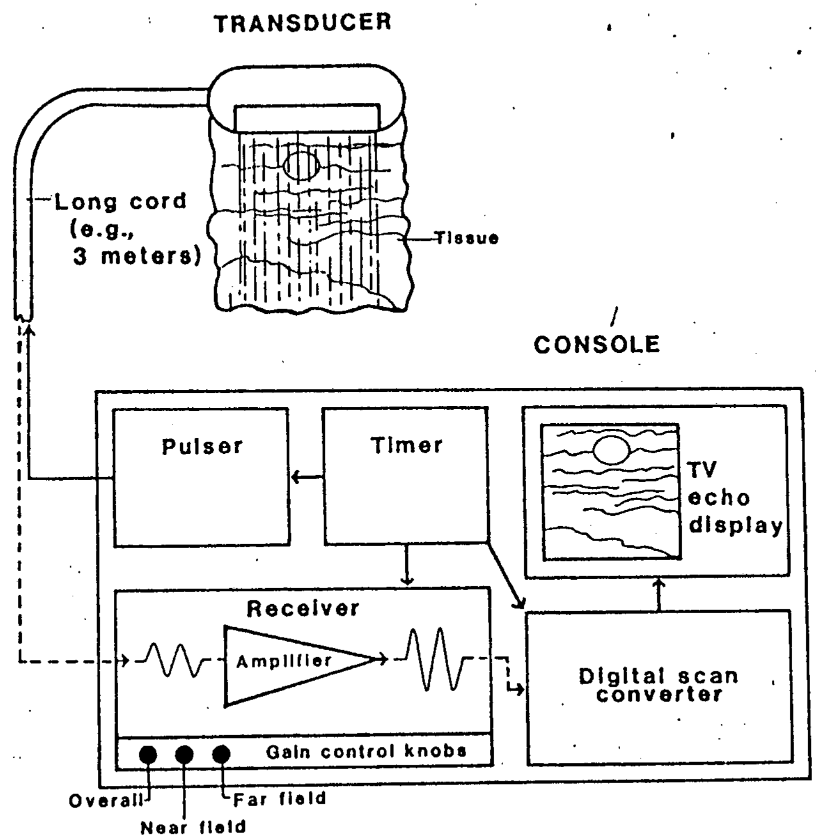

Figure 4. Components of an ultrasound scanner. From (3).

reflector has traveled further and is more attenuated. Gain (specifically time gain compensation) controls provide a means of correcting for losses in signal strength due to increased tissue depth. Correct adjustment of gain is critical in creating a balanced ultrasound image.

Figure 6. Artifacts commonly encountered in ultrasound examination of the reproductive system. A) Enhanced through-transmission beneath the image of an approximately 30 mm ovarian follicle in a mare. The enhancement is the echogenic area (arrow) beneath the nonechogenic (black) image of the follicle. B) Refraction artifacts (arrows) beneath the edges of equine ovarian follicles. C) Specular reflections (arrows) on the upper and lower surfaces of a 4 mm Day 10 equine blastocyst. D) Reverberations (arrows) beneath the image of the vagina in a heifer. The artifact originates from air in the vagina. E) Acoustic shadow (arrow) in an image of an estrus equine uterus caused by a remnant of a fetal bone (echogenic spot in center of the image). F) Electrical interference over the image of the spinal cord (arrow) of a Day 42 bovine conceptus. Note the general haziness of the image and the vertical white static lines over the area of the embryonic vesicle as well as in the bladder (lower half of ...

Reverberation artifacts are commonly seen during intrarectal examination of the reproductive tract because of gas-filled segments of intestine beneath the areas of interest. Reverberation occurs when the sound waves encounter the highly reflective gas-filled bowel and bounce back and forth between the bowel and transducer. Due to the lag time of each returning echo, as perceived by the transducer, bright echoes are recorded on the image at deeper and deeper levels. There are three distinguishing characteristics of reverberation artifacts: 1) they are equidistant, 2) they gradually diminish in intensity, and 3) they are parallel to the reflective interface. Reverberations may sometimes be diminished by adjustment of the gain controls or manually adjusting the reproductive organs thus altering the relationship with the underlying bowel.

Shadowing is an artifact characterized by lack of an echo beneath a very dense structure. It is caused by complete reflection or absorption of the ultrasound beam. This artifact is less common in images of the mare reproductive system because of the relative lack of tissues with density comparable to bone. A notable exception is the occurrence of shadowing beneath fetal bone or bone fragments, following death of the fetus. Sometimes, however, remnants of fetal bone are thin and porous and do not cause shadowing. In cattle, the plicae circulares of the cervix may occasionally cause shadow artifacts. In a large fetus, the centers of ossification will also cause shadows as the formation of bone progresses. A form of shadowing may be seen when the path of the sound beam is obstructed by bowel gas, lack of intimate contact between the transducer and rectal wall, or the presence of fecal material on the face of the probe. The fecal balls of horses are troublesome in this regard and should be suspected when a pronounced shadow appears on the image. When animals are pastured on new green grass, the fecal material may be pasty and form a film over the probe face, resulting in a hazy image. Fortunately, this problem is readily corrected and is not a major obstacle to utilization of ultrasonography.

ULTRASONIC EVALUATION OF THE REPRODUCTIVE TRACT AFTER LAPAROTOMY

Ultrasonic sound waves are almost completely reflected by air, and therefore air between the face of the probe and the rectal mucosa or within the abdomen will seriously affect image quality. Pneumoperitoneum can seriously inhibit ultrasonic examination of the reproductive tract. In a recent study (unpublished), embryos were transferred to the uterus of 15 nulliparous heifers, six to eight days after estrus, via a flank laparotomy. No effort was made to expel air from the abdomen prior to closure of the incision. The heifers were examined ultrasonically for 12 days, starting one week after surgery. The extent that the pneumoperitoneum interfered with image quality was coded on a scale of one (no or minimal effect) to three (maximal effect). The mean values are presented in Figure 7. In 9/15 heifers, there was an intermediate or maximal effect (coded values of 2 and 3, respectively) of pneumoperitoneum on image quality on the first day of examination (seven days after surgery). The interference with image quality declined rapidly over the next three days; on the fourth day of examination, there was no or minimal effect of pneumoperitoneum (coded value of 1) in 11/15 heifers. However, in 2/15 heifers (13%), pneumoperitoneum had an intermediate effect on image quality (coded value of 2) up to the eleventh day of examination (17 days after surgery). In contrast, in another study, 10 heifers were examined ultrasonically for at least 24 days after a midventral laparotomy was performed (unpublished). No attempt was made to expel air from the abdomen when it was closed. The only detected influence of pneumoperitoneum on image quality was a mild effect (code value of 1) for two days after surgery in one heifer. Interference with image quality by pneumoperitoneum is apparently more common and persists longer in heifers after flank laparotomy than following midventral laparotomy.

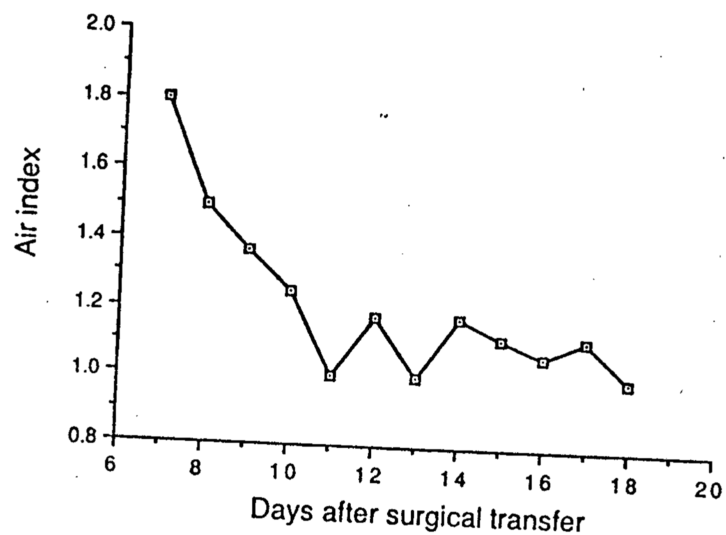

Figure 7. Coded index of the extent of pneumoperitoneum interference with overall quality of the ultrasound image following surgical transfer of embryos through a flank incision.

TRANSRECTAL TECHNIQUES

Preparation of a mare or a cow for ultrasound examination (restraint, evacuation of rectum) is similar to preparation for a rectal examination. The production of the ultrasound image and the interpretation of the image by the operator is an interaction of four factors: operator, scanner, environment, and animal. Considerable operator experience is essential for the detection of subtle structures and differences between tissues. The probe must be manipulated so that the entire uterus can be systematically examined. A high-quality scanner, preferably with at least a 5 MHz probe, is essential for detection of small structures (e.g., follicles <5 mm, Day 11 equine conceptus). The scanner should be positioned close to the operator and at approximately eye level to facilitate viewing and adjustments, but protected from potential damage. An electric outlet free from electronic interference must be available. The intensity of ambient light should be dim to reduce reflections and to avoid excessive brightness or contrast settings on the viewing screen. The animal must be well restrained, as excessive movement will interfere with interpretation of the ultrasound image. Therefore, facilities suitable

...straining animals for manual rectal examinations may be unsatisfactory for ultrasonic examinations. If the feces are loose or sticky, it is more difficult to adequately evacuate the rectum and establish good contact between the probe and the rectal mucosa. The presence of air between the acoustic face of the probe and the rectal mucosa greatly reduces image quality and must be eliminated. This makes the use of a coupling gel desirable. The gel used as a coupling medium must be of a proper viscosity and free of air bubbles. It is helpful to develop a centralized work area where all of the factors contributing to generating good ultrasound images may be controlled and the considerable investment in the ultrasound scanner may be protected. The time required for an ultrasound examination of the reproductive tract is similar to that required for a manual rectal examination.

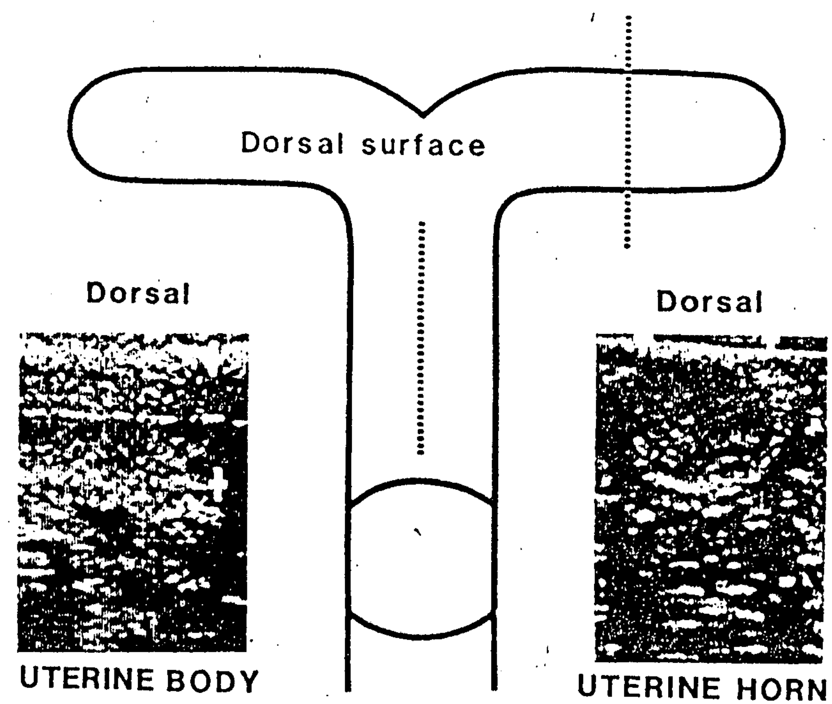

Figure 8. Diagrammatic presentation of the relationships between the orientation of a linear-array transducer and the uterus of a mare. The transducer is represented by the broken lines. The image of the uterine body is longitudinal and the uterine horn is in cross-section. From (3).

The relationships between the orientation of a linear-array transducer and the orientation of the uterine body and horns are shown for mares (Figure 8). Since the transducer is generally held in the sagittal plane, the images of the cervix and the uterine body are longitudinally oriented with respect to the animal's body. The uterine horns in mares are seen in cross-sections (16) as the transducer is moved to the right or left. Depending upon the orientation of a horn at a given examination, it may be necessary to swing the tip of the transducer to the right or left to obtain a true cross-section. In cattle, however, the uterus is coiled and tortuous, and the shape varies with the stage of the estrous cycle (17). The ultrasonic anatomy must be fully appreciated in each cow or heifer to be certain that the entire uterus is examined. A routine that has worked well in our laboratory is as follows: after the removal of fecal material, the ultrasound transducer is covered with coupling gel and inserted into the rectum. The cervix is located and the uterine body is examined in longitudinal sections. The cervix is usually easy to locate due to the increased echogenic response of the plicae circulares. The transducer is moved over the dorsal surface of the uterine body and moved slightly from side to side so that the entire width of the body is examined. When the corpus-cornual junction is reached, the transducer is moved over the dorsal surface of one uterine horn, so that the horn is examined in oblique planes. Then the transducer is rotated laterally to examine the ovary. The opposite horn and ovary are similarly examined. A linear-array transducer produces a longitudinal image with respect to the animal's body. Therefore, the first major curve of the uterine horn is visualized as a pronounced hook-shaped structure curving toward the bottom of the ultrasound screen. Spirals of the distal portion of the uterine horn result in oblique images of the horn. True cross-sectional images of the uterine horns in cattle are not frequently seen. Frequently, a section of the uterus is not adequately examined because the operator moves the transducer too quickly over the serpentine coils of the uterine horns. When searching for small structures (e.g., early embryonic vesicles), the transducer must be moved slowly. The beam is very thin and will quickly pass over a small structure. In this regard, twin embryonic vesicles in mares may produce a double "flashing" effect when they are close together or the twins may be missed if the transducer is moved too rapidly. In mares, careful examination of the entire length of the uterine body also is important in early pregnancy diagnoses because the highly mobile embryonic vesicle is frequently in the body and may be near the cervix prior to its fixation in the caudal portion of a uterine horn at approximately Day 16 (18). In addition, cyclic and pathologic changes that are visible ultrasonically may be more pronounced in the uterine body (16).

As the transducer is moved beyond the tip of a horn in mares, the medial surface of the suspended ovary is reached. The image of the ovarian section, therefore, usually is oriented from medial surface (top of screen) to lateral surface (bottom of screen) with the cranial pole of the ovary to the left and the caudal pole to the right with the scanner set for the preferred orientation. Discernment of the orientation of the ovaries is easier in cattle than in horses. In cattle, the cranial pole and the hilus of the ovary can almost always be identified. In mares, identification of the cranial and caudal poles of the ovary is more difficult. However, the ovaries in both mares and cattle are quite mobile, and the section may involve other planes or the orientation may change even while the examination is in progress. The ultrasound beam samples sequential "slices" of the ovary while the transducer is being rotated; care must be taken to ensure that the entire ovary is exposed. Segments of intestine or fat may obscure the ovary and, therefore it may be occasionally necessary to reposition the ovary in order to locate it or to obtain a clear picture. In cattle, the reproductive tract may be contorted, requiring repositioning.

SPECIAL TECHNIQUES

Special techniques using ultrasonography are as varied as the experiments to which the imaging technology is applied. For example, plastic and metal instruments are hyperechoic and are easily visualized with ultrasonography. We have used ultrasonography to guide an endometrial biopsy instrument to areas of particular interest within the equine uterus. Location and sampling of free-floating intraluminal fluid collections with an insemination pipette connected to an aspiration apparatus also is feasible. Such visualizations are possible because of small, ultrasonically detectable air bubbles in the fluid. We also have visualized the deposition of various amounts (0.5 ml to 1.5 ml) of semen or physiological saline through an insemination pipette into the uterine horns of heifers. Experiments characterizing the movement of simulated embryonic vesicles also have been done (19). The vesicles were made by injecting fluid into rubber balloons made from the finger tips of surgical gloves and coating the exterior with a hormone impregnated silastic compound.

Transabdominal ultrasonically guided biopsy techniques are routinely used in human medicine (20). Specialized transducers with channels for the insertion of needles are used. The tip of the needle is visualized as it passes through the tissue and into the target structure. This technique has been adapted for use in mares (21) and cows (22). In preliminary studies, using ultrasonically guided puncture and aspiration of follicles, 16 oocytes were collected from 34 follicular punctures in mares and 16 oocytes were recovered from 38 follicles in cows.

Contrast agents also may be used in ultrasonography (23-25). In our laboratory various concentrations of gelatin microspheres (Bio-Gel P-60, Bio-Rad Laboratories, Richmond, CA) were injected into ovarian follicles via flank laparotomy. It was possible to identify and monitor individual follicles. This is a promising research tool for monitoring the fate of follicles at physiologically important times during the estrous cycle. Examples of ultrasound images of marked follicles are shown (Figure 9). As the use of ultrasonography increases in research programs, it is inevitable that specialized clinical techniques and applications will be developed.

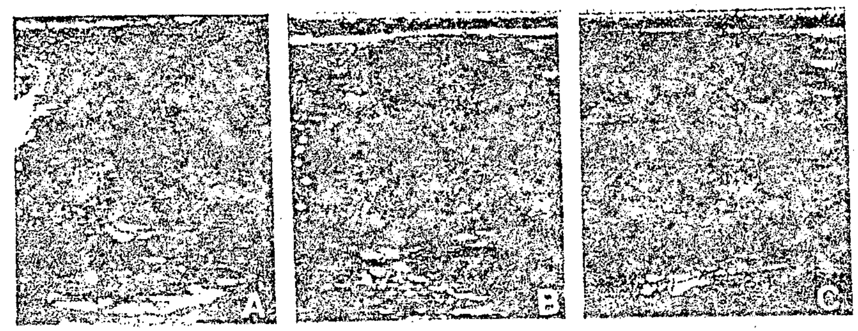

Figure 9. Ultrasound images of an equine follicle marked with an ultrasonic contrast agent. The ultrasonograms were taken immediately after injection of the microspheres (A) approximately 2 hours post-injection before (B) and after (C) ballottment. Backscatter from gelatin microspheres is the cause of the echogenic specks with the nonechogenic follicular fluid. Scale on the left is in centimeters. Images taken with the assistance of D.H. Townson.

DISADVANTAGES

Drawbacks to the use of transrectal ultrasonography in large animals must be carefully considered. Ultrasound scanners represent a substantial capital investment. The price range of scanners currently in veterinary use in the United States is $8,000 to $35,000. The transducers may be easily damaged and the cost of replacement transducers ranges from $2,800 to $8,500. With heavy use, transducers may wear out or loose resolution to the point where replacement is required. In our laboratory, transducers usually require replacement or major repair every year. Current veterinary ultrasound scanners are frequently light and portable. This represents a trade-off with durability. The service and reliability record of individual companies or distributors needs to be examined. Ultrasound scanners may require service which necessitates return of the instrument to the distributor. Excessive delays in the repair of a unit can be disastrous to research or clinical programs.

SUMMARY

Diagnostic ultrasonography is a powerful tool for evaluating the reproductive tracts in horses and cattle. The technology should be considered for use in the embryo transfer industry. Ultrasound imaging technology provides rapid, non-invasive access to the internal reproductive organs. Dynamic structures may be visualized in the living animal --- structures that were previously detectable only in the static state at necropsy or surgical removal. The potential for assessing reproductive structures in the same animals over time has afforded an unprecedented depth to investigations of the dynamic changes in biological structures (e.g., changes in the ovarian follicular population during the estrous cycle and early pregnancy, the process of ovulation, luteal dynamics, and the interactions between the conceptus and uterus). Ultrasound technology is expensive and requires a thorough working knowledge of anatomy and acoustic principles for maximal utilization. The potential, however, is great for future discoveries in both basic and clinical research. We believe that the best is yet to come as basic research utilizing ultrasonography evolves and ultrasonic imaging continues to be incorporated into clinical and research programs.

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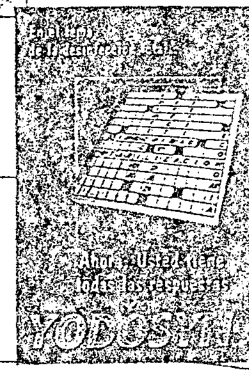


Claudia Jiménez E.

PEER-REVIEWED

Using ultrasonography to determine bovine fetal sex

This experienced ultrasonographer relates why you, too, should learn to determine bovine fetal sex — and how you can get started.

BRAD K. STROUD, DVM
Stroud Veterinary Embryo Services, Inc.
6601 Granbury Highway
Weatherford, Texas 76087

DETERMINING A FETUS' sex during the first trimester of pregnancy is an economically valuable marketing and management tool for today's purebred- and commercial-cattle producers. Considering the speed and accuracy of the technique as done by experienced veterinary ultrasonographers and the economic difference between male and female offspring, fetal sexing is an important element of animal husbandry in markets where the service is available. The limiting factor preventing its widespread application appears to be the lack of veterinarians experienced in the procedure.

Consignments of pregnant and sexed females to purebred beef and dairy cattle sales are beginning to appear in sale catalogs. Cows and heifers carrying female fetuses are bringing considerable bonuses as compared with unsexed contemporaries. Embryo collection can be divided in a more equitable manner with a partner when the resulting pregnancies can be sexed at 60 days. Donor cow collection management is facilitated by sexing the resulting bred recipients so that a determination can be made of whether to flush the cow again. For example, if three or more female fetuses are produced in a particular collection, the breeder may elect to change the sire selection for the next collection or will breed the donor for a natural calf, thus reducing the embryo transfer budget for the year. Also, in times of drought or culling, the older bred females carrying the least-desired sexed fetuses can be tagged for shipping.

Bovine fetal sexing by ultrasonography was first described in 1986.[1] Several investigators have since reported clinical success rates of greater than 90 percent using this technology.[2-4] My own clinical records, from 1989 to the present, reflect a greater than 97% accuracy rate, with most of the misdiagnoses occurring during the first few years of application. In the last two years, I've performed more than 1,500 examinations and made only one reported misdiagnosis.

Selecting the right equipment

Several veterinary ultrasound companies provide high-quality ultrasound units suitable for fetal sexing. Before purchasing or leasing an ultrasound unit for your practice, there are some important points to consider:

- Will the unit be used for applications other than bovine fetal sexing? Since ultrasonography can be used for other species, you may require versatility.
- Will the unit be used primarily

in the clinic or transported to the farm? If your practice is totally mobile, consider a smaller portable unit for fetal sexing and reproductive work.

- Does the company have fast, fair, and effective support service on units being repaired? Ask colleagues in your area about their experiences. If their units have never been repaired, that is a good recommendation.
- Does the sales representative thoroughly train buyers how to effectively use the unit? I have had several calls from veterinarians who could not see a fetal genital tubercle (sex bud) only because the unit's technical settings were incorrect.

Veterinary ultrasound units are equipped with either a 5- or 7.5-MHz transducer, or both are built into the same unit. I recommend the 5-MHz linear rectal transducer for most bovine reproduction applications. The 5-MHz setting is best for determining fetal sex and age and for diagnosing early pregnancy, multiple pregnancies, abnormal uterine intraluminal contents, and cystic ovaries. Though the 7.5-MHz transducer better suits the study of the follicular dynamics of the ovary, the 5-MHz will suffice in most clinical situations.

How to get proper training

There are two phases in learning to perform fetal sexing procedures using ultrasonography in cattle. Phase I is understanding fetal ultrasonographic anatomy and knowing how to differentiate a fetal sex bud from surrounding structures. Phase II is producing the necessary images on the monitor so that an accurate diagnosis can be made. I strongly suggest that Phase I be learned first, or you may wish to sell your unit forthwith.

One way to obtain training is to attend an ultrasonography wet lab, and another is to learn at home. There are advantages and disadvantages to both. Attending a hands-on ultrasonography wet lab can be expensive and can take several days away from your practice, which adds more expense. The advantage of a wet lab is that you work with an experienced ultrasonographer on pregnant commercial-grade cows preselected in the 60- to 90-day range. However, if you don't quickly put to practice what you learned, it could be a wasted effort. Do not expect to complete a bovine fetal sexing wet lab and immediately begin providing this service to your clients. Most veterinarians, even experienced palpators, will need to practice on at least 200 bred cows before achieving competency with fetal sexing procedures.

Learning at home requires resources such as video training tapes,[5-7] ultrasound equipment, and pregnant cows or heifers. Phase I can be learned at your convenience by studying video training tutorials. The beginning of Phase II is best accomplished by performing ultrasonography on five to 10 cows during one- to two-hour sessions (*vs.* on 40 to 50 cows for a half-day or longer). After about 10 short practice sessions, your confidence will grow. Expect the first few fetuses to take 10 minutes or longer to sex. A caudal epidural tail block using 5 ml of 2% ... can be used to ... relaxed rectum ... the local anest... be necessary.

Gaining speed and ensuring sa...

After becoming ... trasonographer, ... find fetal sexing ... procedure. The ... a 60- to 90-day fe... seconds. It takes ... male fetus (15 to ... female (40 to 50 ... is measured from ... the rectum until ...

Figure 1

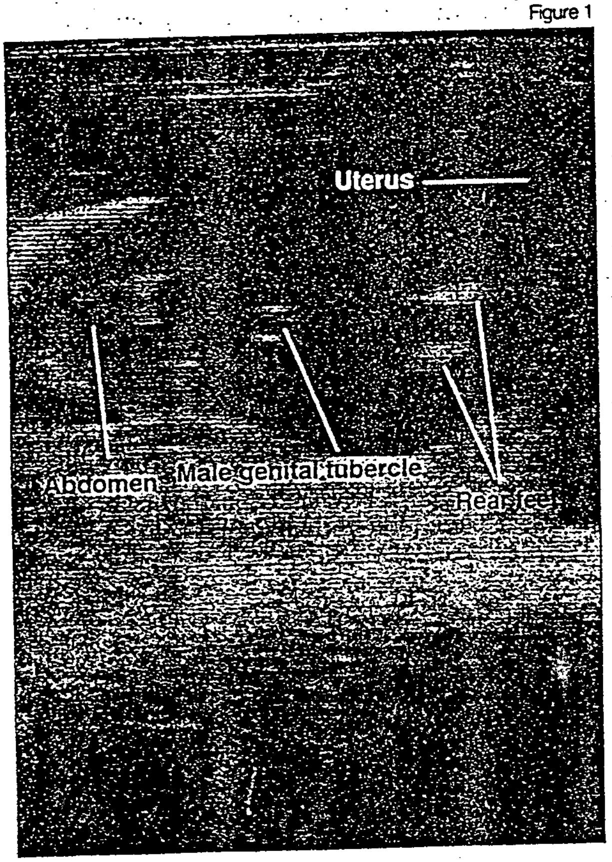
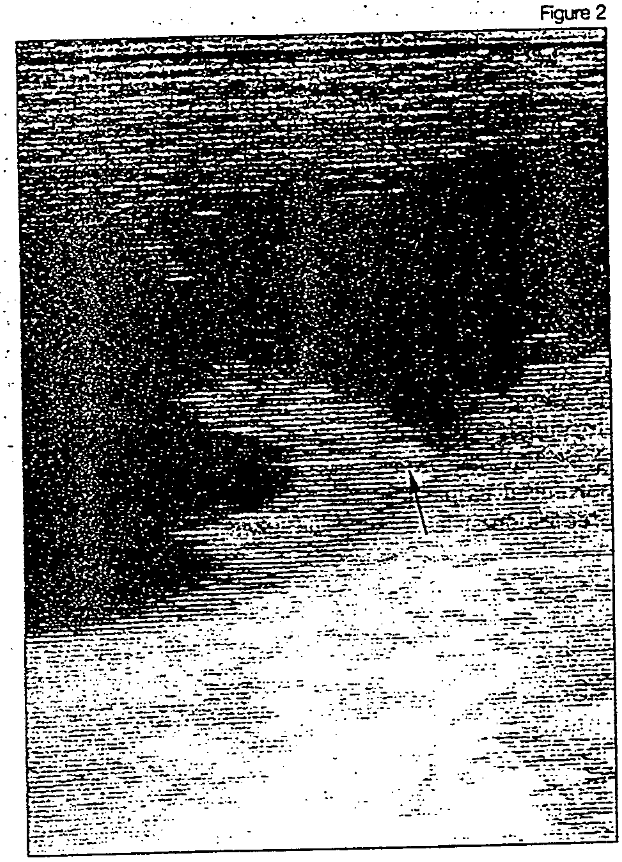


Figure 2



1. An ultrasonogram of a 70-day-old male fetus, cross-sectional view through the abdomen, just posterior to the umbilicus. The genital tubercle appears as a hyperechoic, oval, bilobed structure. 2. An ultrasonogram of a 75-day-old female fetus, cross-sectional view through the rear legs and perineum. The female genital tubercle appears as a hyperechoic, oval, bilobed structure (*arrow*).

Even with experience, occasionally an examination will take three to four minutes. This is usually because a fetus is at an odd angle, requiring the uterus to be physically repositioned by the ultrasonographer. With good facilities, good help, and reasonably docile cattle, 40 to 50 head can be sexed in an hour.

The safety of ultrasonic sound waves has been investigated, and ultrasonography has been found safe for both patients and users.[8] Practitioners must be careful not to overmanipulate the gravid uterus just to get a better view of the fetus. I know of one cow that I caused to abort early in my career as an ultrasonographer. It was a show heifer that had been fed a high-energy diet. The cow's pelvic cavity was fat, making retraction very difficult. Still, I refused to give up and eventually determined that the heifer was bearing a female fetus. Four days later, my client informed me that I was right on target. He had found a female fetus in the heifer's pen and promptly called to let me know how tickled he was that I had made the correct determination.

To get an acceptable view of a fetus so that the sex bud can clearly be seen, some retraction or manipulation must be employed. Obviously, gross overmanipulation could result

Figure 3

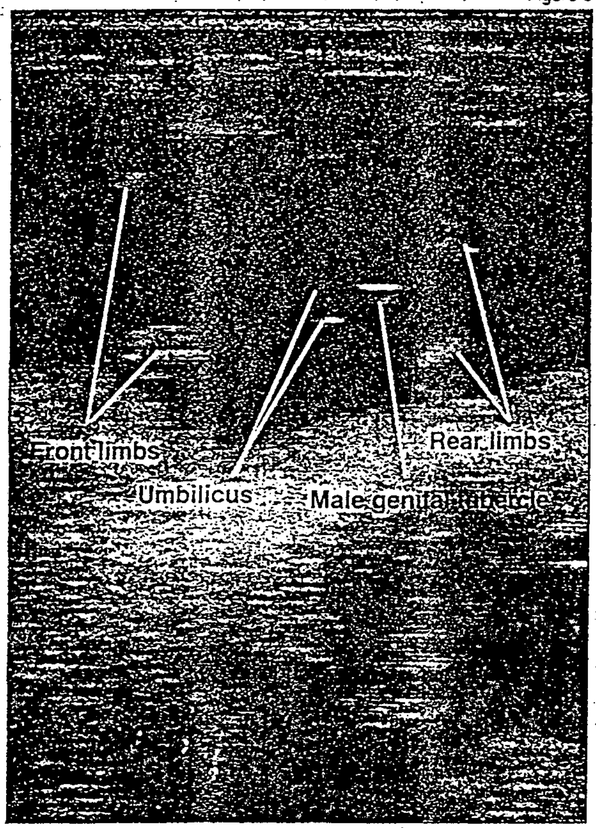
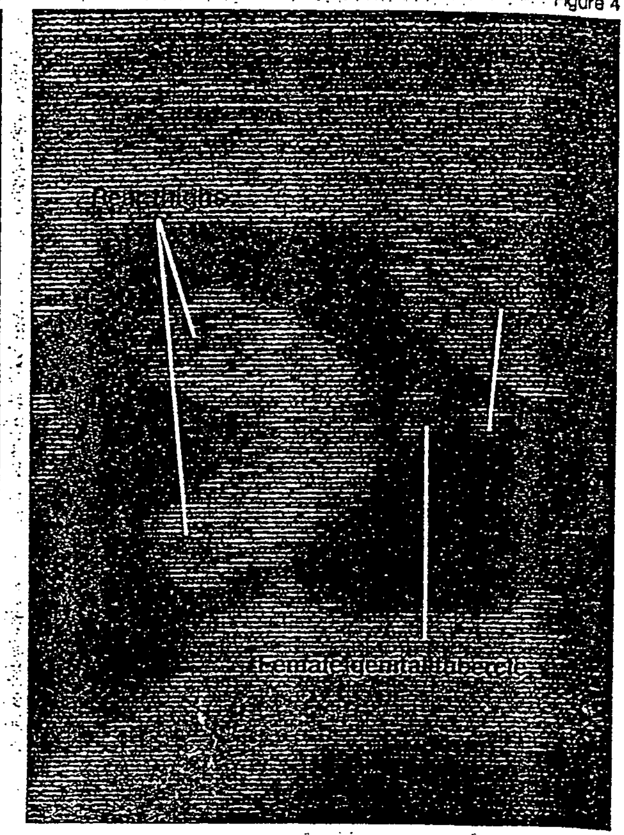


Figure 4



in an abortion, but bear in mind that a certain amount is often necessary. One of my favorite positions is to get the transducer under the gravid uterus, firmly press it against the fetus so that the fetus closely approximates the sound-producing surface of the transducer, and aim it dorsally toward the fetus. I have never found this routine retraction and pressing of the transducer against the fetus to lead to abortion. The fetus is amply protected by amniotic fluid and seems to have an inherent resiliency to withstand manual manipulation. Beware that a frustrated ultrasonographer should be careful not to sex every single patient. Some deep pregnancies can cause difficulty in getting proper positioning of the transducer. The ultrasonographer can be tempted to get a little too rough. Common sense must prevail. As a note of precaution, be very thorough and check for a beating heart during each exam. About two or three of every 100 exams reveal a dead fetus. The ultrasonographer will be blamed for causing the death if he or she fails to diagnose it at the time of the exam.

How ultrasonography works in sexing fetuses

The physics of ultrasonography have been described by previous in-

3. An ultrasonogram of a 65-day-old male fetus, frontal view. The bilobed genital tubercle is seen just caudal to the umbilicus.
4. An ultrasonogram of an 80-day-old female fetus, cross-sectional view through the perineum.

Figure 5

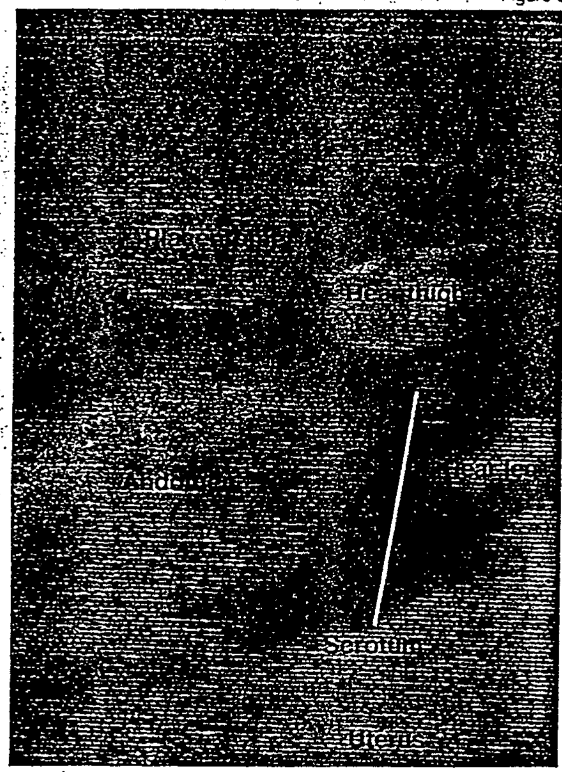
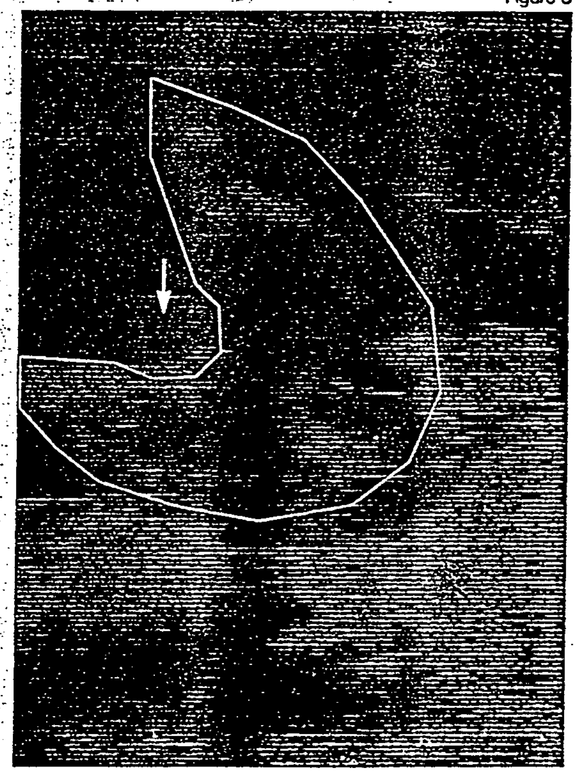


Figure 6



5. An ultrasonogram of an 80-day-old male fetus, frontal view. 6. An ultrasonogram of a 95-day-old male fetus, cross-sectional view of the scrotum (*arrow*) through the inguinal area. The rear thighs are also visible (*outlined area*).

vestigators,[8-10] but for practical purposes, an ultrasound image is similar to a moving radiograph. Ultra-high-frequency (inaudible) sound waves are electrically produced by a transducer, which is housed in the form of a rectal probe. When emitted sound waves hit dense tissue such as bone, they produce strong (high-amplitude) echoes that reflect back to a receiving crystal in the transducer. These strong echoes are electrically converted onto the monitor as white or bright objects. On the other end of the spectrum, when sound waves hit a fluid interface, they pass through the fluid, producing no echo or a very weak echo. Consequently, nonechogenic structures such as fluid appear black on the monitor. Between the spectrum of bone (white) and fluid (black) is soft tissue, which is reflected as various shades of gray on the monitor.

Fortunately for bovine ultrasonographers, fetal reproductive tissues such as the genital tubercles, scrotum, and teats all have specific tissue densities that reflect sound waves at amplitudes different from those reflected by immediately surrounding tissues. Knowledge of this fact along with an understanding of the specific locations of these structures allows practitioners to determine fetal sex.

The ideal time for sexing

By Day 55 of pregnancy in cattle, the male and female fetal sex buds

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Claudia Jiménez E.

PEER-REVIEWED

Measuring the time needed to confirm fetal age in beef heifers using ultrasonographic examination

Ultrasonography is accurate in detecting abnormalities and determining pregnancy stage, but is it worth the extra time and expense? This study of 121 beef heifers is among the first to measure the time needed to confirm fetal age with ultrasonography.

JOHN C. GALLAND, PhD
Department of Clinical Sciences
College of Veterinary Medicine
LISA A. OFFENBACH, BS
Department of Agricultural Economics
College of Agriculture
MARK F. SPIRE, DVM, MS, Dipl. ACT
Department of Clinical Sciences
College of Veterinary Medicine
Kansas State University
Manhattan, Kansas 66506

FETAL AGE CAN BE CONFIRMED quickly in a cattle chute using transrectal ultrasonography, and the procedure may be economical if it helps the producer make earlier culling decisions. Accurate diagnosis of fetal age in beef cattle, particularly heifers, is useful in evaluating individual or herd reproductive problems. An accurate estimate of fetal age enables the veterinarian to better calculate the conception date and hence determine which cows were bred in each 20-day interval of the breeding season. Ideally, the producer would prefer to have all cows bred in the first 20 days to: 1) increase the age of calves at weaning; 2) increase weaning weights of the calves; 3) sort, vaccinate, deworm, and feed cattle in similar stages of reproduction; 4) better manage calving facilities;[1] 5) minimize the calving interval; 6) minimize labor costs of a protracted calving season; and 7) arrange the time of the calving season to coincide with forage and market conditions. In addition, cattle sold together that are uniform in size sell at a higher price.[2]

Precise estimates of conception dates help the producer make culling decisions based on dam and sire reproductive performance. The earlier this information is acquired, the earlier management strategies may be planned and implemented. Therefore, more accurate and earlier determination of the date of conception should be economically advantageous, but it may be costly in terms of capital investment and increased labor costs associated with the use of ultrasonography during cattle processing.

Transrectal ultrasonography permits accurate detection of pregnancy, the stage of pregnancy, and pregnancy abnormalities in cattle.[3-6] Transrectal ultrasonography is more accurate (97.7% accurate in pregnancies 26 to 33 days)[6] than transabdominal ultrasonography (less than 50% accurate at all stages)[7] and rectal palpations performed before 35 days.[5] Rectal palpation is considered virtually absolute after 35 days of gestation if performed by an experienced palpator.[5] Transrectal ultrasonography is possibly a safer method of pregnancy diagnosis than rectal palpation because there is little uterine manipulation or trauma to the amniotic vesicle.[5]

Ultrasonographic images can be recorded on videotape and additional information about the heifer — such as identification number, body condition score, body weight, and pelvic measurements — can be superimposed on the image using a keyboard or microphone. Videotaping the image of the fetus enables the veterinarian to later make precise measurements of the fetal head, body, or amnion, all of which are consistent estimators of gestational age.[3,9]

Using ultrasonography to determine pregnancy may lengthen the examination time at processing, thereby increasing labor and veterinary costs and increasing the potential for physical injury to the animal. Although the sensitivity (97.7%, Days 26 to 33) and specificity (87.8%, Days 26 to 33) of detecting pregnancy with transrectal ultrasonography have been established for cattle,[3] the speed of the procedure has not been documented.

The purposes of the study we report here were 1) to determine the time required to confirm fetal age with ultrasonography; and 2) to evaluate the effect of breed, size of the pelvic area, body condition score, reproductive tract score, fetal age, and processing order on the time required to perform ultrasonography. Ideally, those six independent variables would have no influence on time, and ultrasonography could be used identically for any combination of conditions. As implied by other authors,[9] though, we expected overconditioned heifers and heifers with larger pelvic areas to require more time for ultrasonography because the fetus would be harder to locate. No pregnancies less than 33 days were studied, so we can only speculate that more time may be necessary to detect pregnancies less than 33 days. However, ultrasonography may be more accurate than rectal palpation in detecting pregnancies less than 33 days and in determining the fetus' age.

Materials and methods

For this study, 31 Hereford-Angus crossbred heifers and 90 Gelbvieh-Angus crossbred heifers from a commercial cow/calf ranch in northeastern Kansas were examined using a real-time ultrasonic scanner with a 5-MHz linear array rectal transducer (Aloka® 500V — Corometrics Medical Systems, Wallingford, Conn.). The scanner and transducer were purchased for about $16,000 in June 1990. Additional components used were a videotape recorder and videotape. A 2.5- x 18-in. schedule 40 PVC pipe, capped on the bottom, was mounted with hose clamps to the processing chute and filled with an obstetric lubricant to house the transducer between uses. A hook was mounted to the frame of the chute to prevent the transducer cord from becoming tangled or damaged.

Pelvic areas were measured using a pelvimeter (Rice® pelvimeter — Lane Manufacturing, Denver, Colo.), and reproductive tract scores[10] were assigned on Jan. 23, 1991, four months before the breeding season began. Reproductive tract scores were assigned using a scale from 1 to 5 (1 = immature [<20 mm diameter] and 5 = good tone [>30 mm diameter]).

The heifers were brought in from pasture for processing on Aug. 30, 1991, at the end of the 108-day breeding season. The weather was rainy, but this did not affect processing because the chute was sheltered. The cattle were wet, but not muddy. Lightening caused short power outages during processing but did not affect the ultrasound equipment. A surge protector or uninterruptable power supply might be beneficial to protect the equipment from power surges or outages. Heifers were bred by bulls in pastures, so the exact conception date for each heifer was unknown. Processing included pregnancy diagnosis, preventive treatment for internal and external parasites, vaccination with a *Campylobacter fetus* and five-way *Leptospira* bacterin (Stay-Bred VL5™ — SmithKline Beecham), and assignment of body condition scores.[11] Body condition scores were assigned using a rating system of 1 through 9 (1 = very thin, and 9 = very fat). Although the pelvic area and reproductive tract scores were determined seven months before determining ultrasonographic examination time, body condition scores, and fetal age, we did not expect the temporal difference to affect our results because pelvic area grows linearly in heifers of this age[12,13] and, to be meaningful, reproductive tract scores must be assigned before breeding.[10]

Before ultrasonographic examination, rectal palpation was performed to determine if the heifers were pregnant and, if so, in which uterine horn. During rectal palpation, the operator used a combination of uterine fluid content, placentome size, head size, body length, and uterine horn diameter to estimate the fetal age in five-day increments for gestations less than 100 days. For gestations between 100 and 108 days, the examiner was able to estimate fetal age within two to three days. The health risk to the heifer and fetus of entering the rectum twice, once to determine the gravid horn by rectal palpation and once to confirm fetal age with the ultrasound transducer, was minimal. On many other occasions, the examiner has had students palpate immediately after him without apparent ill effects to the fetus or heifer. The procedure we used was considered quicker than entering the rectum once using the transducer to locate the fetus.

TABLE 1

The Effect of Heifer Characteristics on the Time Used to Confirm Fetal Age by Ultrasonography

Variable	Regression Coefficient	P Value
Pelvic area	0.0734	0.0827
Fetal age	-0.1636*	0.0033
Processing order	0.3046*	0.0004
(Processing order)^2	-0.0024*	0.0002

*Significant at the 95% confidence level.

A stopwatch was used to measure how long it took to diagnose a pregnancy by palpation and the additional time it took to confirm the fetal age with ultrasonography. The stopwatch was started when the rear door of the chute was opened and the examiner stepped behind the heifer. Elapsed times were recorded when the examiner announced the pregnancy status of the cow by rectal palpation and when the fetal age was estimated ultrasonographically and announced. The additional processing time for confirmation by ultrasonography was the difference between these two times, in seconds.

Fetal age was estimated ultrasonographically by viewing the chute-side monitor for one or more of the following conformation criteria: head size, body length, size of feet, and length of extremities. The examiner determined the fetus' age by mentally comparing the conformation criteria with ultrasonograms of fetuses of known ages. All examinations, including the chute-side ultrasonographic examinations, were performed by one examiner.

All data were entered into a SAS® file[14] and statistically analyzed using the univariate procedure to describe the data set, and the SAS regression procedure to determine the effect of heifer characteristics on the time required for ultrasonography. Ultrasonography times greater than two standard deviations above or below the mean were considered statistical outliers. The analyses were done both with and without the outliers to see if excluding or including them altered our findings. They did not.

Stepwise multiple regression was the statistical technique used to as-

TABLE 2
Descriptive Statistics of Pelvic and Body Condition Measures and Fetal Age for 121 Beef Heifers

Characteristic	Mean	Standard Deviation	Minimum	Maximum
Pelvic area (cm^2)	224.53	17.87	181.25	268.25
Pelvic width (cm)	13.37	0.56	12.0	14.5
Pelvic height (cm)	16.77	0.81	14.5	18.5
Body condition score	6.3	0.86	5.0	8.0
Fetal age (days)	89.0	25.71	45	108

sess the impact of breed, body condition score, pelvic area, reproductive tract score, fetal age, and processing order on the time needed to confirm fetal age ultrasonographically. The stepwise and stepwise-backward regression procedures were used to help identify which variables were significant. All pairwise correlations between variables were computed to identify possible interactions that should be included in the model. Processing order and ultrasonography time were plotted, and a second-degree polynomial regression equation was fitted to the data (*Figure 1*).

The results

The total time to process 121 heifers was two hours and 16 minutes, or 67.4 seconds per heifer. The average time used to determine pregnancy status and fetal age by rectal palpation was 11.3 seconds (with a standard deviation of 4.35 seconds). The average time used to confirm fetal age with ultrasonography was 16.1 seconds (with a standard deviation of 6.82 seconds). Seven outliers more than two standard deviations from the mean were excluded after they were determined to be data measurement or recording errors. The most common ultrasonography time was 9 seconds (*Figure 2*). The frequency distribution of ultrasonography time was skewed to the right (*Figure 2*). The fastest ultrasonographic confirmation time was 4 seconds, and the longest was 79 seconds. For a total of 121 heifers, the additional processing time used to confirm fetal age with ultrasonography was 37 minutes, 43 seconds (24% of the total processing time).

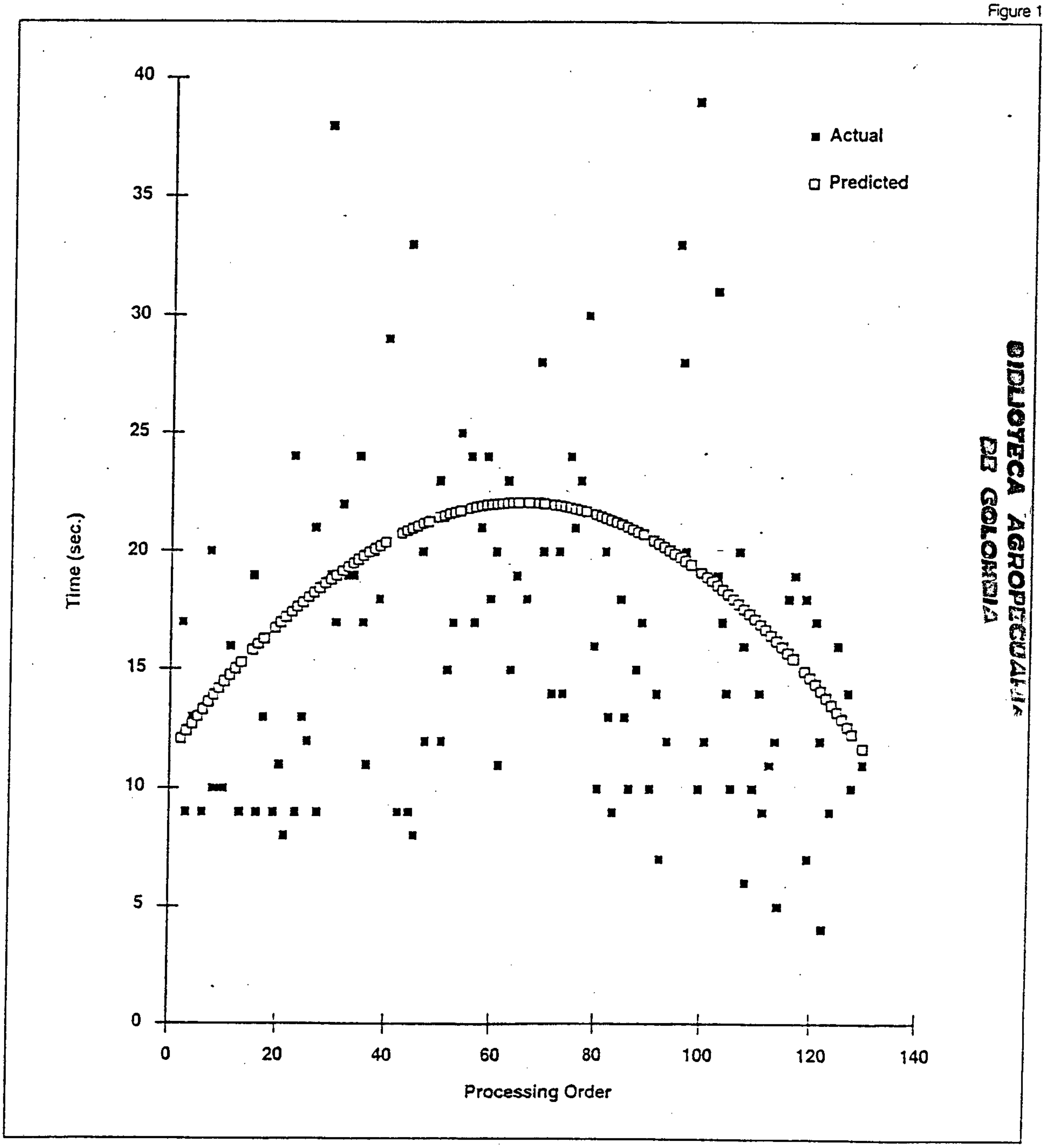
The parameter estimates determined by the regression analysis (*Table 1*) indicated the direction and magnitude of each heifer characteristic (*Table 2*) on the time used to confirm fetal age with ultrasonography. The combination of heifer characteristics explained 21% of the variation observed in time used. Fetal age affected examination time ($p = 0.0033$) because less time was required to determine the age of older fetuses in cattle 40 to 108 days pregnant. However, this relationship may be nonlinear since less time was required to confirm fetal age in gestations between 46 and 60 days and in gestations more than 100 days (*Figure 3*). The effect of pelvic area on examination time was not significant ($p = 0.0827$). And body condition score, reproductive tract score, and breed did not influence processing time. The effect of processing order on ultrasonography time was nonlinear and significant ($p = 0.0004$). When the time used to confirm fetal age was plotted in the order that the heifers were examined, a slight trend of longer times toward the middle and shorter times toward the end of processing was noticed.

Use of ultrasonography did not reverse the pregnancy diagnosis made by rectal palpation for any of the heifers examined. No hemorrhage or rectal tears were observed. In 30 of the 121 heifers that were diagnosed as pregnant, the palpator changed the estimate of fetal age based on the chute-side ultrasonograhic images. However, estimates were not changed by more than five days. Further comparisons of the accuracy between rectal palpation and ultrasonographic examination could not be made because we were not comparing pregnancy determination in two separate heifer groups, one determined by ultrasonographic examination alone and the other by rectal palpation alone.

Is ultrasonography worth it?

Ultrasonography added less than 40 minutes to the total processing time of 121 heifers, but may have contributed to operator fatigue. The av-

Figure 1



1. When the time used to confirm fetal age with ultrasonography for 121 crossbred beef heifers was plotted against the order that the heifers were processed, a slight trend of longer times toward the middle and shorter times toward the end of processing was noticed.

Figure 2

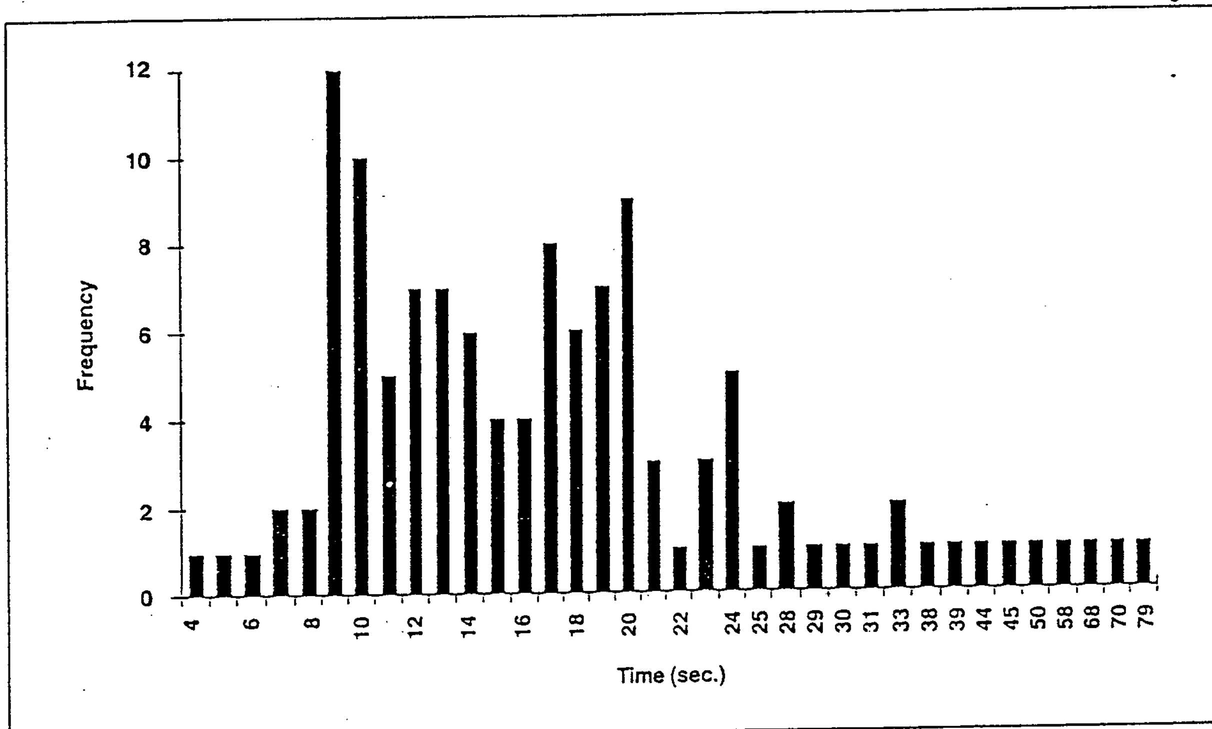
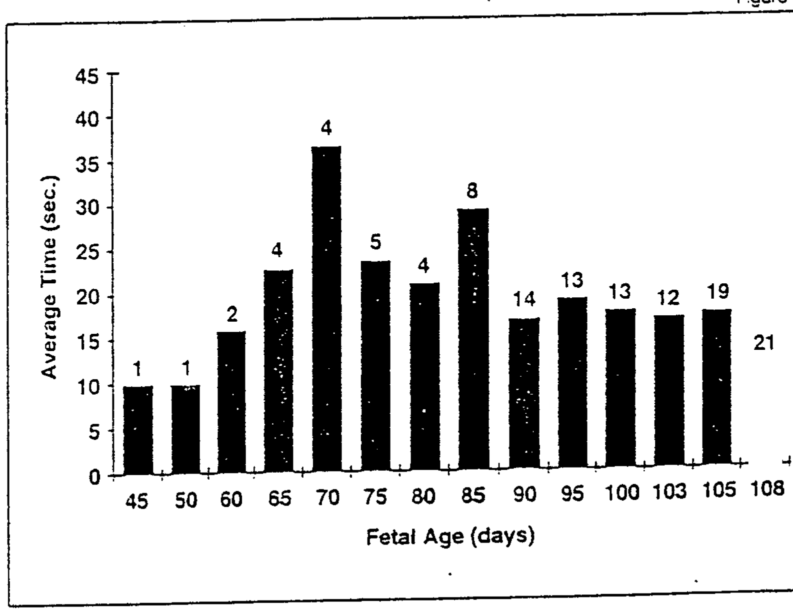


Figure 3



2. The frequency distribution of ultrasonographic examination times. The most common examination time was 9 seconds. The fastest confirmation time was 4 seconds, and the longest was 79 seconds.

3. The average ultrasonographic examination time for each fetal age. (The number above each bar is the sample size.) Less time was required to determine the age of older fetuses in cattle 40 to 108 days pregnant. However, this relationship may be nonlinear since less time was required to confirm fetal age in gestations between 46 and 60 days and in gestations more than 100 days.

erage diagnosis time increased toward the middle of the experiment and then decreased, perhaps because the operator knew he was nearing the conclusion of processing. Increased skillfulness was not considered responsible for the shorter times toward the end of the experiment because the operator was already experienced with ultrasonography. The time used to confirm fetal age (16.1 seconds) ultrasonographically was about one and a half times longer than the time used to detect the horn of pregnancy and estimate the fetal age by rectal palpation (11.3 seconds). The examiner may have spent less time performing the rectal palpation examination than normal, knowing the ultrasonogram would be available to confirm the fetal age and identify reproductive tract or fetal abnormalities. Although knowledge of timing could have affected performance, the operator also considered client interest, and he placed accuracy above speed.

Fetal age was the only characteristic among these heifers that had a significant impact on the diagnosis time. Because the 108-day fetus is larger and has more definable characteristics, fetal age probably was determined faster than with a younger fetus. Ultrasonography time in gestations between 45 and 60 days may be faster because the characteristics of a 45- to 60-day fetus are not changing as rapidly as between Days 60 and 100 of gestation.

The sign of the regression coefficients suggests that as a heifer's pelvic area increases it may be more difficult to locate the fetus, hence more time may be required for ultrasonography. Further research is needed to confirm this hypothesis. Another possible explanation for the slight effect of pelvic area is that pelvic area is probably correlated with ligature, uterine size, and the location of the gravid horn, which were not measured but which might affect ultrasonographic examination time.

Perhaps some of the most useful findings were that the breed, reproductive tract score, or body condition score of the heifers did not affect the processing time with ultrasonography.

Videotaping the image of the fetus allows more accurate measurements to be made after processing, measurements that might be used for research, for additional feedback to producers, and for medicolegal reasons. Of course, it would take more time if the recorded images were later used to make confirming measurements.

Transrectal ultrasonography may be useful in determining fetal age and conception dates more precisely. Ultrasonography may improve estimates of fetal age about 25% of the time, but by no more than five days. Fetal attrition caused by vigorous palpation also may be reduced by transrectal ultrasonography. This study has shown that ultrasonography can be done quickly, but it did not show that ultrasonography is more accurate or safer than an experienced palpator. The combined methods of pregnancy diagnosis made up only about 40% of the total processing time. This emphasizes that the major time cost in pregnancy diagnosis is related more to catching animals and moving them through the chute than to conducting the diag-

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nostic procedures. Subsequent studies could be improved by having several examiners determine fetal age in independent examinations. Further studies that compare rectal palpation with ultrasonography in the accuracy, safety, and time needed to detect and stage the pregnancy might also be useful. In addition, research on the ability to detect pregnancies earlier (<45 days) would be useful. The benefit of using ultrasonography before 45 days is that culling decisions can be made earlier.

After the initial investment for an ultrasound scanner, training, and a videotape recorder, the cost of performing ultrasonography is minimal. Ultrasonographic confirmation of fetal age and imaging of the fetus can be done quickly at chute-side. When deciding whether to use ultrasonography over palpation in their practice, practitioners must weigh the equipment costs and the extra time required against the value of the extra information. The decision will differ among practitioners, depending on the value of their time and their ability to use ultrasonographic equipment quickly and accurately.

ACKNOWLEDGMENTS

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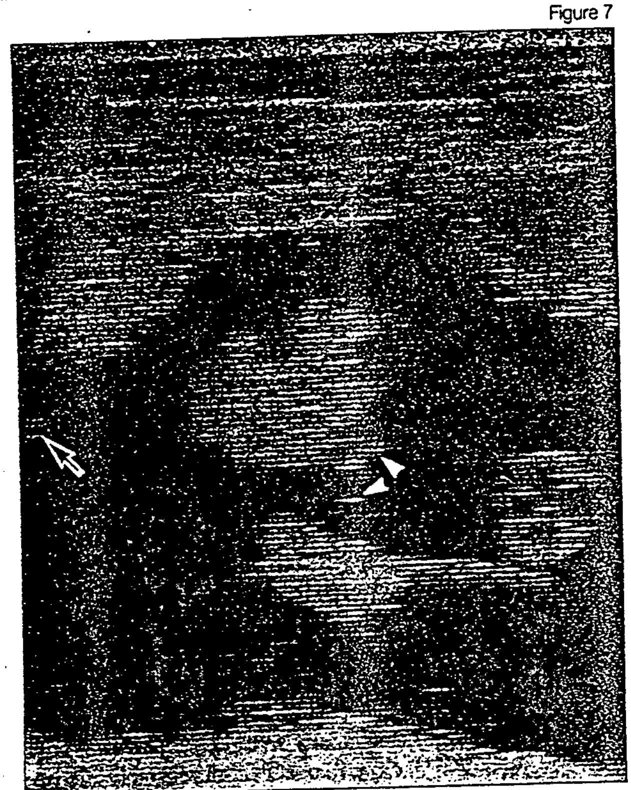
have migrated from the inguinal area to their postpartum locations, just caudal to the umbilicus in the male and to the perineum in the female.[11] Both male and female sex buds are highly echogenic, appearing as bright white objects on the monitor. In addition, both male and female buds ultrasonically appear bilobed, with each lobe having an elongated oval-shaped appearance *(Figures 1 & 2)*.

The transducer or probe should be as close to the genital tubercle as possible (2 to 5 cm) so that a high-resolution image is produced on the monitor. Some fetuses can be sex-tested accurately at 120 days of pregnancy if the transducer can be manipulated close enough to the genital tubercle. In some cases at 90 to 120 days of gestation, the fetus is so deep in the abdominal cavity that it is nearly impossible for the ultrasonographer to reach. I recommend doing fetal sexing between 60 and 90 days gestation. Even when narrowing the range to this time period, some fetuses cannot be successfully sexed. A narrow rectum, an overfat pelvic cavity, or a pneumorectum in the dam are some of the physical limitations that prevent a determination being made. I estimate that one in every 40 to 50 pregnant cows presented for fetal sexing cannot be sexed accurately for the above reasons.

My favorite time for fetal sexing is between 60 and 70 days of gestation. At this time, the fetus can be viewed in its entirety, which makes orientation relatively easy. At 90 days, only parts of the fetus can be viewed at one time. The fetus may present in a frontal, lateral, or cross-sectional position or any oblique variation thereof. Take the view in which the fetus presents; do not try to move the fetus to a different position unless absolutely necessary. It is often difficult to manipulate the gravid uterus, and it adds time to the exam.

Figure 7



7. An ultrasonogram of an 80-day-old female fetus, frontal view. The tail (*outlined arrow*), teats (*arrowheads*), and umbilicus (*black arrow*) are evident.

The steps in the examination

Find the genital tubercle

Take a systematic approach to the exam. Find the head first, then the beating heart, then the umbilicus. Once the umbilicus has been found, slowly and deliberately examine the area just caudal to its abdominal attachment. If the bilobed male genital tubercle is discovered, the exam is finished (*Figure 3*). If no male genital tubercle is discovered, the exam should continue to the perineum in search of the female genital tubercle (*Figure 4*).

Generally, the perineum is more difficult to bring into focus and requires more time. Proceed slowly when approaching the perineum so that the female genital tubercle is not overlooked. It is imperative that the specific genital tubercle is visualized before you declare the sex of the fetus. Do not decide the fetus is female based solely on the absence of a male genital tubercle. A hasty examination of the umbilical area can easily cause the ultrasonographer to overlook the male genital tubercle. The position of the fetus may make the male genital tubercle difficult to see. A slight adjustment of the transducer or fetus sometimes makes an apparently invisible male genital tubercle stand out.

Visualize the secondary sex organs

The scrotum and teats are observable once the fetus is about 75 to 80 days of age (*Figure 5*). From an ultrasonographer's perspective, the scrotum is fully developed at 90 days and is most easily seen on a cross-sectional view between the hind legs of the fetus (*Figure 6*). The mammary tissue likewise can be seen in the same area in the female and appears as a broad area of gray tissue with four bright hyperechogenic teats protruding from it (*Figure 7*). Though the teats are more prominent on a female, they can be seen on a male fetus just anterior to the scrotum. Even though secondary sex organs are relatively easy to observe after 80 days, in my opinion the specific sex tubercle must be observed before a fetus' sex is declared.

Conclusion

Ultrasonographic fetal sexing is a safe, fast, reliable, and profitable procedure. I highly recommend ultrasonographic fetal sexing for progressive bovine practitioners. It is still a new discipline and offers the opportunity for a practitioner to specialize. Ultrasound pregnancy diagnosis may be superior to first-trimester palpation. Ultrasonographers can provide accurate diagnoses that rectal palpation may not provide (*e.g.* a dead fetus).

The marketing and management options of ultrasonography are worth the expense. But before making the capital investment in an ultrasound unit, first decide if the learning curve will fit your schedule and whether your clients want the service. Ultrasonographic fetal sexing has been the most pleasant experience of my practice career in recent years. The images of a fetus moving on the monitor are a remarkable spectacle to the cow owner. In this economically driven world of production agriculture, it's nice to see a genuine smile come over a client's face as he or she observes a fetus' beating heart. And once producers have experienced this service, they become, almost without exception, repeat clients.

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Claudia Jiménez E

Continuing Education Article #7

Clinical Applications of Bovine Reproductive Ultrasonography

Stroud Veterinary Embryo Services, Inc.
Weatherford, Texas
Brad K. Stroud, DVM

KEY FACTS

- When a diagnosis of fetal gender is made, it is imperative that the respective male or female genital tubercle is seen clearly and distinctly.
- Ultrasonographers must have a thorough understanding of ultrasonographic fetal anatomy and develop the skills necessary to produce fetal images that are positioned and focused well enough to diagnose gender.
- The ability to definitively diagnose pregnancy on or before the 27th day of gestation can be important, especially in intensive breeding programs; the ability to diagnose an exposed cow as open for immediate resynchronization and rebreeding is probably even more important.
- With the help of real-time ultrasonography, individuals with minimal experience in rectal palpation can learn skills quickly while simultaneously providing an accurate diagnosis to clients.

The economics of food animal production is the driving force behind advancing technology in the field. Producers of food animals use advanced veterinary technology routinely only if it is profitable. After several years of experience using real-time ultrasonography in bovine reproductive practice and having discovered how to use the technique effectively on a clinical basis, clients are demanding it as routine husbandry.

The physics of real-time ultrasonography have been described in elaborate detail by previous investigators,[1-3] but for the purpose of this article, a brief overview should suffice. A transducer, or probe, has an array of crystals that, when electrically stimulated, produce high-frequency sound waves in a linear, convex linear, or sector (pie-shaped) direction. For bovine reproductive applications, a linear-array transducer is used transrectally in order to facilitate proximity (one to three inches) to the target object. A highly resolved and focused image is thus produced. A linear transducer transmits ultrahigh frequency (inaudible) sound waves along a three- to four-inch axis. The width of the ultrasound waves is approximately one millimeter; therefore, any image projected on the monitor would be comparable to viewing the same structure at necropsy that is opened by a knife in either cross, longitudinal, or oblique sections.

The transmitted sound waves travel through body tissue in a direction determined by the angle of the transducer until they reach a dense tissue reflector. Some of the sound is reflected and returns to receiving crystals in the transducer. The force of the returned waves compresses and expands the crystals which, in turn, produces a voltage that is amplified and converted into lifelike images on a high-resolution monitor.

Tissues have different densities that reflect sound at various amplitudes (strengths). For example, the echo produced from amniotic fluid would be weak or anechoic (black on the monitor), whereas the echo from fetal bone, a dense tissue, would be strong or highly echogenic (almost white on the monitor). Significant bovine intrapelvic reproductive tissue of the uterus

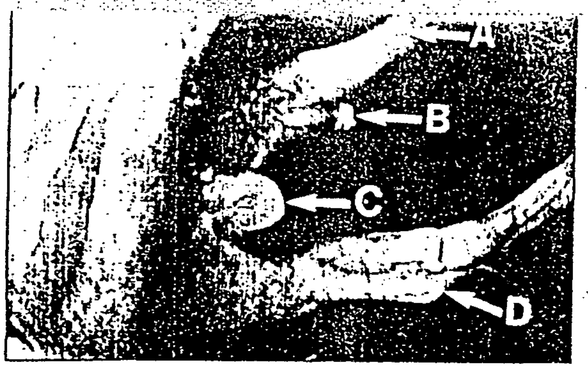

Figure 1A

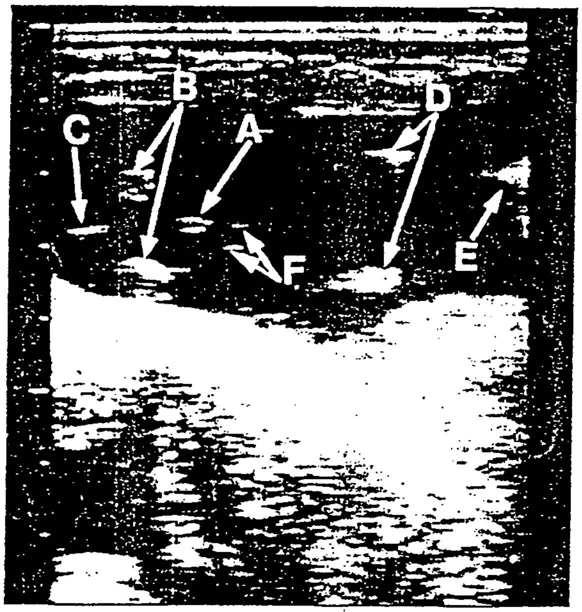

Figure 1B

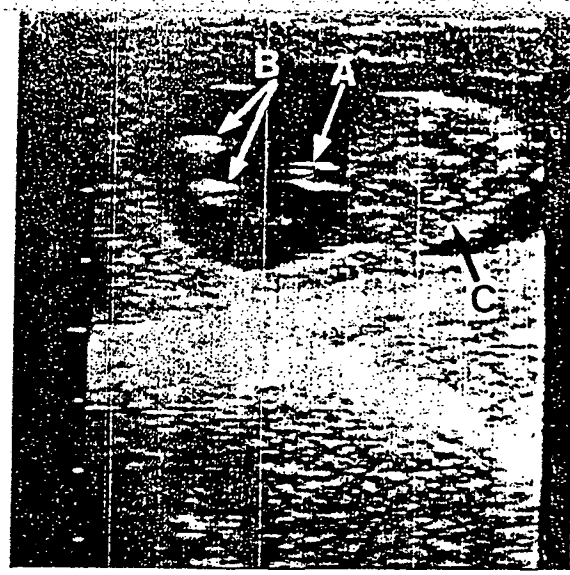

Figure 1C

Figure 1—(A) Ultrasonogram of a 75-day-old male fetus showing umbilicus and genital structures. *A* = umbilicus, *B* = male genital tubercle, *C* = scrotum, *D* = hock. (B) Frontal-view ultrasonogram of male fetus at 67 days of pregnancy. *A* = male genital tubercle, *B* = femur of rear legs, *C* = tail, *D* = front legs (humerus), *E* = head, *F* = lateral borders of umbilicus. (C) Cross-sectional ultrasonogram of a 67-day-old male fetus viewed through the abdomen immediately caudal to the umbilicus. *A* = male genital tubercle, *B* = rear feet, *C* = abdomen.

and ovary (follicular and luteal tissue) as well as various fetal organs have different densities and therefore reflect sound at various amplitudes. These densities are depicted as various shades of gray on the monitor. Most modern, linear ultrasound units produce 64 to 128 shades of gray that result in high-resolution images of clinically important tissues. The gray-scale image is refreshed with current data at the rate of 30 frames-per-second thus creating a *real-time* or moving image.[4] Figuratively, a real-time ultrasonogram is similar to a moving x-ray.

FETAL SEXING

Determining fetal gender is quickly becoming a requirement by purebred beef and dairy clients in cases of embryo transfer, artificial insemination, and natural service pregnant cows used for marketing purposes. Nearly all client feedback indicates at least a 10:1 payback ratio on the cost of ultrasonographic services; this ratio may reach 100:1. The high profit margin is probably caused by the newness of the technology, but the procedure should remain profitable even when the technology becomes commonplace in the veterinary community.

At approximately day 55 of gestation, male and female genital tubercles can be visualized on a high-resolution ultrasound monitor.[5] The fetal sex organs are composed of dense, highly echogenic tissue similar to skeletal structures and therefore are depicted as bright or white structures on the monitor. Male and female genital tubercles appear bilobed on the monitor; each lobe is in the shape of an oval, which aids in differentiation from surrounding structures.[6] The male genital tubercle is found just caudal to the umbilicus (Figure 1), whereas the female genital tubercle is located under the tail (Figure 2).

A systematic approach should be taken by the ultrasonographer when performing fetal sexing (see the box). There are three very important anatomic refer-

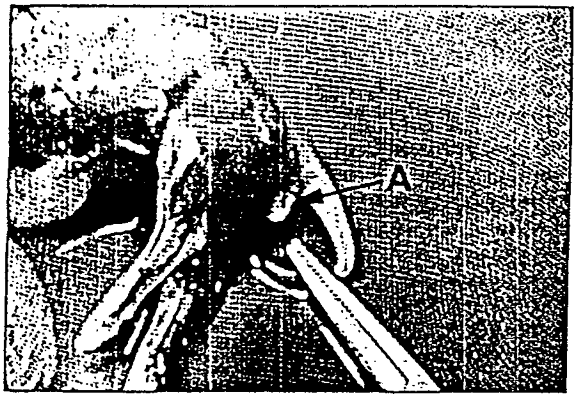

Figure 2A

Figure 2—(A) Lateral-view ultrasonogram of a 65-day-old female fetus. *A* = female genital tubercle. (B) Cross-sectional ultrasonogram of a 75-day-old female fetus through the perineum. *A* = bilobed female genital tubercle, *B* = tail, *C* = rear legs.

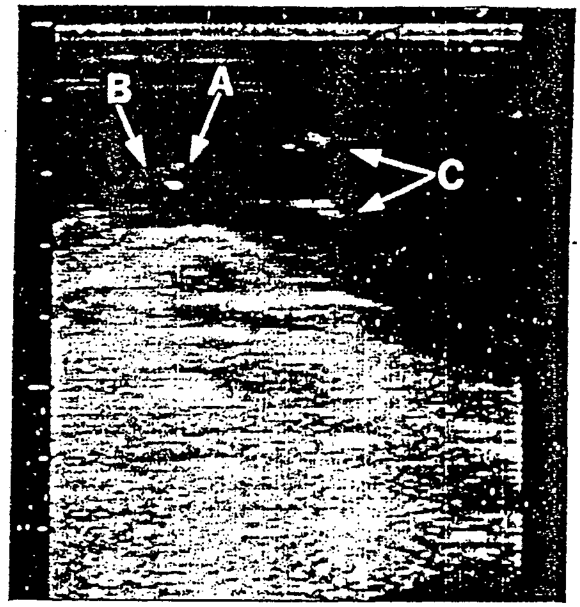

Figure 2B

ences on a fetal ultrasonogram that are critical in achieving proper orientation of the fetus: (1) the head, (2) the beating heart, and (3) the umbilicus. These structures are relatively easy to recognize on the monitor. It is sometimes difficult to differentiate the front legs from the rear legs; therefore, these structures have been excluded from the list of anatomic references. Once the fetus has been located on the monitor, the three anatomic references should be systematically examined to ensure cranial–caudal orientation.

The following three views can be used to observe a fetus during an ultrasonographic examination: a lateral view (which is rarely seen), a frontal view (which is common and the easiest for orientation), and a cross-sectional view (which is most often presented). Angled or oblique variations of these views are generally seen, but, for teaching purposes, all three views are discussed in principle.

During a cross-sectional examination of the fetus, the transducer is placed over the cranium and moved distally through the thorax to review the beating heart; no heartbeat indicates a dead fetus. The transducer is moved further distally to where the umbilicus attaches to the abdomen. At this time, the transducer should be moved slowly back and forth to diagnose the presence or absence of a male genital tubercle. In males, the genital tubercle is immediately caudal to the umbilicus, appears very bright or highly echogenic on the monitor, and is usually bilobed.

If a male genital tubercle is detected, the examination is complete. If a male genital tubercle is not observed, the transducer must be moved distally to the perineal area to detect the presence of a female genital tubercle. The perineal area is the most difficult region of the fetus to focus; therefore, patience is required. The ultrasonographer should move the transducer slowly and must establish the difference between a cross-sectional view of the tail and the female genital tubercle (Figure 2B). The female genital tubercle is generally bilobed or trilobed, whereas the tail is a monolobed structure. Frequently, the tail and female genital tubercle are seen simultaneously and the ultrasonographer should definitively distinguish one structure from the other.

When the fetus is in a frontal position, the head, thorax, abdomen, and inguinal area can be viewed. The transducer should be manipulated so that the umbilical attachment to the abdomen comes into focus. In males, immediately caudal to the umbilicus is the hyperechogenic male genital tubercle (Figure 1C). The frontal view is excellent for diagnosing gender because the perineal area can also be viewed; however, some finesse by the technician is required. The female genital tubercle is sometimes superimposed over the tail. If the transducer is tilted either to the left or right (creating a slightly oblique angle), the two structures can be effectively separated optically.

Lateral-view orientation is relatively easy to achieve but is not commonly used. From my experience, the female genital tubercle is somewhat difficult to visualize using this position. The male genital tubercle at 60 to 100 days and often the entire penis at a 90-day pregnancy examination is easily seen on a lateral-view ultrasonogram.

When a diagnosis of fetal gender is made, it is im-

Important Points to Fetal Sexing

- Fetal sexing is best done between 60 and 100 days of gestation. Sexing is easiest for orientation when done from 60 to 70 days. Sexing done later than the 100th day of gestation is difficult because the transducer cannot be placed into the abdomen.
- Sex is diagnosed based on the observation of the male or female genital tubercle.
- Because of positioning, the fetus may not be able to be sexed. If ultrasonographers are not 100% confident in determining the sex, a diagnosis should not be made.
- The transducer should be moved slowly.
- The sexing procedure approaches 100% accuracy under ideal conditions (i.e., a well-restrained animal, low ambient light, good equipment, and an experienced technician). A 97% accuracy rate is expected.
- The average time for sexing a male fetus by an experienced ultrasonographer is 45 seconds.[8]
- The average time for sexing a female fetus by an experienced ultrasonographer is 100 seconds.
- The gravid uterus must sometimes be manipulated per rectal palpation before an ultrasonographic examination is done so the transducer can be strategically placed close to the fetus.

perative that the respective male or female genital tubercle is seen clearly and distinctly. Diagnosing gender on the absence of the opposite genital tubercle is not advised. For example, it is usually faster to diagnose a male because the umbilicus is easy to find. By following the umbilicus to its site of attachment to the abdomen, the male genital tubercle can easily be seen. To diagnose a fetus as female based on the absence of a male genital tubercle without observing the perineal area and clearly seeing the female genital tubercle can be disastrous because of the erroneous information. At certain angles, the male genital tubercle may not be focused properly and can be overlooked.

A female fetus can be misdiagnosed as male when the tail is tucked between the hindlegs.[7] The tip of the tail can actually approach the umbilicus and create a hyperechogenic structure similar to a male tubercle on a cross-sectional view. Ultrasonographers must be patient and decisive in order to avoid misdiagnosis. With experience, making an accurate diagnosis should not be a problem.

At approximately 80 or 90 days of gestation, fetal sexing is enhanced by secondary anatomic structures. In males, the scrotum has developed and can easily be seen on a frontal view or a cranial–caudal cross-sectional view between the rear legs. In females, the teats are very distinct in the frontal and cranial–caudal views. Diagnosing sex based on the presence or absence of these structures is not advised; however, the scrotum and teats are helpful adjuncts to the genital tubercles when diagnosing sex.

Ultrasonographers must (1) have a thorough understanding of ultrasonographic fetal anatomy and (2) develop the skills necessary to produce fetal images that are positioned and focused well enough to diagnose the proper gender. As soon as these criteria are met, ultrasonographers will become proficient in determining fetal gender. A considerable amount of practice is needed in order to achieve a professional level of expertise in making a consistent and accurate diagnosis. Reaching that level can be quite frustrating, but, with patience, it can be done in a reasonable time frame.

DIAGNOSIS OF EARLY PREGNANCY

The ability to definitively diagnose pregnancy on or before the 27th day of gestation (day 0 = standing estrus), is important, especially in intensive breeding programs.[9] The ability to diagnose an exposed cow as open for immediate resynchronization and rebreeding is perhaps even more important. This can have a profound effect in decreasing the total number of open days in intensive embryo transfer and artificial insemination programs.

On an ultrasonogram, the lumen of an open bovine uterus should not normally contain nonechogenic (black) areas. Exceptions include cows in estrus,[10] anestrous cows with a very flaccid uterus, or cows with a pathologic condition.[11] The nonechogenic line of cows in estrus is usually visible along the entire length of the uterus. This black line represents the secretory fluids of the uterus that are in part responsible for transportation of sperm. Normal estrus fluid sometimes pools in the greater curvature of the uterus, giving the false impression of early pregnancy fluids. An examination of the ovaries during estrus would reveal a mature follicle on one ovary and no luteal tissue on either ovary. The uterine myometrium of a cow in estrus is toned by palpation and appears thickened on the ultrasound monitor as compared with that of a cow in diestrus or one in the early stages of pregnancy. A thorough history of the cow is imperative. The animal could be in standing estrus during the examination without any prior knowledge of its condition.

Some anestrous cows, especially those with a very flaccid uterus, pool small amounts of fluid in the uterine lumen. This is normal and seems to pose no clinical threat. A quick view of the ovaries of anestrous cows reveals no luteal tissue, which is unlike that of pregnant animals. Pathologic contents of the uterine lumen usually contain echogenic specks of free-floating exudate mixed with nonechogenic fluid. These fluids are unlike those produced by the conceptus, which are almost completely nonechogenic.[10] When a purulent exudate is in the uterus, it appears highly echogenic and can be overlooked (because it looks like normal uterine tissue) except for the fact that it moves freely in the uterine lumen.

In the early stages of pregnancy, the uterine lumen contains various amounts of nonechogenic fluids that are produced by the conceptus. The amount of fluid depends largely on the stage of the pregnancy as well as the relative size of the uterus. For example, primigravid heifers have been diagnosed as early as day 12 via an ultrasonographic examination.[12] Under field conditions, mature cows are not reliably examined until day 25.[13] I wait until day 27 to diagnose an animal as open and base the diagnosis solely on the absence of nonechogenic fetal fluid (Figure 3). The reason for waiting until day 27 to diagnose a cow as open is that some early developing embryos seem to produce smaller amounts of fluid than do other embryos. In addition, old and large cows, especially dairy breeds with large uteri, are sometimes more difficult to examine. At day 27, I will occasionally request a reexamination if only a small amount of fluid is detected.

Inexperienced ultrasonographers are recommended to wait until day 30 to diagnose a cow as open. By day 30, a large amount of fetal fluid can be detected and the fetal heart beats visibly.[14] A corpus luteum on the ipsilateral ovary helps to confirm early pregnancy if ultrasonographers are in doubt.

The gravid uterine horn in early stages of pregnancy should be examined in longitudinal and cross-sectional planes. In some cows, the uterine lumen tends to be somewhat flattened instead of round or oval. In flat lumens, a cross-sectional examination may not readily indicate pregnancy whereas a longitudinal examination would easily do so. Previous investigators recommend little if any manipulation of the reproductive tract for an ultrasonographic examination[15]; however, in some cows, prior manual retraction of the uterus per rectal palpation is very helpful. An ovary or uterine horn is often tucked under the broad ligament, and digital manipulation of the organ is required in order to gain access. This allows placement of the transducer over the surface of the organ and provides a thorough examination. All of our in-house recipients and artificially inseminated cows are tested for pregnancy at day 27 or 28 via ultrasonographic examination. Routine manipulation of uterine horns (while the transducer is concurrently held) is done to

Figure 3—Early-pregnancy ultrasonogram at 23 days. *A* = amniotic fluid, *B* = uterine horn.

ensure a thorough examination before a cow is diagnosed as open.

EARLY EMBRYONIC DEATH

For reasons pertaining to ultrasonography, the period of early embryonic death is defined as the first trimester of pregnancy. The reported incidence of early embryonic death varies depending on such factors as nutrition, enzootic disease, and other causes.[16-18] In the initial stages of early embryonic death, palpation is obviously inadequate to make an accurate diagnosis.[19] Such cows seem to be pregnant on rectal palpation based on ballottement of fetal fluids. With the use of real-time ultrasonography, however, an early diagnosis is possible.[14] An examination of the fetus as early as day 30 reveals the cessation of a heartbeat during cases of embryonic death. Separation of fetal membranes from the uterus as well as echogenic specks of dead tissue floating in the fetal fluids are also detectable in early embryonic death. In the latter stages of early embryonic death, the fetal image is distorted and sometimes invisible.

A diagnosis of embryonic death is usually made during fetal sexing or when a client prefers that an ultrasonographic examination (instead of palpation) be performed to pregnancy test a cow or heifer consigned to a purebred sale. A diagnosis of embryonic death made via an ultrasonographic examination saves not only dollars but potential ill feelings among the buyer, seller, and veterinarian who diagnosed the pregnancy by palpation. In our embryo transfer facil-

ity, we routinely examine all pregnant recipients at day 90 via ultrasonographic examination before releasing them to a client. Between day 27 (initial examination of pregnancy) and day 90 of pregnancy, a 6% embryonic death loss is evident.

MULTIPLE PREGNANCIES

In mares, twin pregnancies are relatively easy to diagnosis because of the roundness and relatively rapid development of the amniotic vesicle.[20] The amniotic vesicle in cows is elongated; this makes the detection of twins more difficult either by palpation or ultrasonography. In embryo transfer operations, sometimes twin embryos are transferred into single recipients and a subsequent ultrasonographic examination 30 days later reveals the results. If twins are detected, they can be rechecked at day 60 to determine the sex. If twins of the opposite sex are diagnosed, clients can exercise their options.

After a donor cow has been superovulated (day 0 = standing heat), most fertilized embryos have traversed the oviduct and moved into the uterus by day 7 (flush day for a superovulated cow).[21] It is relatively common for a donor to be collected (flushed) at day 7 only to be reflushed the following day (day 8) and recover more embryos.[a] All embryos in the uterus cannot be assumed to be collected from every flushed donor. For this reason, it is routine practice to either infuse the uterus with an embryocidal antibiotic immediately after flushing and/or give prostaglandin treatment shortly after the flush to prevent unwanted pregnancies. Prostaglandin is sometimes inadvertently forgotten, and one or more fetuses survive the flush process to establish pregnancy. If estrus is not detected after flushing, donors should be checked for pregnancy and especially for more than one fetus. A thorough ultrasonographic examination of the uterus reveals, in the case of pregnancy, the total number of fetuses present. Management decisions can be made accordingly.

ABNORMAL OVARIES AND UTERUS

The most common pathologic ovarian conditions seen in practice are follicular and luteal cysts. Diagnosis of these conditions by palpation is often reliable, but with real-time ultrasonography, most guesswork is eliminated. Ultrasonography allows clinicians to specifically differentiate between the two types of cysts by resolving any luteal tissue present in a luteal cyst (Figure 4). If enough luteal tissue is present, a prostaglandin analogue is our treatment of choice. Palpation occasionally leaves practitioners wondering whether a cyst was present; ultrasonography facilitates a definitive diagnosis.

[a] Stroud BK: Personal observation, Stroud Veterinary Embryo Services, Inc., Weatherford, Texas, 1994.

Endometritis without a palpable exudate in the uterus or any vaginal drainage is normally difficult to diagnose. Abnormal fluids or exudates, however, are easily detected in the uterine lumen by an ultrasonographic examination.[11] Intraluminal contents can vary from black, nonechogenic fluids with free-floating echogenic specks to an organized, purulent exudate that appears echogenically similar to surrounding tissues. Intraluminal contents can be differentiated from surrounding tissues by observing back-and-forth motion in the lumen of the uterus. After performing ultrasonographic examinations on approximately 15,000 cows, less than 50 (approximately 0.3%) that also palpated normally have been diagnosed with intraluminal exudate. Endometritis is different from early pregnancy fluids in that free-floating intraluminal echogenic specks of exudate always appear with the condition; early pregnancy fluids appear homogeneously black and are virtually free of echogenic specks (unless embryonic death has occurred).

DONOR MANAGEMENT

In-house donor management can be greatly enhanced with the use of real-time ultrasonography.[15,22] Much work has been done in recent years in the area of follicular wave dynamics and dominant follicles using ultrasonography in the hope of increasing the number and quality of transferrable embryos in superovulated cows.[23–29] There is still much to learn concerning this subject. From a clinical standpoint, multiple examinations are required to definitively diagnose when a dominant follicle has lost its dominant effect and a new wave of follicles is beginning to grow. This seems to be the most opportune time to initiate a superovulation regimen in a donor cow in order to synchronously stimulate a healthy cohort of young follicles. Multiple examinations, however, are not always practical in clinical practice, but an ultrasonographic examination on the first day of superovulation can be beneficial by detecting the presence or absence of small immature follicles (>2 mm in diameter) on the ovaries of the donor. The presence of these small follicles is at least an indication of a potentially good superovulatory response; in some instances (when a large number of small follicles is present), the presence of follicles is an indicator of potential overstimulation. Gonadotropin doses are adjusted and decreased on such donors.

If few, small (2 mm to 5 mm) follicles are observed on the first day of superovulation when scanned with a 5-MHz rectal transducer (follicles smaller than 1.5 mm in diameter cannot be detected ultrasonographically with a 5-MHz transducer), an accurate prediction of a subsequent superovulatory response is not always possible. Follicles smaller than two millimeters

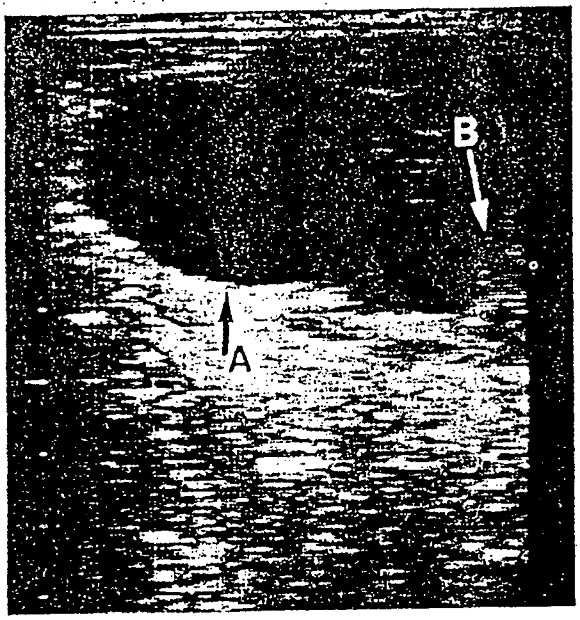

Figure 4A

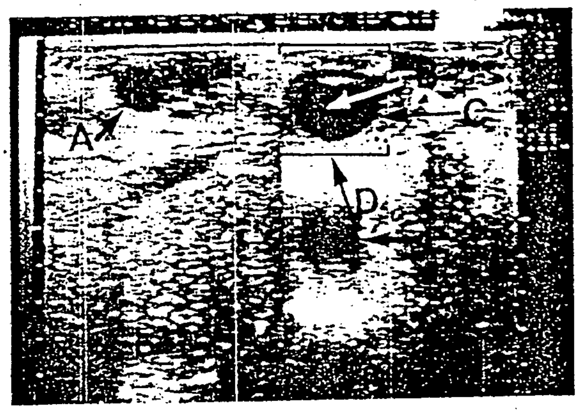

Figure 4B

Figure 4—(A) Ultrasonogram of a follicular cyst. *A* = follicular cyst, *B* = normal ovarian stroma. (B) Split-screen ultrasonogram of the left and right ovaries. The left ovary has a 14-mm follicle. The right ovary has a luteal cyst. *A* = 14-mm follicle, *B* = fluid segment of the cyst, *C* = luteal tissue, *D* = luteal cyst, *E* = mirror-image artifact of the cyst.

in diameter can be stimulated to mature and ovulate. Very few if any of these cows overstimulate (defined as too numerous to count corpora lutea associated with a high percentage of nonviable embryos recovered) in response to a superovulation treatment. Scanning before superovulation also detects ovarian cysts. This prevents nonresponses on donors scheduled for superovulation.

As soon as a superovulated donor is in standing estrus, an ultrasonographic examination can help to determine the number of follicles that have been stimulated by the treatment. When only one or a few follicles are observed, a backup sire can be selected. This saves valuable semen for a time when more ova may potentially be fertilized. The observation of multiple follicles does not guarantee ovulation of all follicles. Sometimes none or only a few observed follicles ovulate; therefore, if multiple follicles are observed, multiple ovulations may possibly occur.

A superovulated donor can be rectally palpated on the day of collection, and the number of corpora lutea usually correlates closely with the number of embryos and/or ova collected. Predictions that are usually the result of misdiagnosing follicles as corpora lutea by rectal palpation are sometimes made. A follow-up ultrasonographic examination of the ovaries after misdiagnosis usually substantiates that palpated structures were not corpora lutea but instead unovulated follicles.

RECIPIENT MANAGEMENT

When recipient cows are presented to practitioners for an embryo transfer procedure, palpation of a distinct corpus luteum with a palpable papilla occurs approximately 70% of the time.[b] Another 20% of corpora lutea has a nonpalpable papilla. Experienced practitioners, however, can determine if luteal tissue is present deep within the ovarian stroma. The remaining 10% cannot be accurately diagnosed by palpation alone, but any luteal tissue present can be observed via ultrasonography. Nonpalpable luteal tissue is resolved with an ultrasonographic examination. This allows confident transferral of embryos into synchronous recipients without palpable corpora lutea. As with donor management, nonpalpable cysts can be definitively diagnosed in recipients by ultrasonography, which prevents further embryo wastage.

Embryos are routinely transferred into synchronous recipients six, seven, or eight days after a standing heat.[30] If 21 days represents a normal estrous cycle, any nonpregnant or open recipient should recycle in approximately 14 days after transfer. Frequently, some recipients (although pregnant) exhibit strong signs of estrus at or about day 14 after transfer. This sometimes synchronizes with the heat of another superovulated donor. If the recipient is presented for an embryo transfer from the second donor seven days after this estrous activity (day 28 in the case of pregnancy), palpation is inadequate to determine a definitive open or pregnant status. An experienced ultrasonographer can diagnose the recipient as pregnant (from the original donor) or open and eligible for an embryo (from the second donor).

[b]Stroud BK: Personal observation, Stroud Veterinary Embryo Services, Inc., Weatherford, Texas, 1994.

TRANSVAGINAL OOCYTE COLLECTION

After bovine in vitro fertilization was introduced in the early 1980s,[31] a noninvasive, nonsurgical procedure to harvest oocytes directly from donor ovaries was needed. Laparoscopy was the early method of choice, but many obstacles rendered it impractical.[32] The procedure was rather traumatic. Large donors were difficult to manipulate because the ovaries were displaced deep into the abdominal cavity where the view was obstructed by viscera.[33]

In the late 1980s, real-time ultrasonography was being explored as a reliable method to harvest oocytes nonsurgically.[34,35] Since that time, commercial groups have followed with similar success[36-38] and the process has, at least to date, proven relatively atraumatic to the ovary and periovarian tissues.[39] An elongated vaginal probe housing the transducer head and needle guide is placed into the vaginal vault. The technician uses one hand on the probe handle and the other is placed into the rectum to manipulate the ovaries to the tip of the transducer. As soon as the ovary is in focus on the ultrasound monitor, a 50-cm long, 17- or 18-gauge needle is introduced into the lumen of the needle guide, through the vaginal wall, and into a follicle (Figure 5). While the follicle is invaded with the collecting needle, gentle aspiration is provided by an aspiration device. Nonechogenic follicular fluids (along with the oocyte and attached cumulus cells) are quickly aspirated, and the black follicle disappears on the monitor. The technician moves to the next follicle and proceeds until all follicles are removed from the ovaries. In general, the oocyte recovery rate per punctured follicle is approximately 60%.

To date, most donors collected by this procedure have been clinically infertile and are not capable of carrying their own fetus to term or of producing viable embryos by routine embryo transfer processes. Little can be lost in this case by potentially creating adhesions on the fimbria and ovary if the cow is already infertile. The procedure is therefore attractive to owners who would otherwise have to cull the cow for infertility. One investigator has reported that a few donors have actually rebred after undergoing the oocyte collection process.[37]

Most practitioners report little or no damage to periovarian structures after transvaginal ultrasonographic oocyte collection. If this holds true, the rapid advancement of in vitro fertilization technology in cows may make this process important to normally fertile donors as well. Different sires could be used on the same collection of oocytes without determining the blood type of the offspring. Superovulation would not be necessary, and donors could be collected on at least weekly intervals.[40] Sexed semen may also become a commercial option under controlled in vitro fertilization conditions if recent data continue to be favorable.[41] More data on potential damage to the ovaries of normally fertile donors are needed before repeated aspiration becomes commonplace in the purebred cattle industry; such data should pay specific attention to the number of attempts of these procedures.

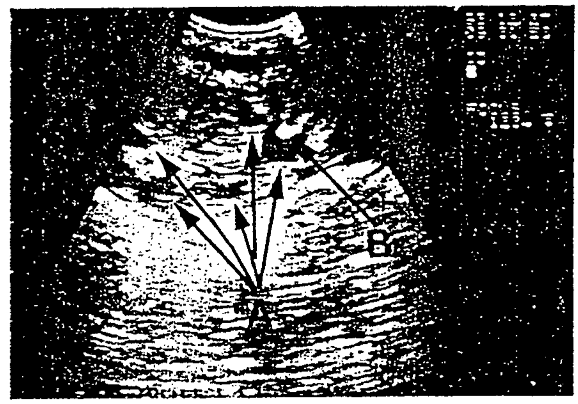

Figure 5—Transvaginal ultrasonographic oocyte recovery. The image was produced by a convex linear transducer. The ovary has several 4-mm to 7-mm follicles. *A* = follicles, *B* = tip of 18-gauge aspiration needle inside a follicle.

CHOOSING A UNIT AND TRANSDUCER

Several companies are currently marketing veterinary ultrasound units in the United States. Major considerations in making a selection are resolution quality, price, serviceability, portability, availability of new as well as loaner units, and the willingness on the part of the salesperson to educate the buyer before and after a sale. The cost of veterinary ultrasound units ranges between $5000 and $20,000, depending on the resolving capabilities, number of transducers, and other technical features.

For clinical bovine reproductive use, I have found a 5-MHz linear rectal transducer to be the most versatile and effective. This unit performs adequately on early pregnancy examinations; fetal sexing; pathologic ovaries; and, in general, most all reproductive uses. A 7.5-MHz linear transducer may be more practical if follicular dynamics research is indicated. When doing transvaginal oocyte recoveries, I have found that a convex linear transducer gives the technician much more flexibility in gaining access to the hard-to-reach follicles as compared with a linear transducer.

If at all possible, buyers should sample any potential ultrasound unit before purchase. Most major veterinary conventions have representatives on the trade show floor that are more than happy to show their product; however, live cows are recommended as the test host. If portability is a major concern, the buyer should definitely consider the size, weight, stability,

and the intended usage for the unit. For example, if fetal sexing is to be done heavily in an ambulatory practice, resolution and portability are major concerns and the unit should be tested under those conditions before purchase.

CONCLUSION

In this age of information and advancing technology, cattle producers are continuously seeking new ways to cut costs; quantitatively measure their products; be innovative in marketing; and, in general, be profitable. Producers look to veterinarians for advice on new medical and nutritional products and services to obtain a professional opinion on efficacy and how products and services may or may not fit profitably into their operation. Veterinarians should stay abreast of this ever-changing profession and make sensible decisions concerning their clients' long-term interest. In my opinion, bovine reproductive ultrasonography can, in most operations, be profitable for cattle producers when used by experienced veterinary ultrasonographers.

It is my estimation that very few bovine practitioners currently use an ultrasound unit in their practice for reproductive purposes. In my practice, however, which is strictly bovine reproduction, clients demand the service once they have had it. Much of the guesswork involved with palpation is eliminated, which gives the client complete confidence in a diagnosis, especially when the specific area of interest on the monitor is pointed out to them.

The addition of a printer or a VHS recorder to the ultrasound unit can document a specific examination and back up a practitioner's diagnosis. For example, if an early pregnant (35 to 100 days) cow or heifer is consigned to a sale and needs to be tested for pregnancy by a licensed veterinarian, a diagnosis of pregnant (via palpation) may be made when the cow perhaps is carrying a dead fetus. The cow is sold and diagnosed as bred, and the buyer finds the cow in heat a few days later. Negative thoughts abound among the buyer, seller, and veterinarian involved as a result of the original diagnosis, not to mention the loss of revenue by all parties. If an ultrasonographic examination had been performed to diagnose pregnancy or fetal gender, the lack of a heartbeat would have been detected and all events would have been prevented. As more and more cattle producers are exposed to ultrasonographic technology by reading trade journals, attending purebred sales where consigned cows have been diagnosed by an ultrasonographic examination, and conversing with breeders who have used the method, they will recognize its added benefits and eventually seek out a skilled practitioner who can provide the service for them.

The veterinarian must determine whether investment in a unit and learning its use on a professional level is practical. To become proficient in diagnosing fetal sex, early pregnancy, and normal and abnormal ovarian structures largely depends on the palpation experience level of the practitioner. The more palpation experience a veterinarian has, the faster he or she will learn to manipulate the transducer to get a focused, diagnosable image on the monitor. I have personally trained veterinarians from foreign countries who have only limited training in palpation and they have learned the technique very quickly.

There are three major obstacles to overcome when learning how to use an ultrasound unit. First, a thorough knowledge of what specific objects look like on the ultrasound monitor is imperative (e.g., normal and abnormal ovaries and female and male fetuses). Besides commercial video tutorials,[7] newcomers must also learn from attending wet labs or by first-hand experience. This can take a considerable amount of time and a tremendous number of cows with adequate breeding records to support them.

Secondly, beginning ultrasonographers must also be able to get a focused and diagnosable image on the monitor. There is more to ultrasonography than placing the transducer in the rectum of a cow and aiming it in the general direction of the fetus or ovaries. Achieving quality images comes from experience on the part of the ultrasonographer. The structure (e.g., ovary or fetus) is generally in better focus when it is only two to five centimeters away from the transducer head. This requires some manipulative skills on the part of the technician and an understanding of the anatomy in question. A valuable tip to the student is to move the transducer slowly in the rectum when approaching the area of interest. Many inexperienced ultrasonographers tend to move the transducer too quickly, thus bypassing critical landmarks that are beneficial for orientation.

Thirdly, beginning ultrasonographers must learn how to operate the ultrasound unit to its maximum benefit. Some ultrasound units have simple control panels whereas others have rather sophisticated ones. Again, the salesperson in charge should spend time with the buyer, showing how to fine-tune the system under different conditions to obtain the maximum resolution from the unit.

To make an accurate diagnosis via an ultrasonographic examination, ambient lighting is imperative. A darkroom is ideal for viewing the monitor and helps the human eye recognize as many shades of gray as possible. An ultrasonographic examination done in a well-lighted area is similar to watching television in the front yard on a sunny day—the picture cannot be seen. If there is no option but to examine cows in lighted conditions, some type of hood must be draped over the monitor to facilitate effective gray-shade delineation.

Some intangible benefits arise from using ultrasonography in practice. Ultrasonographers inevitably become more proficient in rectal palpation. The difference between a luteal cyst and a normal fluid-filled follicle is easily discernible by real-time ultrasonography but is very subtle by rectal palpation. After having viewed several hundred of each via an ultrasonographic examination, diagnosis by palpation becomes easier. The same holds true for early pregnancy testing. The art of palpation takes literally thousands of cows and months if not years to become proficient. With the help of real-time ultrasonography, an individual inexperienced in rectal palpation could learn skills much more quickly while simultaneously providing a more accurate diagnosis to clients.

Aside from direct income from services rendered, ultrasonography can be a tremendous practice builder. Patients are referred from veterinarians and other clients from surrounding areas for cows to be examined for various problems and fetal sexing. These referrals, almost without exception, come back on a regular basis when ultrasonography is indicated for a diagnosis. Some referred clients have their first exposure with an embryo transfer practitioner and eventually incorporate embryo transfer procedures on their herd. A client's perception of a progressive veterinarian who uses such high-tech diagnostic equipment as an ultrasound unit is greatly enhanced.

The bottom line is that ultrasonography in a bovine practice can be profitable to veterinarians and clients. Veterinarians must understand that the learning curve is time consuming and sometimes frustrating. The initial investment a high-quality ultrasound unit also warrants considerable deliberation—ultrasound units are expensive. An extremely busy practitioner may not have the time to learn how to use the unit, which would make its purchase ill-advised; however, if bovine veterinarians want to improve their image, enhance their diagnostic skills, and become a leader in a relatively new discipline of clinical veterinary medicine, ultrasonography may be the tool to achieve these goals.

About the Author

Dr. Stroud is affiliated with Stroud Veterinary Embryo Services, Inc., Weatherford, Texas.

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ARTICLE #7 REVIEW QUESTIONS

The article you have read qualifies for ½ hour of Continuing Education Credit from the Louisiana State University School of Veterinary Medicine. *Choose only the one best answer* to each of the following questions; then mark your answers on the registration form inserted in *The Compendium*.

1. An ultrasonographic examination to determine fetal sexing is best done
   a. between 30 and 60 days.
   b. between 50 and 80 days.
   c. between 60 and 90 days.
   d. between 75 and 100 days.

2. Both male and female genital tubercles can best be described ultrasonographically as
   a. monolobed and hypoechogenic.
   b. monolobed and hyperechogenic.
   c. bilobed, hyperechogenic, and oval shaped.
   d. slightly echogenic and bilobed.

3. Secondary fetal anatomic structures, such as the teats in females and the scrotum in males, begin to appear ultrasonographically at _____ of pregnancy.
   a. 50 days
   b. 80 days
   c. 100 days
   d. 120 days

4. In cows, pregnancy can be diagnosed as early as 22 or 23 days after breeding using a 5-MHz transducer. An experienced ultrasonographer should diagnose an open condition at _____ days.
   a. 23
   b. 25
   c. 27
   d. 35

5. Which of the following is the first ultrasonographic indication of early embryonic death?
   a. lack of a fetal heartbeat
   b. separated fetal membranes from uterus
   c. free-floating specks of tissue in amniotic fluid
   d. lack of organ identification

6. Which of the following statements is most accurate?
   a. Fifty percent of day 7 (day 0 = standing heat) corpora lutea have a definitive palpable papilla, and another 20% are detectable by an ultrasonographic examination.
   b. Seventy percent of day 7 corpora lutea have a definitive palpable papilla, and most of the remaining 30% are detectable by an ultrasonographic examination.
   c. Luteal tissue is not significantly different from normal ovarian stromal tissue and therefore is extremely difficult to diagnose using ultrasonography.
   d. Any follicle larger than eight millimeters in diameter will either ovulate or become cystic.

7. Which of the following statements pertaining to ultrasonographic transvaginal oocyte collection is true?
   a. Donors can be collected as often as once weekly.
   b. Usually a long 17- or 18-gauge needle is used for the procedure.
   c. Follicles from two to eight millimeters in diameter contain the healthiest cohort of oocytes.
   d. all of the above

8. Which of the following statements regarding ultrasonography is true?
   a. A big mistake for inexperienced ultrasonographers is to move the transducer too quickly across the target object, which makes referencing position and location difficult.
   b. Dark, ambient lighting conditions are helpful in reading the ultrasound monitor.
   c. Restraint of the cow is important, and a caudal epidural block is sometimes helpful.
   d. all of the above

9. Which of the following is an important consideration when choosing an ultrasound unit?
   a. cost
   b. portability
   c. service reputation of seller
   d. all of the above

10. Which of the following statements regarding ultrasonography is true?
   a. Ultrasonography makes practitioners more proficient at rectal palpation.
   b. Ultrasonography is an up-and-coming discipline in clinical veterinary practice.
   c. Ultrasonography has tremendous potential economic ramifications for practitioners and clients.
   d. all of the above

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Continuing Education Article #7

Use of Real-Time Ultrasonography in Bovine and Equine Reproduction

KEY FACTS

- The use of real-time B-mode ultrasonography in bovine and equine practices has expanded significantly during recent years.
- It is imperative to understand ultrasound artifacts; distant enhancement, specular reflection, and acoustic shadowing have a diagnostic usefulness.
- Changes in the ultrasonographic appearance of the endometrial folds within the lumen of the uterus can be used to evaluate the stage of the estrous cycle in cows and mares.
- Ultrasonography is used in cows and mares to determine fetal sex between two and four months of gestation.
- The bull's testicular parenchyma appears as a homogeneous hypoechoic structure with a central line representing the mediastinum testis.

Purdue University
Augustine T. Peter, DVM, PhD
Samuel Jakovljevic, DVM, MS

University of Saskatchewan
Roger A. Pierson, PhD

THE ADVENT of diagnostic ultrasonography instruments was a landmark event in veterinary medicine. The development of real-time imaging and specialized transducers in the late 1970s made this technology adaptable for the transrectal study of the internal reproductive tract in large animals. With an ultrasound scanner, an operator can now visualize organs previously accessible only by palpation. In addition, ultrasonography is a noninvasive method and examinations can be carried out quickly, easily, and as many times as necessary in individual animals.

The use of real-time ultrasound equipment in broodmare practice has expanded significantly since it became available. Many studies in the past decade have demonstrated the use of ultrasonography in detecting morphologic changes associated with physiologic events in the ovary (follicular and luteal), pregnancy, early embryonic death, and fetal sex. Ultrasound equipment has also become an adjunct in diagnosis and management of infertility in cows and mares. Most recently, ultrasound technology has been used in the cattle industry in the development of more efficient superovulatory protocols, embryo collection, and recipient synchronization techniques. New uses of ultrasonography involve evaluation of the male reproductive system. The noninvasive nature of the ultrasound procedure also provides a technique for the diagnosis of disease conditions of the testicles and accessory sex glands in bulls and stallions.

The types of tissue being studied and the basic principles of diagnostic ultrasonography must be constantly integrated. Scanning technique, instrument adjustment, anatomy, and an understanding of the basic concepts of acoustic physics combine to yield a technically correct and aesthetically pleasing ultrasound image.[1] The purpose of this article is to summarize the principles of ultrasound imaging technology and reproductive system imaging in cows and mares for practitioners.

PHYSICS OF ULTRASOUND IMAGING

The basic principles of ultrasound imaging are relatively simple. When stimulated by electrical pulses, piezoelectric crystals of a transducer emit low-intensity, high-frequency sound waves. When directed into the soft tissues of the body, portions of the sound waves are reflected back toward the crystals of the transducer, which also serve as receivers. The proportion of the sound beam that is reflected or echoed is received and converted to electrical impulses; the impulses are processed by a computer and displayed according to a predetermined mode: A-mode, B-mode, or M-mode.[2] In addition, vascular structures of the reproductive tract can be studied with Doppler ultrasonography. The Doppler phenomenon is the change in sound frequency of a moving object as perceived by a stationary observer. Doppler ultrasound machines detect frequency change and, therefore, movement, usually converting it to an audible signal.

THE INSTRUMENTS

Modern ultrasound instruments used to examine the reproductive tract of large animals typically are B-mode, real-time scanners. B-mode refers to brightness modality. The ultrasonographic image is a two-dimensional display composed of lines of gray dots of varying brightness. The computer allocates to each dot (pixel) of the displayed tissue echotexture a number (typically 0 to 32 or 64, depending on the individual instrument) related to the brightness of that dot. With real-time ultrasound equipment, signals are repeatedly transmitted, received, and processed so there is a continually updated visual image of the tissue. This allows for the observation of structure and motion. In other words, real-time imaging refers to the live or moving display in which the echoes are recorded and renewed continuously. Linear-array transducers provide a larger ultrasonographic window for viewing the fetus, whereas sector devices generally afford the examiner greater resolution when imaging small parts or specific organs.

The linear-array transducers commonly used in clinical reproduction have a row of crystals arranged along the length of the transducer face, hence, the term *linear array*. The crystals vibrate when energized by short bursts of electric current. The resolving power of the transducer depends on the frequency of the sound waves. High frequency (5.0 to 7.5 MHz) provides greater detail, whereas lower frequency (3.0 to 3.5 MHz) provides greater tissue penetration. The lower frequency transducers are suited for viewing larger structures at a greater distance from the transducer (e.g., imaging a large fetus); the higher frequency transducers are intended for detailed study of small structures close to the transducer (e.g., evaluating the ovaries and uterus) and are preferred for examinations of the reproductive tract of large animals. Other factors may influence the resolution of a transducer, such as the method of focusing the sound beam and the size of the crystals; further discussion of these factors is beyond the scope of this article.

TERMINOLOGY

Tissues have the ability either to transmit or reflect the sound waves to varying degrees. Two general terms relate to the ability of a given tissue to transmit or reflect ultrasound. The term *anechoic* (or *nonechogenic*) is used to describe those structures that transmit virtually all incident sound waves but do not reflect any of them. Because body fluids (follicular fluid, yolk-sac fluid) do not reflect sound waves, the images of liquid-containing structures appear black on the screen and are described as anechoic. *Hyperechoic* areas reflect most of the incident sound back to the transducer, transmit less sound to deeper tissues, and appear white on the display. These are typically the dense tissues in the reproductive system (e.g., fetal bone, bovine cervix). *Hypoechoic* or *hyperechoic* are relative terms used to describe the echogenicity or sonographic appearance of the soft tissues in relation to the surroundings.

COMMON ARTIFACTS

For the purpose of the following discussion, artifacts can be defined as interactions between the ultrasound waves and animal tissues that affect the display of the image but do not have biological importance. The following artifacts are most commonly observed in ultrasonography of reproductive organs in large animals and are illustrated in Figure 1.

Distant Enhancement. The phenomenon of *enhanced through-transmission* occurs when the incident sound beams strike the far wall of a fluid-filled structure (such as a follicle or embryonic vesicle). Echoes from the far wall appear to be brighter than are the echoes arising from the near wall or surrounding tissues. Tissues in the region behind a fluid-filled structure also appear to be brighter because sound waves passing through fluid are not as attenuated as waves passing through adjacent tissue. The intensity of the echoes resulting from enhanced through-transmission can be reduced by proper adjustment of the gain controls, making this artifact less pronounced.[1]

Refraction Artifact. The portion of the sound beam that strikes the side of the curved boundary of a structure at an angle less than 90 degrees may bend or refract, causing a shadowing or lack of echo formation beyond the site of refraction. This artifact appears as a result of a combined effect of refraction, deflection, and attenuation of the sound beam. It is commonly seen when the beam encounters the sides of fluid-filled follicles or spherical equine embryonic vesicles.

"Six and Twelve O'Clock" Artifact. The portions of the beams that strike the near and far surfaces of a fluid-filled spherical structure at an angle of 90 degrees may produce a highly echogenic reflection. Specular reflection is present on both the near (nearest to transducer) and far surfaces of the imaged structure ("six and twelve o'clock" artifact). Interestingly, this artifact helps to identify the early (3 to 6 mm) equine embryonic vesicles.

Reverberation. Reverberations occur when returning ultrasound waves are reflected back into the examined tissue by the transducer face. This artifact causes a second echo to be displayed at a depth twice that of the original acoustic interface; this can be repeated multiple times within the image. Reverberation is commonly seen when gas-filled seg-

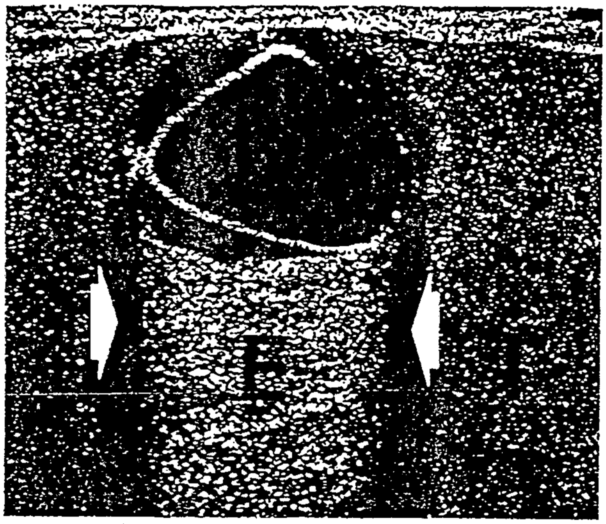

Figure 1A

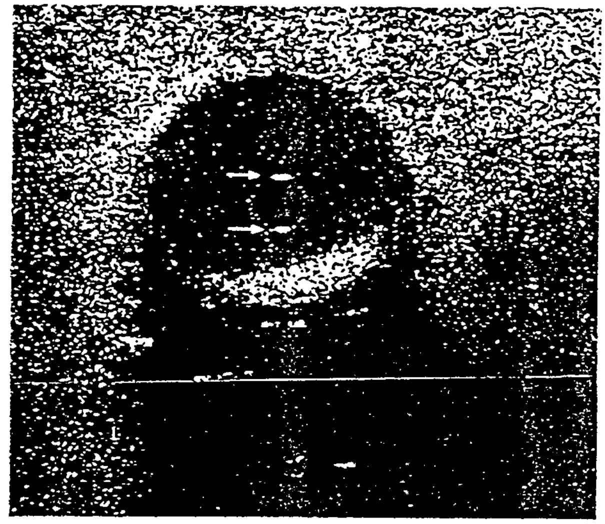

Figure 1B

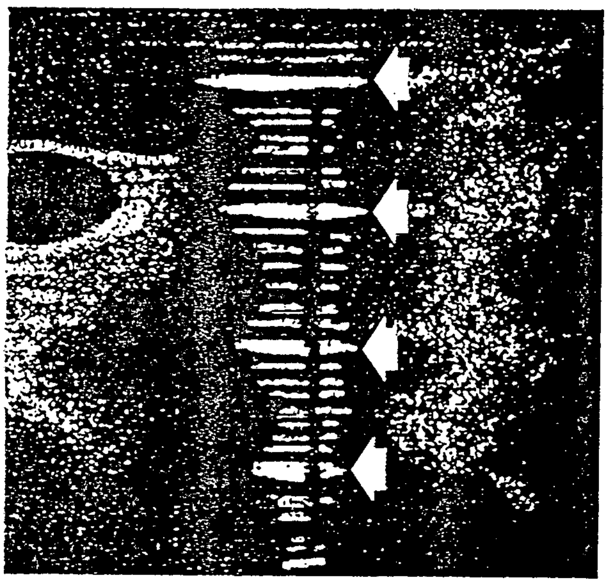

Figure 1C

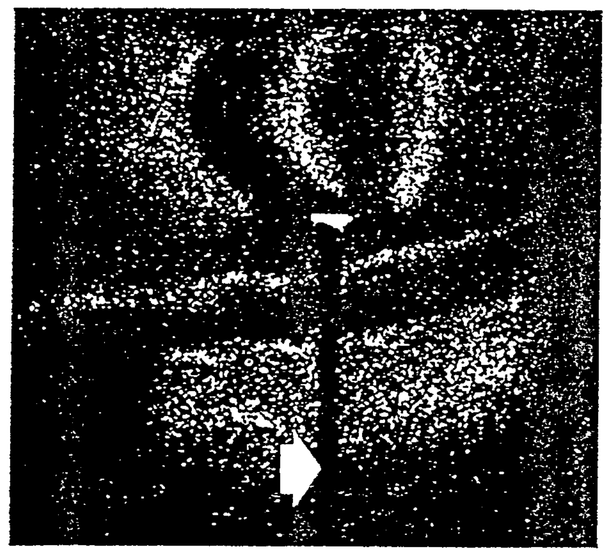

Figure 1D

Figure 1—(A) Enhancement of the echotexture beyond a fluid-filled ovarian follicle (*E*). The surroundings (*T*) are relatively less echogenic. Refraction artifacts (*arrows*) are present on each side of the enhanced area. (B) "Twelve and six o'clock" artifact at near and far side of a blastocyst. (C) Reverberations (*arrows*) beyond an interface separating two tissues with a highly different acoustic impedance. (D) Acoustic shadowing (*arrow*) beyond a reflector. (From Pierson RA, Kastelic JP, Ginther RJ: Basic principles and techniques for transrectal ultrasonography in cattle and horses. *Theriogenology* 29:3–37, 1988. Modified with permission.)

ments of intestine are present beneath the area of interest. There are three distinguishing characteristics of reverberation artifacts: (1) they are equidistant, (2) they gradually diminish in intensity, and (3) they are parallel to the reflective interface. Reverberations may sometimes be diminished by adjustment of the gain controls or manually adjusting the reproductive organs, thus altering their relationship to the underlying bowel.

Acoustic Shadowing. Shadowing occurs when most of the incident sound beams are attenuated or reflected or both at an acoustic interface. Structures beyond that interface cannot be imaged, and an acoustic shadow is formed. This shadow may occur when the sound waves are reflected by fetal bone or bone fragments (after death of the fetus). In addition, acoustic shadows are formed when loops of gas-filled intestine are located between the rectal wall and the ovaries or uterus. In cattle, the plicae circulares of the cervix may occasionally cause acoustic shadowing.

REPRODUCTIVE SYSTEM EXAMINATION

The procedure for transrectal ultrasonographic examination is similar to the procedure for rectal palpation. No additional restraint is required. The same precautions that apply to palpation per rectum are applicable to transrectal scanning. A dimly lit examination room provides the best environment to evaluate the finer details of the displayed image. It is important to use a machine with a durable, atraumatic 5-MHz transducer that is specifically designed for intrarectal insertion. The transducer should be well lubricated and shielded by the examiner's hand to avoid attachment of fecal material to the probe. Because air cannot propagate ultrasonographic signals and results in severe attenuation of the incident beam, close contact between the transducer and the tissue to be examined is essential. After evacuation of feces from the rectum, the probe is introduced and moved across the reproductive tract in a thorough and systematic manner.

IN COWS, the cervix is easily located with the increased echogenicity of the cervical folds. The transducer is moved over the dorsal surface of the uterine body and shifted slightly from side to side so that the entire width of the uterus is examined. When the bifurcation is reached, the transducer is moved along the dorsal surface of one uterine horn; the scanning plane of that horn is therefore oblique. The transducer is then rotated laterally to examine the ovary. The opposite horn and ovary are similarly examined.

In mares, the tubular genitalia are roughly shaped in a Y or a T configuration. The broad ligament attaches to the dorsal aspect of the uterus and suspends it from the sublumbar region; consequently the free surfaces of the horns are ventral. The internal structures are scanned in the following order: bladder, uterine body, right uterine horn, right ovary, uterine body, left uterine horn, left ovary, uterine body, and cervix.[1-4]

APPLICATIONS IN COWS

Ovaries

Ovarian Structures. With ultrasonography, one can monitor the growth and regression of ovarian structures on a sequential basis in a noninvasive manner. The three principal components of ovaries (follicles, corpora lutea, and stroma) are easily distinguished by ultrasonography, and the ultrasound-directed examinations offer an accurate way of determining ovarian structures and their dimensions.[5,6]

Bovine follicles, like other fluid-filled structures, appear as anechoic (black) areas on the screen. Follicles usually can be distinguished from other anechoic areas by a well-defined, relatively smooth outline. Irregular shapes are attributable to compression from adjacent follicles or from a luteal structure or stroma. Some of the apposed walls of similar-sized adjacent follicles appear straight, especially during evaluation of the ovaries of cows induced to superovulate. The apposing walls in groups of follicles sometimes are too thin to be detected, thereby causing irregular forms consisting of two or more follicles. Care is required to minimize confusing follicles with other anechoic areas, such as the nonluteinized central portion of a corpus luteum or cross sections of blood vessels. The gain, the brightness, and the contrast of the ultrasound unit must be properly adjusted to produce sharp follicular outlines with minimal artifacts.

Follicular Growth. The resolving power available on ultrasound machines has allowed visualization of the patterns of growth and regression of individual follicles during the estrous cycle in cows. In cows, waves of follicular activity are characterized by the periodic emergence of a cohort of follicles. In a few days, one follicle becomes dominant to a large diameter, whereas the other follicles (subordinates) regress. The changing composition of waves has been studied by maintaining the day-to-day identity of individual follicles, including the subordinates.[7-10] These studies have revealed new findings about follicular growth in cows and have clearly demonstrated that follicular growth occurs in waves. The number of follicular waves that occur in interestrous intervals, however, is not definitely known; there may be two or three waves of follicular growth between each ovulation. Not only does this new concept of ovarian dynamics provide information to help better interpret palpation findings, but it might also explain variation seen in intervals from prostaglandin treatment until the onset of ovulation. Because there are several waves of growth and degeneration of follicles during the estrous cycle, the response rate and time to onset of estrus after prostaglandin injection may well depend on the degree of synchrony of follicular development and corpus luteum regression. In addition, ultrasonographic return of ovarian activity in postpartum cows has provided a greater understanding of ovarian function than available through rectal or necropsy examinations.[11] Current research projects are directed toward problems occurring in postpartum cows, particularly delay in return to estrus and postpartum anestrus.

Ovulation. Ovulation is detected as the disappearance of a large follicle that was present at a previous examination and subsequent formation of a luteal gland. Usually the site of ovulation can be imaged; however, this may be more difficult in cows than in mares because of the raised ovarian structures of the mare's ovary. The apposed walls of the collapsed follicle can be distinguished from the surrounding stroma.

Corpus Luteum. Three days after ovulation, the corpus luteum can be detected as a well-defined echogenic structure.[12] It has been suggested that some of the corpora lutea may have fluid-filled areas with them. Echogenic masses may be visible within these cavities; the masses are believed to be the collection of hemolyzed red blood cells.[12] It is interesting to observe that the cavity-corpus luteum did not interfere with pregnancy and serum progesterone concentrations were not different between the two types of corpus luteum.[12]

Ovarian Abnormalities. In addition to monitoring folliculogenesis[13] and evaluating luteal glands, ultrasonography can be used to diagnose cystic ovarian conditions,[13,14] ovarian abscesses, and neoplasms. A clinical diagnosis of ovarian cysts in cows in the past has been based on the reproductive history and per rectum palpation of a smooth, fluid-filled structure greater than 2.5 cm in diameter persisting on the surface of the ovary in the absence of a corpus luteum.[14] Farin et al[14] have used sector-scan ultrasonography to differentiate follicular cysts from luteal cysts. These researchers have also used serum progesterone to confirm ultrasonographic findings. They describe the ultrasonograms of the cysts in the following manner: "Ultrasonograms of luteal cysts had gray echogenic patches along the inner cyst wall or within the antrum of the cyst. In contrast, ultrasonographic images of follicular cysts had an uninterrupted anechoic antrum with a relatively smooth, thin wall and fewer or no echogenic patches."[14] The findings suggested that luteal cysts can be detected more accurately than follicular cysts (92.5% versus 75%). Ultrasonography also can be used to monitor responses of follicular and luteal cysts to hormone treatments.[13] This technology has been used extensively in monitoring ovarian structures in postpartum cows. For example, ultrasonography has been used to determine that uterine infections were related to delayed postpartum folliculogenesis,[15] to the occurrence of short luteal phases after the first postpartum ovulations,[16] and to the development of cystic ovaries.[17] Ultrasonography also has been used to study ovarian responses to gonadotropin-releasing hormone injections in cows with retained placenta.[18]

Superovulation and Embryo Transfer. Ultrasonography is routinely used in many embryo transfer programs[19,20] monitoring ovarian status after superovulation treatment. Some potential uses are correlating the number of corpora lutea with the number of embryos collected at flushing as well as assessing the efficiency of the superovulation protocol. Although currently in a research phase, ultrasound-guided follicular puncture is being used to harvest bovine follicular oocytes.[21–23]

Uterus

Uterine Structures. An important use of diagnostic ultrasonography is in the evaluation of normal morphologic changes that occur in the uterus. Ultrasonographic changes of the uterus include variation of the thickness of the uterine body, evidence of increased vascularity and edema, and accumulation of intrauterine, intracervical, and intravaginal fluids.[24] These characteristic changes can be used to evaluate the stage of the estrous cycle in individual animals.[25] The uterus is difficult to search in cattle because of the convolutions of the uterine horns. The examiner must use great care in determining that the entire uterine horn has been imaged.

Pregnancy Diagnosis. The most prevalent clinical use for ultrasonography in cattle is to detect pregnancy and estimate fetal age.[26–30] A recent report concluded that the rate of correct pregnancy diagnosis using ultrasonography was 33% in cows up to 16 days after estrus. The percentage increased after 17 days and reached 100% by day 20.[30] Transrectal ultrasonographic scanning can be used to determine the age and development of the bovine fetus beyond two months of gestation.[31] More work is needed to establish the normal bovine fetal growth pattern as indicated by sonographic fetometry, and this information might help us to observe irregular fetal growth and choose elective abortion.

Determination of Fetal Sex. A powerful new use of ultrasonography is in determining the gender of the fetus,[32] and this technique has a place in advanced cattle breeding and management systems. After ultrasonographic diagnosis of fetal sex, management decisions on the disposition of cattle with male or female fetuses can then be made by the owners. This procedure can be done between 55 and 60 days of gestation.[33] Scrotal and preputial swellings of the male fetus and vulval swellings of the female fetus are the landmarks used in identifying the sex of the fetus. In general, ultrasonographic imaging of fetuses to determine fetal sex has been performed from 48 to 119 days after conception and the predictive accuracy has ranged from 92% to 100%. Although the technique is highly accurate for diagnosis of fetal sex, some experience may be necessary for the clinician to gain proficiency.

Uterine Pathology. Detecting uterine pathology in cows may be another use of ultrasonography. In the diagnosis and management of uterine abscesses, tumors, and adhesions of uterus to ovaries, ultrasonography can be immensely useful. In one report, a 7.5-MHz probe was used per rectum to determine the relationship of uterine mass to adjacent organs (particularly the ovaries).[34] It was also possible to identify the relative thickness and the nature of the mass (i.e., dense connective tissue versus purulent debris).

APPLICATIONS IN MARES

Ovaries

Estimating the Stage of the Estrous Cycle. As previously mentioned, the follicles appear as anechoic (black) structures. Equine follicles are easily imaged transrectally because they are large (10 to 40 mm), filled with fluid, and readily accessible. Even small follicles (< 10 mm) can be imaged and may be diagnostically important in evaluating the response to treatments for follicular stimulation. Usually they are circular; however, presence of luteal glands or other follicular structures may give an irregular shape to follicles. Changes in the follicular size before ovulation can be monitored.

The annual reproductive cycle of the mare is divided into a period of sexual competence (breeding season), characterized by ovulatory estrous cycles, and sexual incompetence (nonbreeding season), characterized by anovulation. These two seasons are separated by a period of transition. The lengthy transition period (60 to 90 days) is characterized by a complex chain of events that includes reinitiation of estrous behavior and ovarian follicular development. Ultrasonographic images of the ovaries are characterized by the presence of numerous small (3 to 10 mm) follicles and by the absence of a luteal gland. During this transitional period, it is difficult to detect ovulation based on sexual behavior and rectal palpation findings. The status of the ovaries (active or inactive) can be determined by the presence or absence of corpus luteum, respectively, via ultrasonography.[1-4]

Assessing Preovulatory Follicles. The preovulatory follicle characteristically changes from a roughly circular shape to a pear shape. Although formation of a stigma does not precede or predict ovulation in mares, the protrusion of the follicle toward the ovulation fossa is readily observed before ovulation. In addition, increased echogenicity of the follicular fluid and thickness of the follicular wall are other characteristics observed before ovulation.[4,35] These ultrasonographically discernible characteristics can be used as an aid for predicting imminent ovulation and the optimal time for breeding.[36]

Predicting Ovulation. Ovulation is defined clinically as the total absence of the soft follicular structure previously palpated in one of the ovaries. Disappearance of a large, fluid-filled, anechoic structure followed by the appearance of an echogenic area in one of the ovaries indicates ovulation. These findings can supplement rectal palpation. It has been observed that the process of ovulation (loss of follicular fluid) can be as short as five minutes.[37] A small amount of residual follicular fluid can sometimes be detected at the site of ovulation. The residual fluid usually disappears over a period of 0.5 to 20 hours.

Examining the Corpus Luteum. A peculiar ultrasonographic characteristic of the equine corpus luteum is a distinct hyperechogenicity of the gland during the first three or four days after ovulation.[38] The echogenicity gradually decreases throughout diestrus and then increases again just before luteal regression. Two ultrasonographically distinct luteal morphologies have been described. One type, classified as uniformly echogenic, is present in approximately 50% of corpora lutea; the remaining half of luteal glands develop an anechoic center of the structure. The anechoic center has been determined to result from hemorrhage into the lumen of the collapsed follicle after ovulation. The formation of a corpus hemorrhagicum may not be functionally important because it was not observed in every mare after ovulation before the formation of corpus luteum.[38,39]

Diagnosing Ovarian Irregularities and Pathology. Persistence of anovulatory hemorrhagic follicles and prolonged maintenance of a corpus luteum are some of the ovarian abnormalities that can be detected by the ultrasound-directed examinations.[36] The use of ultrasonography also is indicated in differential diagnosis of ovarian tumors. The multicystic architecture of the granulosa cell tumor gives a very characteristic appearance on the ultrasound scan. This readily enables differential diagnosis from other solid neoplastic lesions, such as melanoma, teratoma, and dysgerminoma.[40,41] The echogenic density of the cyst walls also distinguishes the tumor from the physiologic condition of the multiple follicular development that occurs commonly in barren and maiden mares early in the breeding season.[40] Another report suggested that granulosa cell tumors can be described ultrasonographically as a uniformly dense structure with one or several large fluid-filled cysts[42]; however, this was not the appearance in all the cases. According to the report, there was no typical ultrasonographic appearance of the granulosa cell tumors that could enable a definitive diagnosis. Ultrasonography may be a diagnostic aid, however, when used in conjunction with the history and findings on rectal palpation.

Uterus

Endometrial Folds During Estrus. The ultrasonographic anatomy of the uterus is influenced by the stage of the estrous cycle, which may be influenced by reproductive steroids. During diestrus, individual endometrial folds are not discernible and the uterus appears homogeneous. The most profound change during estrus involved the development of individual endometrial folds resulting in alternate and intervening echogenic and nonechogenic fold areas. The echogenic areas are attributable to the reflections of tissue-dense central portions of the folds, and the nonechogenic portions are probably the result of edematous portions of the folds or free estrous fluid between the folds.[43] The above findings along with changes in the size of the preovulatory follicle may provide valuable information about the stage of the estrous cycle.

Pregnancy Diagnosis. Ultrasound examinations are performed late in the mobility phase of the embryo (days 13 to 15). During this time, the uterus develops a characteristic tone. When searching for the embryonic vesicle, the transducer should be moved very carefully in order not to miss any portion of the reproductive tract.[44] It is emphasized that palpation is not necessary for pregnancy diagnosis, and the potential for harm to the embryo through digital manipulation is not present with ultrasound examination only. Later in gestation (after day 100), transabdominal ultrasonography can be done to glean information about fetal orientation and viability.[45]

Detection of Twins and Embryo Reduction. Diagnosis of twins enables use of one of many methods to reduce one of the embryos. It has been suggested that both synchronous and asynchronous ovulations can contribute to development of twins.[46,47] Because survival of twin embryos to the fetal stage is considered to be an undesirable event, diagnosis of twins early in gestation gives an opportunity to eliminate one or both of the conceptuses. Embryo reduction is defined as the natural elimination of one member of a twin set. This biological embryo reduction mechanism occurs between days 25 and 35 of pregnancy.[1] In this regard, it has been observed[48] that the incidence of postfixation embryo reduction for unilateral twins was higher (89%) than for bilateral twins (11%). Furthermore, it has been speculated that the embryo reduction in unilaterally fixed twins occurs when a major portion of the vascularized area of the wall of one vesicle is in apposition with the adjacent vesicle rather than with the endometrium.[47]

MANUAL ELIMINATION of one member of a twin set is another option that can be performed at the end or just after the maximum mobility phase (maximum mobility phase is between days 11 and 15 after ovulation). This method has been used successfully on broodmare farms, especially if the technique is performed at 15 or 16 days after ovulation.[49,50] For this reason, pregnancy examination should be done late in the mobility phase (days 13 to 15). Examination 13 to 15 days after the first ovulation minimizes the possibility of missing the smaller member of the set resulting from asynchronous ovulation.[51] In bilaterally fixed twins, the success rate is higher if performed between days 23 and 25 after ovulation.[52] In unilaterally fixed twins, manual reduction may be done on the day of fixation or soon thereafter. The vesicles may sometimes be manually separated by persistent manipulation of the dorsal uterine wall at the site of the vesicles.[52] When separation fails, an attempt can be made to rupture one vesicle by methods described elsewhere.[48] Ultrasonographic methods have been extensively used to monitor the events in both biological and manual embryo reduction methods.

Early Embryonic Death. The incidence of early embryonic death reportedly ranges from 5% to 30% in established pregnancies. If remnants of a vesicle are detected during ultrasound examinations in a mare previously confirmed pregnant, it is very likely that early embryonic death has occurred. Other ultrasonographic findings may include irregular and indented vesicles.[37] Prominent endometrial folds, if accompanied by a yolk-sac vesicle that is small for breeding dates, also suggest an impending early embryonic death and return to estrus.[1,4]

Determination of Fetal Sex. Fetal sex can be determined by transrectal ultrasonographic assessment of the relative location of the genital tubercle (forerunner of penis or clitoris) of the fetus. The optimal time for determination of fetal sex is between days 59 and 68.[53] By a mean of day 63, the genital tubercle is located caudal to the umbilical cord in male fetuses and under the tail in female fetuses.[53] The genital tubercle in both males and females is distinctly bilobed by day 51 and becomes trilobed after day 88. In older male fetuses, the genital tubercle or penis is represented by three parallel echogenic lines just caudal to the umbilical cord.[53] Although the technique is highly accurate for diagnosis of fetal sex, some experience may be necessary for the clinician to gain proficiency.

Uterine Pathology. Fluid accumulation resulting from pathologic conditions (pyometra) and cystic enlargements (cystic complexes and lymphatic lacunae) can be diagnosed by ultrasound-directed examinations.[4,36,54] The major use of ultrasonography in uterine pathology is to detect endometrial cysts. Endometrial cysts are well suited to be studied by ultrasonography because they are fluid-filled and nonechogenic.[55] The ultrasonographic pathology of the cystic structures is characterized by compartmentalized or multilobulated nonechogenic images. Cystic complexes or lymphatic lacunae frequently are observed by ultrasonography on the exterior aspects of the uterus (perimetrium), and they also can be extensive. The extensive nature of the cystic conditions can be confirmed by ultrasonography. Ultrasonography may be useful in detecting uterine hematoma in mares.[56] The sonographic technique also would allow visualization and estimation of the amount of purulent material in pyometra cases and monitoring of the response to treatment.[a] The events preceding fetal death and collection of fetal debris and fetal bone in the uterus after fetal death can be observed by ultrasonography.

REPRODUCTIVE SYSTEM EXAMINATION OF BULLS AND STALLIONS

Accessory Sex Glands

Palpation per rectum has been used as a method for studying the accessory sex glands in large animals. In bulls, the soft consistency of the vesicular glands and ampullae and the inaccessible location of the bulbourethral glands and disseminate prostate limit the usefulness of palpation per rectum.[57]

Ultrasonography is a noninvasive technique that can be used to assess normal function and to detect pathologic lesions in the accessory sex glands of bulls and stallions.

The anatomic relationships, physical dimensions, and acoustic characteristics of stallion accessory sex glands have been determined by use of transrectal ultrasonography.[58] Potentially, transrectal ultrasonography may be used directly and noninvasively to study the pattern of stallion accessory sex gland activity during seminal emission and ejaculation.[59] Similar studies apparently have not been performed in bulls.

Problems of the Penis

In problems related to the penis of stallions, ultrasonography can be used to arrive at a diagnosis. For example, the cause of priapism in a stallion, thrombosis of the corpus cavernosum penis (CCP), was diagnosed by ultrasonography.[60] Ultrasonography of the corpus cavernosum penis to

[a]Personal observation, Peter AT, Purdue University, West Lafayette, IN, 1989.

detect cavernosal fibrosis may be useful in assessing prognosis for recovery from priapism.

Testicles

Diagnostic ultrasonography evidently offers an exceptionally fine tool for evaluating testicular and scrotal disease in bulls.[61] The technique is easily performed and affords information about the structure of the testicle not available by any other means. Manual palpation, circumference measurement, and semen evaluation provide important information regarding breeding soundness but may not allow detection of all potentially serious diseases.[61] Results of a recent study have demonstrated that the bull's testicular parenchyma appears as a homogeneous hypoechoic structure with a hyperechoic central line representing the mediastinum testis. The tail and head of epididymis are identifiable and appeared more hypoechoic than did the testicular parenchyma. Results indicate that the bull's testicular diameter could be accurately measured by ultrasonography. As further studies are performed, it seems that ultrasound evaluation of the testicle may form a useful adjunct in breeding soundness examination.[62]

Ultrasonography has been used to detect chronic epididymitis in stallions.[63] The affected epididymis appeared hyperechoic compared with the testicle. Normally, the epididymis appears hypoechoic compared with the testicle. In this case, ultrasonographic findings were interpreted as fibrosis attributable to chronic inflammation.[63]

In the northern climates, testicular damage resulting from freezing can be assessed by ultrasonography. Similarly, in extremely warm weather, the heat-imposed damage to sperm production can be determined by scanning the testicles for possible structural changes. This may be yet another avenue for use of ultrasonography in large animal reproduction.

CONCLUSION

Ultrasonography is an excellent tool in the hands of an experienced clinician. Although ultrasonography is used extensively in equine reproductive management, its use in bovine practice is limited as a result of many factors, with one of the most important factors being the cost of the equipment. Barring its use in bovine fetal sexing, application of bovine ultrasonography in other situations may not be cost-effective. Second, most of the routine reproductive problems in bovine practice can be managed without ultrasound equipment. Third, a great deal of time is required for the clinician to gain enough proficiency in use of the equipment and interpretation of the images for routine use. If the equipment is put to use efficiently, the initial investment can be recovered much earlier. Despite its limited use in bovine reproduction, ultrasound equipment may become a popular and practical instrument in the next decade both in equine and bovine reproductive management.

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About the Authors

Dr. Peter, who is a Diplomate of the American College of Theriogenologists, and Dr. Jakovljevic are affiliated with the Department of Veterinary Clinical Sciences, School of Veterinary Medicine, Purdue University, West Lafayette, Indiana. Dr. Pierson is affiliated with the Department of Obstetrics and Gynecology, University of Saskatchewan, Saskatoon, Saskatchewan, Canada.

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ARTICLE #7 REVIEW QUESTIONS

The article you have read qualifies for 1/2 hour of Continuing Education Credit from the Louisiana State University School of Veterinary Medicine. *Choose only the one best answer* to each of the following questions; then mark your answers on the registration form inserted in *The Compendium*.

1. Which of the following ultrasonographic instruments are most often used to examine the reproductive tract of large animals?
   a. Doppler scanners
   b. A-mode scanners
   c. B-mode scanners
   d. M-mode scanners

2. The resolving power of the transducer depends on the frequency of the sound waves. Lower frequency (3.0- to 3.5-MHz transducer)
   a. provides less tissue penetration.
   b. is not suited for viewing larger structures.
   c. is intended for detailed study of small structures.
   d. provides greater tissue penetration.

3. Which of the following artifacts is least likely to be caused by equine embryonic vesicles?
   a. distant enhancement
   b. specular reflection
   c. acoustic shadowing
   d. refraction artifact

4. Which of the following statements best describes equine follicles?
   a. They are difficult to visualize.
   b. They are echoic.
   c. Their shape does not change before ovulation.
   d. Their walls thicken before ovulation.

5. Which of the following statements best describes the equine corpus luteum as revealed by ultrasonography?
   a. It is a totally nonechogenic structure.
   b. There is only one type of corpus luteum based on the ultrasonographic structure.
   c. The echogenicity remains the same during diestrus.
   d. The corpus luteum is highly echogenic during the first three days after ovulation.

6. In horses, fetal sex can be determined by ultrasonography in which of the following time periods?
   a. between 15 and 20 days after ovulation
   b. between 120 and 140 days after ovulation
   c. between 59 and 68 days after ovulation
   d. during the sixth month of gestation

7. Which of the following statements about twinning in horses based on ultrasonographic information is true?
   a. Twins always occur from synchronous ovulation.
   b. Postfixation embryo reduction is higher in bilateral fixation than in unilateral fixation of the twins.
   c. Both synchronous and asynchronous ovulations can contribute to the development of twins.
   d. The biological embryo reduction occurs 10 to 15 days after ovulation.

8. Which of the following statements about bovine follicular growth determined by ultrasonography is true?
   a. There is only one follicular wave in an estrous cycle.
   b. It is hard to monitor the growth of an individual follicle.
   c. There is more than one follicular wave in an estrous cycle.
   d. The bovine follicle always appears circular like the mare follicle.

9. Which of the following statements about determining fetal sex in cows by ultrasonography is true?
   a. It should be done before 30 days of gestation.
   b. It should be done beyond 200 days of gestation.
   c. It is generally done between 48 and 119 days of gestation.
   d. It is impossible to determine the sex of the fetus by ultrasonography.

10. Which of the following statements best describes the ultrasonographic appearance of the testicle of a bull?
   a. The testicular parenchyma appears as a homogeneous hyperechoic structure.
   b. The testicular parenchyma appears as a heterogeneous hyperechoic structure.
   c. It appears as a hypoechoic structure with a hyperechoic central line representing the mediastinum testis.
   d. The tail and head of the epididymis appear more hyperechoic than does the testicular parenchyma.

Claudia Jiménez E

Clinical and research applications of real-time ultrasonography in bovine reproduction: A review

Raja Rajamahendran, Divakar J. Ambrose, Bruce Burton

Abstract

Transrectal real-time ultrasonography has proved to be a rapid and reliable technique for studying reproductive functions in cattle. Through ultrasonography it is now established that follicular growth occurs in wave-like patterns during each estrous cycle. It has been shown that follicular growth and regression continue during early pregnancy, as well as in the postpartum anestrous period. Ultrasound has also helped us to understand the influence of dominant follicles on medium and small follicles. Among the numerous demonstrated applications of ultrasonography, early pregnancy diagnosis, fetal sexing, and postpartum reproductive management appear to be promising areas for immediate application. The new information that has been generated through ultrasound has thrown light on hitherto poorly understood areas of ovarian follicular dynamics, corpus luteum function, pregnancy establishment, and embryonic development in cattle, thereby opening newer areas for research. Still there is great potential for the continued application of this technology to further our understanding of the reproductive processes and to maximize reproductive efficiency of the bovine species. The significant contributions of real-time ultrasonography to the study of bovine reproduction in general and its practical applications in particular are discussed in this paper. The need for taking up technology assessment studies and for the introduction of low-cost portable equipment are stressed. Literature search for this review was done by scanning Current Contents Series 1991–92, AGRICOLA 1980–92, and MEDLINE 1990–92.

Résumé

Revue de l'utilisation de l'imagerie avec les ultrasons en reproduction bovine dans les domaines de diagnostic médical et de recherche

L'échographie effectuée par voie transrectale est une méthode fiable et rapide pour suivre le cycle reproducteur chez les bovins. L'imagerie avec les ultrasons a permis de visualiser la croissance folliculaire, laquelle se présente sous forme d'ondes à chaque cycle d'oestrus. De plus, il est démontré que la croissance et la régression folliculaires se poursuivent jusqu'au début de la gestation et durant la période d'anestrus post-partum. L'échographie a aussi contribuée à déterminer le rôle des follicules dominants sur les follicules de moindre taille. Le diagnostic précoce de gestation, la détermination du sexe du foetus et la régie de la reproduction en période post-partum représentent des domaines prometteurs d'utilisation immédiate de l'échographie. Les informations générées par l'imagerie avec les ultrasons ont permis d'élucider plusieurs questions dans les domaines peu connus de la dynamique ovarienne folliculaire, de la fonction du corps jaune, de l'implantation et du développement embryonnaire chez la vache, et ainsi d'élargir les domaines de recherche. L'utilisation de cette technologie permettra d'améliorer nos connaissances sur le processus de la reproduction et de maximiser les performances en reproduction chez les bovins. Dans ce communiqué, les auteurs discutent de l'importante contribution de l'échographie en reproduction bovine en général et de son utilisation pratique. De plus, ils soulignent la nécessité d'effectuer des études technologiques d'évaluation et de la mise en marché d'un équipement portatif à prix populaire. La revue de la littérature a été effectuée en consultant Current Contents, séries 1991–1992, AGRICOLA 1980–1992 et MEDLINE 1990–1992.

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Introduction

Real-time ultrasonography has gained tremendous popularity in recent years as a diagnostic as well as a research tool in veterinary and animal science. Reports on the diverse applications of ultrasonography, continued improvements to imaging quality, availability of portable ultrasound scanners, and reduction in equipment costs have led to its general acceptance by the veterinary profession. As a diagnostic aid, ultrasonography is well suited for bovine practice, particularly for the examination of reproductive organs. The technique is noninvasive, relatively simple and effective, safe to both the subject and the operator, portable, and ultrarapid, since the ultrasound image facilitates immediate interpretation and diagnosis in most circumstances. Even though the first report on the application of ultrasound for pregnancy detection in sheep was made over 25 years ago (1), the high cost of the equipment has contributed to the

Department of Animal Science, University of British Columbia, Vancouver, British Columbia V6T 1Z4.

reluctance of the veterinary profession to adopt it, in contrast to its widespread acceptance as a clinical tool in human medicine. Interest in ultrasonography among both veterinarians and animal scientists began to grow in the early eighties, following reports (2–4) on the usefulness of the technique in studying the reproductive organs of the cow. Since that time, a dramatic growth in the application of real-time ultrasonography has been witnessed. Over the past decade, several applications of ultrasonography in bovine reproduction have been described (5–34, Table 1).

Reviews on the use of ultrasound in diagnostic veterinary medicine and its research applications in cattle and other farm animals have appeared recently (35–41). However, with the widening scope of ultrasonography, an enormous amount of information is being generated rapidly. It is impossible for practitioners to keep abreast of all published information. Periodic "progress reports" in the form of review articles thus serve to fill in the information gaps. This review aims to recapitulate the significant contributions made by real-time ultrasonography in the past decade and update the more recent developments in diagnostic ultrasonography with particular reference to bovine reproduction. We hope that such a focused review will be useful, specifically to those associated with bovine reproduction.

Table 1. Applications of real-time ultrasonography in bovine reproduction

Application	Reference
I. Female Reproductive System	
• follicular dynamics during	
a) estrous cycle	5,6
b) pregnancy	7,8
c) postpartum period	9,10
d) superovulation	11,12
• ovulation process	13,14
• corpus luteum morphology and growth	15,16
• normal uterine status	3,17
• pregnancy diagnosis and detection of	18,19
early embryonic death	20,21
• fetal imaging	22
• fetal sex	23
• uterine involution	24,25
• cystic ovarian conditions	26,27
• changes during induced embryo mortality	
• pathological conditions of the reproductive system	17,28,29
II. Male Reproductive System	
• testicular tissue	30,31
• status of accessory sex glands	32
III. Other applications	
• collection of oocytes from in situ ovarian follicles	33
• artificial insemination training	34

Materials and methods

The literature search for this review was performed by computer-aided scanning of Current Contents Series 1991 and 1992 (Institute for Scientific Information, Philadelphia, Pennsylvania, USA), MEDLINE 1990 to 1992 (Excerpta Medica, New York, New York, USA), and CD-ROM AGRICOLA 1980 to July 1992 (National Agricultural Library, Beltsville, Maryland, USA). Recent issues (July 1992 onwards) of popular animal and veterinary science journals available at the University of British Columbia libraries, and research papers available on personal files of the authors were also consulted for relevant literature. Ultrasound, Ultrasonography, Ultrasonic, Bovine, Cattle, Reproduction, Follicle, Cyst, Cystic, Uterus, Ovary, Fetus, Fetometry, Imaging, Sexing, Pregnancy diagnosis, and Corpus luteum were the key words used for literature search. We scrutinized all the literature that we had access to, and excluded or included papers based on the following criteria. All papers reporting a new application of ultrasound were included. Reports supporting or contesting previous findings were included or excluded at our discretion, depending on their importance and relevance to context.

Equipment for ultrasound scanning

Sector and linear-array, real-time [B-mode (brightness modality)], ultrasound devices are commonly available for veterinary applications. In general, linear-array transducers are used with linear-array imagers, and sector transducers are used with sector scanners. Scanners that can be used with both sector and linear-array transducers are also available. A linear-array transducer has several piezo electric crystals (which emit high frequency sound waves on being energized) arranged in a row, while the sector transducer has only a few such crystals. The other major difference between the two systems is that the image produced by the linear-array transducer appears rectangular on the screen, whereas the sector transducer produces a pie-shaped image corresponding to the field of scan. Readers interested in detailed information on the principles and types of ultrasound equipment available are directed to the relevant literature (42–46). The most common approach for scanning bovine reproductive organs is per rectum, using a transrectal transducer and a linear-array scanner. Transvaginal scanning is performed, usually with sector transducers, for certain special applications. Transducers usually come in 3.0, 3.5, 5.0, and 7.5 MHz frequency ranges. The tissue penetration of sound waves and the image resolution depend on the frequency of the transducer used. Accordingly, a 3.0 MHz transducer will give greater tissue penetration but minimum detail, whereas a 7.5 MHz transducer will give minimum tissue penetration yet maximum resolution. A transducer of 5.0 MHz is a general purpose one, providing reasonably detailed images of ovaries and uterus.

Continued improvements to the existing models of ultrasound scanners are essential. Presently, most of the clinical ultrasound equipment used for diagnostic purposes in cattle is manufactured primarily for the medical profession and equipped with modified transducers for veterinary use. Easily portable but sturdily built scanners, capable of withstanding tough field conditions, particularly dust, moisture, sunlight, extremes of temperature, and voltage fluctuations, need to be designed for veterinary use. Szenci (47) described the practicality of using a battery (direct current) operated portable ultrasound scanner rather than the widely used alternating current machines. The total weight of the equipment was only 6 kg including the battery, a built-in video recorder, and transducer. The machine was capable of providing four hours of continuous operation without recharging, and it could be recharged from an automobile cigarette lighter outlet. If transducers with advanced features such as the ability to alter frequencies between 3.5, 5.0, and 7.5 MHz could be built, it would be of great advantage because of the wide range of applications that they would provide. An important factor that presently restricts the use of ultrasonography is the cost of the equipment; for example, the present cost of a basic model with a general purpose transducer is about $25,000. If cheaper machines become available, more and more practitioners will be interested in this technology.

Applications of ultrasound to ovarian physiology

Follicular turnover during estrous cycles

Ovarian follicular growth and regression have long been subjects of speculation and controversy, resulting in conflicting hypotheses (48). Now, through the use of ultrasound, it has become firmly established that follicular growth during the bovine estrous cycle occurs in wave-like patterns. Even though there are reports indicating the appearance of two, three, and, sometimes, even four waves during each cycle , a two-wave pattern in cows and a three-wave pattern in heifers appear to be the norm (5,6,49). A follicular wave involves the synchronous growth of a group of follicles from which one attains dominance over the others to become the dominant follicle. Each dominant follicle has a growing phase and a static phase, each lasting about 5–6 d. The first-wave dominant follicle is anovulatory. It remains dominant for 4–5 d, and generally by day 11 or 12 of the cycle it loses its dominance and begins to regress. In the meantime, the second wave of follicles has been recruited and selection of the second-wave dominant follicle has taken place. In a two-wave cycle, this follicle goes on to ovulate, while in a three-wave cycle, the second dominant follicle also regresses making way for yet another cohort of follicles, the third wave.

Follicular turnover during pregnancy

Ultrasonographic studies performed during early pregnancy (7,8,50,51) indicate that waves of follicular growth continue even during pregnancy. A wave-like pattern of follicular growth and atresia continues until at least day 60 in pregnant cows, just as it does in normally cycling cows. One study (51) revealed that pregnant cows have more follicles detectable by ultrasound than do nonpregnant cows; however, there appeared to be no difference in the size of the dominant follicles between the two groups. Earlier, it had been reported (50) that pregnant heifers have smaller dominant follicles than do nonpregnant heifers. The continuous secretion of progesterone during pregnancy is thought to be responsible for follicular turnover. Follicular turnover during mid and late gestation has not been investigated.

Follicular turnover during the postpartum period

Ovarian activity in postpartum dairy and beef cows has been characterized (9,10,52,53), and distinct differences are evident between the two. Studies on dairy cows by Rajamahendran and Taylor (9) and Savio *et al* (10) resulted in consistent observations that a) in more than 80% of cows, the first ovulation was unaccompanied by overt signs of estrus, and b) the length of the second cycle (luteal phase following first ovulation) was about 23 d. The length of the first cycle was of either short, 17 ± 7 d (9), or normal, 22 ± 9 d (10), duration. Even though a predominantly two-wave follicular growth pattern was observed in these studies, one, two, and three-wave patterns occurred, depending on the initial day of dominant follicle detection. If the dominant follicle was detected after 20 d postpartum, the cycle duration was consistently short (10).

Studies on beef suckler cows (52,53) indicated that patterns of follicular growth differ between first and second cycles. Similar to the observations made for dairy cows, it was recorded in both studies that over 80% of the cows did not show any estrus behavior before the first ovulation. However, the beef cows, unlike dairy cows, had a short luteal phase (<10 d) following the first postpartum ovulation.

Further studies are obviously needed in this very important area to add to the available information. The postpartum period in the dairy animal is a crucial window which could possibly be manipulated with the help of ultrasound to improve reproductive efficiency by closely monitoring the animals. Detection of silent estrus and timely insemination of postpartum cows will play an effective role in reducing the number of open days, thereby improving reproductive efficiency of the herd (see comments at the end of this article).

Follicular development during superovulation

Ovarian responses to superovulation have been studied in heifers (11,12), cows (54), and buffaloes (55). Even though it is possible to categorize animals as good, average, and poor responders, based on ultrasonic imaging of ovaries, there seems to be no significant advantage in using ultrasound over rectal palpation, particularly for assessment of ovarian response. In a recent report (56), the usefulness of ultrasound in monitoring superovulation was critically evaluated, and it was concluded that neither is it possible to obtain an accurate estimate of follicles or luteal structures, nor is it possible to follow the development of individual follicles by ultrasound scanning. Thus, the limitations seem to outnumber the advantages of using ultrasound for monitoring ovarian responses in superovulated cattle. Therefore, for the embryo transfer practitioner, the use of ultrasound for the above purpose may not be justified. However, the use of ultrasound should not be neglected by researchers studying variations in superovulation responses, as it may provide very useful information. If daily ultrasound monitoring is feasible, the technique could help when having to make such crucial decisions as whether to continue with follicle stimulating hormone (FSH) treatment, if the ovarian response is poor after the first few FSH injections.

Investigations on the influence of a dominant follicle on superovulation responses have been initiated (57–60). No conclusive evidence has been presented in these studies to suggest a positive or negative effect of the dominant follicle on superovulation. However, there seems to be a negative influence exerted by the dominant follicle that is present at the time of superovulation on embryo yield.

Table 2. Accurancy/predictive value of ultrasound in pregnancy diagnosis

Animal	n	Transducer frequency (MHz)	Days post-AI	Accuracy of positive diagnosis or PPV[a] (%)	Comments	Reference
Cows and heifers	113	3.5	45	100	Accuracy of positive diagnosis varied from 93–100% from 30 d onwards. Accuracy of negative diagnosis varied from 68–100%	19
Cows	100	3.5/5.0	27–29	*97	NPV[b] = 92%	47
Cows and heifers	320	3.0	25–30	94	Ultrasonic observations confirmed by rectal palpation on day 60. Embryo visible by day 30	70
Cows	80	3.5	42	100	Accuracy of +ve diagnosis was 100% in cows aged <2 years even by d 28, but 0% in cows aged >8 years'	71
Heifers	36	5.0	20–22	100	Observed only 50% accuracy for +ve diagnosis between d 10 and 18	72
Cows	85	5.0	26–29 30–33	*89 *90	NPV = 100% NPV = 94%	73
Cows	39	7.5	16 20	33 100		74
Cows	148	5.0	21–25 26–33	*68 *90	NPV = 64% NPV = 97%	75
Cows and heifers	200	5.0	23–31	*70	Cows and heifers combined. PPV for cows=65%; heifers=87%	76
Cows	143	5.0	25–35	*100	PPV was 100% beyond day 27 and the NPV was 100% beyond day 28	77

[a] PPV = Positive predictive value (Figures with asterisk indicate PPV)
[b] NPV = Negative predictive value
AI = Artificial insemination
Heifer = Bred nulliparous female

Assessment of ovulation and corpus luteum dynamics
Ovulation can be unmistakably detected by ultrasonography, since it is characterized by the abrupt disappearance of the large ovulatory follicle (13,14). Even though the process of ovulation in cattle has apparently not been studied by continuous ultrasonic monitoring, various reports indicate the usefulness of ultrasonography performed at 2 h (61), 3 h (55), and 4 h (13) intervals for detecting ovulation and determining the temporal relationships among estrus, ovulation, progesterone and luteinizing hormone (LH) levels, milk yield, and body temperature. One study (61) showed that the rise in vaginal temperature is a reliable measure of the times of ovulation and LH surge. The time interval to ovulation tends to be dependent upon parity, with pluriparous cows ovulating earlier than their biparous counterparts.

The ultrasonic appearance of the corpus luteum (CL) has previously been described (4,51,62–64). Kastelic *et al* (64) reported that up to 73% of CL were detectable by day 0. However, the findings of Pieterse *et al* (16) contradict the above observation in that only a 43% positive predictive value and 33% sensitivity were obtainable with ultrasound for detecting young (days 1–4 postovulation) CL. Such a huge variation between the two reports in the reliability of ultrasound for CL detection is bound to raise questions about the credibility of this technique. Even though both studies used 5 MHz transducers and linear array scanners, differences in their scanning methods and equipment may have contributed to the variations. In the one study (64), a transrectal approach was adopted, while a transvaginal approach was used in the other (16). Further, the sensitivity of the ultrasound scanners used could have been different, as they were from different manufacturers (Tokyo Keiki LS-2000H in the former study versus Pie Medical-400 in the latter). Generally, with a good quality scanner and general purpose (5 MHz) transducer, coupled with adequate experience, there should be no difficulty in determining the CL status of cattle from day 3 onwards. The use of ultrasound for accurate determination of CL status could also be of particular advantage in certain exotic bovine species, such as the water buffalo, in which accurate detection of a CL by transrectal palpation often proves difficult, even during the mid-luteal phase (65). Development of accessory CL following human chorionic gonadotrophin (hCG)-induced ovulation of the first-wave dominant follicle, has been monitored (66) by ultrasound.

Ultrasonography in pregnancy diagnosis
The first reported use of real-time ultrasonography for pregnancy diagnosis in cattle was in 1982 by Chaffaux *et al* (2). They used a 3.5 MHz transducer for

transrectal ultrasonography and observed irregularly shaped nonechogenic structures in the lumen of the uterus from day 28 postinsemination. The embryo proper was identified within this vesicle from day 35 onwards. Pierson and Ginther (67) later reported that it is possible to recognize the presence of an embryo within the uterus between days 12 and 14 following insemination. In their study, eight heifers were bred at estrus and transrectal ultrasound scanning was done daily from day 0 to day 50 postbreeding. Curran *et al* (68,69) characterized the ultrasonic anatomy of the developing bovine conceptus from days 10 to 60. An embryonic vesicle was first detectable at a mean 11.7 ± 0.4 d and the embryo proper was visible by 20.3 ± 0.3 d postbreeding. A 5.0 MHz transducer was used and the most significant finding of the study was that it is possible to detect embryonic loss in heifers as early as day 20 postbreeding. The successful application of ultrasound to early pregnancy diagnosis in cattle under farm conditions was soon reported (70). A 3.0 MHz transducer was used to scan 320 cows and heifers. Pregnancy was detectable as early as day 25 postartificial insemination (AI), and the embryo was visible by day 30. The ultrasonic observations were later confirmed on day 60 by rectal palpation. Accuracy of positive diagnosis was 94%, when animals were examined by ultrasound at about 41 days postbreeding.

Several reports on the application of real-time ultrasonography for pregnancy diagnosis in cattle are available, but inconsistencies exist among them in terms of the reliability of the results for early diagnosis. Since it would be quite exhaustive to discuss the wide variations among the reports, we have summarized the information from some of the important references (19,47,70–77) in Table 2, so that readers may make their own judgement.

The level of accuracy in pregnancy diagnosis achievable through ultrasound appears to vary widely and may depend on a variety of factors. The type of ultrasound equipment used (sector or linear), frequency of transducer selected, scanning frequency (whether the animal was scanned once or several times), age and parity of the animal selected, stage at which examined (number of days postinsemination), the reporting criteria chosen, and the experience of the operator all seem to contribute to the variability. Expression of diagnostic accuracy in terms of the positive or negative predictive value is perhaps the most accepted criterion for reporting. The positive and negative predictive values may be expressed as (a/a+b) x 100 or (c/c+d) x 100, respectively, where "a" is the number of correct positive diagnoses, "b" is the number of incorrect positive diagnoses, "c" is the number of number of correct negative diagnoses, and "d" is the number of incorrect negative diagnoses made (see Table 2 for examples).

It is evident that a 5 MHz or a 7.5 MHz transducer tends to provide more reliable results than does a 3.0 MHz or a 3.5 MHz transducer for early pregnancy diagnosis in cattle. However, the reliable period for pregnancy diagnosis with a positive predictive value of over 95% varies between days 20 and 42 postbreeding. Based on these results, the most realistic early date for reliable pregnancy diagnosis by ultrasound under field conditions may be day 30 postbreeding. Even if early pregnancy is confirmed through ultrasound, it is still advisable to watch the animal closely for estrus and to reconfirm pregnancy around day 60, either ultrasonically or through a carefully conducted transrectal palpation, to rule out chances of embryonic loss after the first ultrasonic confirmation of pregnancy. Even though reports suggest the possibility of confirming pregnancies using ultrasound between days 16 and 21 (68,69,78,79), one should realize that these studies were performed under a research setting, often with repeated and frequent examinations. Since it is extremely difficult to satisfy research requirements under field conditions, attempts to confirm pregnancies earlier than day 30 is not advisable. If the diagnosis can wait, it is probably advisable to delay the examination by an extra five days to minimize the risk of possible trauma to the early fetus, particularly if the operator is not well experienced in ultrasonography.

Fetal imaging by ultrasound

Ultrasound has been used to monitor and document morphological changes in the bovine fetus at different stages of gestation. Conventionally, studies of embryonic development in cattle have depended on aborted fetuses, or those obtained at necropsy or slaughter. One of the early reports on the use of transrectal real-time ultrasonography to study early embryonic development in cattle was by Pierson and Ginther (67). They reported that the embryonic vesicle gradually increased in length until day 26 when it started encroaching into the opposite horn. By day 32, the embryonic vesicle fully occupied both horns. The heart beat was visualized between days 26 and 29. Another study from the same laboratory (69) reported the detection of ultrasonographically identifiable characteristics of the bovine conceptus during days 20 to 60 for gross fetal morphology, fetal heart beat, allantois, spinal cord, limb buds, amnion, optic vesicle, optic lens, split hooves, ribs, and fetal movement. Other workers (78) also found the technique useful to monitor embryonic growth and suggested that such close monitoring of the embryo would help to investigate early embryonic death in cattle.

Kahn (20,21) used transrectal ultrasonography with sector transducers (3.5 MHz and 5.0 MHz) to characterize changes in the size of fetal organs and body parts and to register the relative frequency of different intrauterine positions between 30 d and 10 mo of gestation. Until the fourth month, anterior and posterior presentations occurred with almost equal frequency, with a predominance of anterior presentations during months 5–7. Most large organs of the head, thorax, abdomen, and pelvis were visible with ultrasound during the first four months. Accessibility to the latter three body regions was restricted later on. However, in about 80% of the cases examined, the head was accessible throughout all stages of pregnancy. Fluid filled structures (eyes, braincase, heart, and stomach) were most easily recognizable because of the nonechogenic nature of their contents. Visualization of the entire fetus was difficult in advanced stages of pregnancy on account of the limited field of view and depth penetration of the sound waves. For close range-visualization of the fetus, the 5 MHz transducer was used, while the 3.5 MHz transducer was preferred for viewing internal organs. The study demonstrated that gross anatomical structures of the bovine fetus can be observed in utero by transrectal ultrasound.

In a similar study performed on *Bos indicus* cows (79), the embryonic vesicle was first observable between days 18 and 20, fetal heart beat was detectable by day 22.6, and fetal movements were seen by day 50.7 ± 1.0. Growth of the embryo proper increased steadily till day 39, with a rapid increase in growth rate thereafter. The overall growth of the *Bos indicus* embryo was slower than that of the *Bos taurus* embryo.

In summary, sonographic imaging is a promising versatile technique to monitor fetal growth and well-being. The results available clearly demonstrate that transrectal ultrasound scanning is a precise technique for the determination of age and intrauterine development of the bovine fetus, and has several distinct advantages over conventional methods.

Fetal sex determination by ultrasound

One of the early reports of visualization of male and female characteristics of bovine fetuses by real-time ultrasound was by Muller and Wittkowski (80). Eighty-two cows were studied between 57 and 120 d gestation using both 3.0 MHz and 5.0 MHz transducers. The scrotal swelling in male and mammary glands in female fetuses were the references for sex determination with an accuracy of 94% between days 70 and 120. Kahn (21) reported that accurate sex determination can be performed after day 60 and that the gender of a male fetus was less difficult to determine than that of a female, based on the presence or absence of a scrotum.

Reports of fetal gender determination based on the genital tubercle are also available (22,81,82). In both sexes, the genital tubercle (forerunner of penis and clitoris) was easily recognizable by ultrasound as a prominent bilobular structure. However, it was not a useful ultrasonic indicator of sex until it reached the vicinity of the umbilical cord in males and the tail in females. On days 48 and 49, the genital tubercle was located between the hind limbs. In male fetuses it then moved cranially, reaching a point just caudal to the umbilical cord by day 56, on average. In female fetuses, it reached a point near the tail around day 54 (82). Curran and Ginther (22) reported up to 100% accuracy in sex determination by ultrasonography between days 50 and 100. However, considerable experience was found to be essential for the accurate determination of sex. The average time required to determine fetal sex varied from 2–15 min per cow (22,83).

In summary, prenatal sex determination is possible in cattle by transrectal real-time ultrasonography under both research and farm conditions. It appears to be a rapid and reliable technique. Accuracy of sex determination by an experienced operator is nearly 100% between days 60 and 70 of gestation. Diagnoses were inaccurate or impossible before 60 d of gestation and became less reliable as the age of the fetus advanced beyond 100 d. Predetermining the sex of fetuses carried by pregnant recipient animals will be of great advantage to commercial embryo transfer companies in planning marketing strategies. Diagnosis of fetal sex will also help dairy farmers in deciding whether or not to retain pregnant cows already earmarked for culling, depending on the sex of the fetus. Sexing of twins is also advantageous as it allows selective termination of unwanted pregnancies, such as those involving a male and a female fetus, which would otherwise bear a freemartin.

Ultrasonography in the diagnosis of ovarian and uterine abnormalities

The ultrasonographic appearance of a cystic CL was first described by Reeves *et al* (3). The usefulness of ultrasonography in diagnosing cystic ovarian conditions of the cow were soon reported by others (24,25,29,84) and provided practical diagnostic guidelines for differentiating follicular and luteal cysts. Follicular cysts revealed large (25–55 mm) nonechogenic areas with very thin walls. Luteal cysts on the contrary appeared as nonechogenic areas surrounded by echogenic tissue of varying thickness (2–5 mm). In cystic cows, treated with gonadotropin-releasing hormone, the wall of the cyst increased in thickness from 2 mm to 6 mm over a two-week period (29). Rajamahendran and Walton (85) and Peter *et al* (86) used ultrasonography to monitor the dynamics of follicular cyst formation following steroid administration in dairy cows. Prater *et al* (87) described the usefulness of ultrasound in detecting ovarian neoplasia.

Ultrasonography has also been found to be immensely useful in diagnosing uterine pathological conditions. Detailed studies (17,28) of common uterine pathological conditions, such as endometritis, pyometra, mucometra, and mummified and macerated fetuses, indicate that images of inflammatory conditions of the uterus are generally characterized by a distended lumen, filled to varying degrees with partially echogenic "snowy" patches. In conditions where fetal remnants are present, images allow visualization of the fragments. For instance, in the macerated fetal condition, the fetal bones were identifiable as echogenic particles in the uterine lumen suspended in the fetal fluids, and the uterine walls were thickened. In mummified fetuses, the uterine fluids were absent and the fetal mummy appeared as a poorly defined echogenic mass.

Studies have investigated the fate of the bovine conceptus and CL after embryonic death had been induced during early gestation using luteolytic substances, the intrauterine administration of colchicine, an antimitotic agent, or pure cultures of *Actinomyces pyogenes* (26,27). Through sequential ultrasound evaluations, changes in embryonic viability, cervical patency, uterine fluid volumes, and CL status were recorded. Both studies concluded that the CL of pregnancy was maintained when embryonic death resulted from the administration of colchicine or from bacterial invasion. In contrast, when abortion was induced with a luteolytic agent, the CL regressed within 24 to 72 h. Additionally, significant observations were that embryonic loss following luteolysis was characterized by rapid loss of the conceptus with minimal degeneration. The elimination of the conceptus and its breakdown products were primarily by expulsion through the cervix rather than by resorption (26).

Ultrasonography has thus been found to be a useful clinical tool for monitoring the response of cystic ovaries to therapy, studying induced cyst formation, studying conceptus loss following induced abortions, and diagnosing several kinds of ovarian and uterine pathological conditions.

Ultrasound in oocyte aspiration and in other applications

Rapid developments are taking place in bovine in vitro fertilization (IVF) leading to increased success in production of IVF embryos. Bovine IVF largely depends on oocytes aspirated from ovaries collected at slaughter, although laparotomy and laparoscopy are surgical approaches to procure follicular oocytes from the live cow. While repeated laparotomy for follicular aspiration is not a feasible proposition for obvious reasons (surgical trauma, postsurgical adhesions, and ethical considerations), laparoscopic follicular aspiration has been demonstrated to be a feasible and repeatable technique (88), yielding an up to 88% recovery rate. However, the long term effects of laparoscopy on the reproductive function and general health of animals subjected to the procedure are of serious concern, due to the invasive nature of the technique.

Over the years, alternative methods of obtaining follicular oocytes have been investigated. A technique for the aspiration of bovine oocytes during transvaginal ultrasound scanning of ovaries was first described by Pieterse *et al* (33), using a 5.0 MHz sector transducer. Both normally cycling and superovulated cows were used for transvaginal oocyte aspirations, and a 27.4% oocyte recovery was attained. Ovaries of superovulated cows were found to be easier to handle and aspirate, while puncturing small follicles was often difficult and risky, with increased chances of injury to the cow's rectum or even the operator's hand.

In a follow-up study (89), repeated follicular aspiration was performed on 21 cows up to three times during each estrous cycle, at approximately six-day intervals over a three-month period. On every occasion, all follicles more than 3 mm in size were punctured and aspirated. The mean total number of follicles punctured per cycle was 12.6 ± 0.3, with the maximum number of follicles for puncture being available on day 3 or 4. The overall oocyte recovery rate was 55%, demonstrating substantial improvement in the efficiency. The IVF rate of transvaginally collected oocytes was significantly higher than that of oocytes aspirated from ovaries obtained at slaughter. The repeated interventions had no apparent deleterious effect on the estrous cycles of the animals studied (90). The findings indicated that transvaginal, ultrasound-guided, follicular aspiration is less traumatic and less invasive than laparoscopy, and that it is possible to repeat the procedure without follicular stimulation and without affecting the cyclicity of the animal. Repeated oocyte collections for IVF from the same cow was possible over several months, and more than 30 transferable embryos per cow could be produced in one year. These findings were further substantiated (91) by demonstrating that without any hormonal pretreatment, immature oocytes collected nonsurgically from cows during normal estrous cycles can be used successfully for in vitro production of viable embryos. This report proposed the transvaginal, ultrasound-guided, follicular aspiration technique in combination with IVF as an attractive and potential alternative to superovulation for bovine embryo production.

Apart from oocyte aspiration, the transvaginal, ultrasound-guided, puncture technique may also be useful for several other applications; for example, aspiration of fetal fluids for sex determination, biochemical analysis, and hormonal estimation; sampling of uterine contents for diagnostic purposes; subsampling of follicular fluid and fluid in the central cavity of CL; injection of substances into the ovaries, follicles, uterus, et cetera; and perhaps even selective elimination of embryos during the early stage of unwanted twin pregnancies. Successful collection of bovine fetal fluid through a transvaginal, ultrasound-guided, puncture technique has already been reported (92). The earliest successful aspiration of amniotic fluid was on day 44 of pregnancy. Even though this study demonstrated the possibility of repeated sampling of amniotic and allantoic fluids up to five times at weekly intervals, the risk of intrauterine fetal death increased with repeated punctures.

The usefulness of real-time ultrasonography in AI training has been reported (34). Ultrasound was used to evaluate the efficiency of AI trainees in depositing semen at the desired site by using a brass bead and string attached to the AI sheath, which was deposited at the site of AI. The location of the bead was immediately confirmed by ultrasound scanning. This method of training is reportedly quick, easy, and effective.

Ultrasonography in male reproduction

Breeding soundness assessments of dairy bulls are currently based on semen parameters, scrotal circumference, and testicular palpation. Specialized examination procedures, such as testicular biopsy, thermography, or tonometry, may involve risks to the reproductive potential of the bulls. Because of this, there has been interest in the application of ultrasonography to assess the normal anatomical appearance of bull testes (30) and accessory sex glands (32). Studies (93,94) have also investigated the possible correlation between ultrasonically determined testicular parameters and breeding soundness score parameters. The testicular diameter measured accurately by ultrasound correlated well with testicular circumference, weight, and volume (94). However, a routine testicular ultrasound examination contributes no significant additional information that could be of value in breeding soundness evaluations (93). Sidibe *et al* (31) also found ultrasonography not useful for the objective evaluation of artificially induced testicular degeneration in the bull. Since ultrasound waves have no adverse effects on testicular development, sperm production, and semen quality (95), scope for increased application of ultrasonography in male reproduction still remains. Despite the discouraging results obtained (31,93), real-time ultrasonography may have significant advantages over other techniques in the diagnosis of testicular and epididymal abnormalities. The most promising application, however, seems to be in the diagnosis of pathological conditions of the accessory sex glands, since digital palpation has severe limitations.

Comment

In less than a decade, the quantum of new information generated through the use of diagnostic ultrasound in the field of bovine reproduction is enormous. The advent of ultrasound technology, with the important capability of following the sequential growth and demise of follicles has improved our understanding of folliculogenesis and CL dynamics during different reproductive states. This has contributed richly towards a better understanding of the complex subject of animal reproduction as a whole. The reputation of ultrasound for safety (96) and ease of operation only strengthens its potential for future applications. Even though the technology has been in vogue for over 10 yr, no study has so far systematically analyzed the cost-effectiveness of ultrasonography in routine herd management. Will the routine use of ultrasound improve the economic performance of such herds? As of today, there is no definite answer to this question. A preliminary evaluation along these lines was conducted in the authors' laboratory (97), where ultrasound imaging is being used for routine check-up of all cows (herd size ≃ 40 milch animals) between 30 and 40 d postpartum to evaluate their reproductive status. Based on the findings, appropriate managemental measures are taken immediately. This procedure helps in early detection of silent estrus, anestrus, and cystic ovarian conditions, and has proved useful in reducing days to first service, days open, and calving interval. It seems apparent that continuing the practice will further help in improving the efficiency of the herd. It would be worth taking up such investigations on large herds, so that critical evaluations could be made of the economic benefits that ultrasound promises to offer.

The feasibility of transcervical, ultrasound-guided, intrafallopian placement of gametes, zygotes and embryos has been demonstrated in human reproduction (98). Such novel approaches may have practical value in bovine reproduction as well. Particularly in the transfer of valuable, in vitro produced, zygotes to the recipient fallopian tube to overcome in vitro developmental blocks, thereby increasing the chances of successful implantation.

There is wide scope for the use of ultrasound as a tool to increase our understanding of bovine reproduction and to manipulate the reproductive processes to maximize the reproductive efficiency of this species. We are confident that this modern technology will soon be a popular tool for early pregnancy diagnosis, prenatal sexing, and the reproductive health management of cattle.

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Answers to Quiz Corner/Les réponses du Test Éclair

1. c — Some infected cats will die from FeLV infection; however, many more will recover and become immune.
   c — Quelques chats infectés par le FeLV mourront; cependant, beaucoup plus se rétabliront et seront immunisés.

2. c — Hypertonic enemas should not be administered to cats or small dogs, especially if the animal is obstipated.
   c — Les lavements hypertoniques ne devraient pas être administrés aux chats ou à de petits chiens; surtout s'ils souffrent de constipation opiniâtre.

3. d

4. b — These horses should not be allowed to eat anything before definitive treatment at a referral center. Treatment usually involves general anesthesia and softening of the feces. The other options would be appropriate.
   b — Ces chevaux ne devraient rien manger avant le traitement définitif au centre de référence. Le traitement implique habituellement une anesthésie générale et le ramollissement des fèces. Les autres options seraient appropriées.

5. a — Tetracyclines are specific treatment for chlamydial diseases of sheep.
   a — Le traitement aux tétracyclines est spécifique pour les infections chlamydiales des moutons.

6. c — Electric heating pads may cause thermal burns and are particularly dangerous for the unconscious or immobile patient. They have no place in clinical practice and their use only invites a lawsuit.
   c — Les coussins chauffants électriques peuvent causer des brûlures et ils sont particulièrement dangereux pour le patient inconscient ou immobilisé. Ils n'ont pas leur place dans une pratique vétérinaire et leur utilisation ne peut que vous attirer des poursuites judiciaires.

7. a

8. b — Calving interval is the most encompassing measure of reproductive performance. However, it is the slowest to change and, therefore, is not a good indicator of short-term performance to use for decision making.
   b — L'intervalle vêlage-vêlage est la mesure la plus globale de la performance de reproduction. Cependant, la modification de cet indice se fait très lentement et, par conséquent, cet indice n'est pas un bon indicateur de la performance à court terme à utiliser pour la prise de décision.

9. b — A tear of the medial meniscus occurs in 40% to 60% of cases involving rupture of the cranial cruciate ligament.
   b — Une déchirure du ménisque médial se produit dans 40 % à 60 % des cas de rupture du ligament croisé cranial.

10. c — The protein content of milk replacer should be at least 20%. The National Research Council recommends 22%. However, 20% is adequate provided that all of the protein ingredients are from milk sources.
    c — Le contenu protéique du lait de remplacement devrait être d'au moins 20 %. Le National Research Council recommande 22 %. Cependant, 20 % est un contenu adéquat en autant que tous les ingrédients protéiques proviennent de source lactée.

Claudia Jiménez E

ULTRASONOGRAFIA DEL APARATO REPRODUCTOR DE LA VACA VACÍA

La ultrasonografía (US) en los bovinos ha ganado popularidad en los últimos años, ya que se ha convertido en una herramienta de diagnóstico para el médico veterinario, así como también en una herramienta importante en procesos investigativos que involucran el aparato reproductor del bovino.

A continuación se citarán algunas de las aplicaciones mas comunes del ultrasonido en la vaca vacía:

1. ACTIVIDAD OVÁRICA

Dentro de las aplicaciones del ultrasonido, la actividad ovárica es tal vez la mas estudiada en el bovino. Un adecuado examen del ovario por ultrasonido requiere de habilidad por parte del examinador para ubicarlos en la cavidad pelviana. Igualmente, se hace necesario que el ovario se pueda manipular manualmente con suficiente destreza, con el fin de lograr varias imágenes ecográficas y así detectar las diferentes estructuras presentes en el mismo. Es importante anotar, que el ovario debe entrar en estrecho contacto con el transductor para así lograr buenas imágenes y poder discernir la mayor cantidad de estructuras presentes en él.

En la pantalla del ecógrafo, los folículos se caracterizan por ser estructuras relativamente circulares, menores de 2.5 cm, que contienen una cavidad anecogénica rodeada de una pared ecogénica delgada. Se debe tener en cuenta que una sola toma del ovario no permite dar una diagnóstico definitivo sobre que estructura (folicular o luteal) se halla dominando en el momento del exámen y obviamente, es importante evaluar detalladamente ambos ovarios.

a. DINÁMICA FOLICULAR: El estudio ecográfico sobre la dinámica folicular ha permitido determinar que dicha dinámica es diferente en estados como prepubertad, pubertad, ciclo estral y posparto. A través del ecográfo se logró que los estudios, que antes eran postportem, se realizaran "in vivo", permitiendo de esta manera ver los diferentes estadios de desarrollo de los folículos. De esta manera se logra identificar que el bovino presenta de dos a tres ondas de desarrollo folicular, la última de las cuales culmina con la ovulación del último folículo dominante.

Los diversos estudios muestran que las ondas foliculares se presentan desde los dos meses de edad. Igualmente, se ha demostrado a través del ecógrafo que cada onda folicular tiene una duración de alrededor de 11-12 días y que los folículos involucrados en cada onda presentan una etapa de reclutamiento, seguida de una selección de un folículo que se tornará dominante y que ocasionará atresia (regresión) del resto de folículos.

En cada onda, el folículo dominante muestra una etapa de crecimiento que dura de 5-6 días, después de lo cual presentan una fase estática que tiene una duración de 4-5 días. Si este folículo no se torna en ovulatorio, hacia el día 11 del ciclo sufrirá atresia.

Experimentos como el de Purwantara et al. (1992) ilustran lo anteriormente descrito (Tabla 1).

TABLA 1. Seguimiento ecográfico de la cantidad de folículos presentes y del diámetro del folículo dominante y del cuerpo lúteo, en los primeros siete días del ciclo estral (Purwantara et al., 1992).

Día	Cantidad (No.)			Diámetro (mm)	
	FPeq	FMed	FDom	FDom	CL
0	23.9	1.1	0.2	4.3	9.4
1	22.9	3.5	0	5.4	10.6
2	20.7	3.7	0	7.6	13.7
3	21.3	3.8	0.3	9.1	16.7
4	20.5	2.7	0.9	11.1	19.1
5	20.3	1.6	0.9	12.0	20.9
6	19.3	0.9	1.1	13.1	23.2
7	20.7	0.5	0.8	14.0	21.9

En este estudio se puede observar la gran cantidad de folículos pequeños que inician su desarrollo en la primera onda folicular. Sin embargo, se puede observar que este número disminuye notoriamente cuando el tamaño folicular aumenta hasta llegar a ser un solo folículo que se considera como folículo dominante y que ha ocasionado que la gran mayoría de los folículos sufra atresia.

Una de las preguntas que se genera a partir de este tipo de estudios es; ¿Cuál es la capacidad del ecógrafo para detectar todos los folículos en crecimiento?. Es indudable que un transductor de mayor frecuencia (7.5 MHz) permitiría una mejor detección de folículos pequeños. Sin embargo, el transductor de 5 MHz, que es el que comúnmente se usa en reproducción bovina, presenta cierta confiabilidad como se describe en la tabla No. 2.

TABLA 2. Correlación entre la detección de folículos por ultrasonografía y por ovarios de vacas sacrificadas (Kamimura et al., 1993).

	US	MATADERO	r
2-4 mm	14.8	16.3	0.57
5-9 mm	4.0	3.8	0.43
10-14 mm	1.0	1.0	0.71
> 15 mm	1.3	1.0	0.85
F. Ov.	16.8	16.3	0.95

Esta tabla nos muestra que a medida que aumenta el tamaño folicular la sensibilidad del ecógrafo aumenta, hasta tal punto que es muy fácil determinar la presencia y el número de folículos dominantes en un momento dado del ciclo. Igualmente, los datos nos sirven para mencionar que en general, el instrumentador del ecógrafo puede detectar folículos con tamaños superiores a 2 mm y a partir de estos folículos pequeños, se puede realizar el seguimiento de crecimiento, atresia y selección del folículo dominante.

La última etapa del desarrollo folicular culmina con la **ovulación**. Esta es, sin duda alguna, una de las aplicaciones prácticas del US en la reproducción bovina. Al realizar un seguimiento de la última onda folicular, el folículo dominante se podrá seguir hasta que alcance su máximo tamaño. Cuando esto ocurre, el folículo empezará su proceso ovulatorio; dicho proceso se puede identificar a través del ultrasonido, ya que el folículo que originalmente era redondeado por la gran cantidad de fluido acumulado en su interior, empieza a perder forma. Adicionalmente, el poco fluido folicular presente en este momento, empieza a tornarse ecogénico y las pared folicular finalmente se colapsa.

Es indiscutible que este tipo de seguimientos cobra mayor importancia a nivel de investigación en fisiología reproductiva. Sin embargo, mas adelante se discutirá las aplicaciones prácticas que este tipo de estudios genera. Adicionalmente, este comentario me sirve para destacar, que sin un adecuado conocimiento de la fisiología, en este caso folicular, seria practicamente imposible evaluar el ovario, ni sería posible determinar su estadio fisiológico o patológico para posteriormente tomar alguna conducta propedéutica.

b. CUERPO LÚTEO (CL): sobre esta estuctura se evalúa la formación, desarrollo, duración y su posterior dimisión por acción de la prostaglandina.

El CL se caracteriza a la ecografía por ser una estructura ovalada y ecogénica de tipo transitorio (12 días). Las profesionales que manejan la reproducción bovina saben que el diagnóstico del cuerpo lúteo es imprecindible para detectar ciertas patologías y para conducir ciertas terapias hormonales. Desafortunadamente, la certeza de dicho diagnóstico no es del 100 por ciento y el ecógrafo indiscutiblemente sería una herramienta útil como diagnóstico confirmativo (tabla 3).

TABLA 3. Valores predictivos de detección del cuerpo lúteo por palpación y por ultrasonografía (Gutiérrez et al., 1996).

		Palpación rectal		Ultrasonido	
Verdaderos	+	18.1%	87.5%	26.5%	92.4%
	-	69.4%		65.9%	
Falsos	+	8.6%	11.4%	5.3%	7.6%
	-	3.8%		2.3%	
Sensibilidad			82.5%		91.6%
Especificidad			88.9%		92.7%

Vale la pena anotar que este estudio se realizó por profesionales con amplia experiencia en palpación rectal, lo cual explica el alto porcentaje de certeza, a través de esta técnica. Adicionalmente, cabe preguntarse cual sería el porcentaje de detección de CL en animales cebuínos donde se sabe que en un gran porcentaje desarrollan CL internos que dificultan su diagnóstico. Con estos preceptos, se podría decir que el ecógrafo podría mejorar notoriamente la presición del diagnóstico en este tipo de animales y que es un instrumento que ayudaría mucho mas a aquellos profesionales con poca experiencia en palpación rectal.

Con respecto al seguimiento de la formación, desarrollo y regresión del cuerpo lúteo, la ecografía ha sido mas utilizada en investigación que a nivel pragmático. Este tipo de estudios implica un seguimiento diario de las estructuras ováricas para lograr mediciones y determinar cuando el cuerpo lúteo termina su desarrollo y cuando inicia su regresión. Como se observó en la tabla 1, el desarrollo del CL dura alrededor de cinco días donde alcanza su máximo diámetro. Igualmente, otros estudios han mostrado que el proceso de luteolisis, que dura alrededor de 72 horas ocasiona una regresión del CL a una tasa de 1.2 cm/día

La detección del cuerpo lúteo posterior a la ovulación tal vez sería una de las aplicaciones prácticas del ultrasonido. Según Kastelic et al. (1988), el CL se detecta desde el día 1 de la ovulación con un 73% de certeza. Sin embargo Pieterse et al. (1990), sugiere que la certeza es de 33% en los días 1-4 del ciclo estral teniendo en cuenta el día cero como el día de la ovulación. Las diferencias dependen claramente de qué tan periódico se realice el seguimiento. Si se realizan ecografías diarias desde antes de la ovulación es posible detectar el sitio del folículo ovulatorio que será reemplazado por el CL y de esta manera lograr observar el desarrollo progresivo del CL. Por el contrario, si no se detectó el folículo ovulatorio será muy dificil detectar el sitio donde iniciará el crecimiento del CL hasta que no halla tomado una forma clara de CL.

Un hallazgo interesante a nivel de matadero y ahora a nivel del animal vivo es, el de la presencia de CL con cavidad (llamados también CL quísticos). Con el ecógrafo es posible determinar que este tipo de estructuras son formadas después de la ovulación y que no afectan para nada la ciclicidad, ni la fertilidad de la vaca. Vale la pena anotar que son estructuras que se deben diferenciar de los quistes ováricos patológicos, los cuales sí se consideran que afectan ciclicidad y fertilidad.

c. PATOLOGÍAS OVÁRICAS: dentro de las patologías ováricas, el diagnóstico de la enfermedad quística ovárica (COD) es tal vez la de mayor implicaciones prácticas. Los quistes ováricos son estructuras anovulatorias, con un tamaño > 2.5 cm de diámetro y que se han diferenciado de acuerdo a su capacidad de producir progesterona en dos tipos, los quistes foliculares (QF) y los quistes luteales (QL). Dicha capacidad de producir progesterona va ligada directamente al grosor de la pared del quiste (tejido luteal) lo cual ha permitido que se realice diagnóstico diferencial a través de la palpación rectal y de la ultrasonografía (Tabla 4).

TABLA 4. Caracterización ultrasonográfica de quistes foliculares (QF) y quistes luteales (QL).

QUISTES FOLICULARES	QUISTES LUTEALES
Diámetro > 2.5 cm	Igual
Contenido anecogénico	Cavidad anecogénica de menor tamaño, con "nieve"
Pared delgada	Anillo anecogénico de variable grosor
75.0% precisión por US	92.6% de precisión por US

Al igual de lo mencionado anteriormente con relación al diagnóstico del CL por palpación rectal, en los quistes se da una situación similar. Aunque no tengo información relacionada con la precisión del diagnóstico por palpación rectal, es posible asegurar que esta sería menor a la del diagnóstico ecográfico.

En la tabla 5 se puede observar que la precisión del diagnóstico para QL es mayor que para el QF. Las razones son sencillas. El quiste folicular es una estructura con pared delgada mientras que el quiste luteal es una estructura con pared gruesa. La pregunta es, ¿Cuál es el límite del grosor de la pared folicular para diferenciarla entre un quiste folicular y uno luteal? Esta pregunta no es fácil de responder y la manera mas exacta de diferenciarla es obviamente una medición de niveles de progesterona. Sin embargo, los niveles de progesterona no están claramente relacionados con el grosor de la pared del quiste (tablas 5 y 6).

TABLA 5. Evaluación del diagnóstico y tratamiento de quistes luteales con Ultrasonido y Prostaglandina F2alfa respectivamente (Jeffcoate y Aycliffe, 1995).

Diámetro cm	P4 ng/ml	Relación pared/cavidad	Días al estro
3.5	4.5	2.7/1.3	4
3.3	> 10	3.0/2.0	4
3.3	8.1	3.4/2.8	3
3.6	4.9	3.5/2.4	3
Sensibilidad	92.6%		

TABLA 6. Diagnóstico de quistes foliculares por niveles de progesterona (Jeffcoate y Aycliffe, 1995).

Diámetro cm	P4
5.0	0.5
3.0	0.2
3.6	1.4
2.9	2.5
Sensibilidad	75.0%

Es importante a notar, con base en los resultados de las tablas anteriores, que el tamaño del quiste no tiene relación directa con su capacidad de producir progesterona. Igualmente, la tabla 5 nos muestra una medición que es factible realizar para quistes luteales mas no para foliculares. Dicha medición es la relación diámetro total/diámetro de la cavidad que nos indicaría el grosor de la pared del quiste y nos permitiría de alguna forma encausar nuestro diagnóstico. Desafortunadamente, no existe suficiente información para estandarizar este tipo de medidas y lograr así determinar con certeza cual es un QL y cual es un QF. A pesar de esto, se considera que si el grosor de la pared folicular es superior a 2 mm, es posible clasificar a este quiste dentro del grupo luteal (Kahn y Leidl, 1989).

2. EVALUACIÓN ECOGRÁFICA DEL ÚTERO VACÍO

El diagnóstico ultrasonográfico permite evaluar los cambios morfológicos del útero durante el ciclo estral (estro y diestro), durante la involución uterina posparto así como también nos permite detectar estados patológicos del mismo.

A la ecografía, se pueden diferenciar claramente estructuras como vagina, cuello y cuernos uterinos, (figura ?). Es importante recalcar nuevamente, la necesidad de que el operario del ecógrafo maneje adecuadamente la palpación rectal y la identificación de estas estructuras, pues de otra manera será muy difícil identificarlas a través del US.

Para el examen del útero, el transductor se debe colocar dorsal a las estructuras. Inicialmente, se realiza examen de la vagina, seguido de cuello, cuerpo y cuernos uterinos. La vagina, cuello y cuerpo uterinos se verán en el monitor con corte de tipo longitudinal debido a que el transductor se halla colocado en esta forma. Por el contrario, el cuerno uterino dependiendo de la posición del transductor, presentará cortes de tipo circular (posición transversal) o longitudinal (posición longitudinal). En el examen del útero es importante minimizar al máximo la distancia entre el transductor y las estructuras. Esto requiere de cierta presión realizada con el transductor teniendo cuidado de no lesionar el recto.

La vagina se observa como una estructura ecogénica que no debe presentar contenido durante la etapa de diestro. En el caso de estro, dichas paredes vaginales se observan distendidas por un fluido ecogénico que corresponde al moco cervico-uterino. Las tumoraciones y abscesos vaginales se observarían como estructuras ecogénicas antes del cuello. La neumovagina se identificará como una falta de transmisión de imagen en el monitor debido a la presencia de gas. La urovagina, en general coincidirá con acúmulo de abundante fluido anecogénico que puede presentar grados variables de ecogenicidad dependiendo de la presencia o no de vaginitis.

El cuello es la estructura mas ecogénica del tracto reproductivo. En el estro, al igual que en la vagina, se puede detectar acúmulo de fluido anecogénico en la parte central del cuello, correspondiente al moco cervico-uterino y las tumoraciones y abcesos se verán similares a los descritos para vagina.

El cuerpo y cuernos uterinos son las estructuras que requieren de mayor atención a la ultrasonografía. Los cambios fisiológicos se evalúan con base en parámetros tales como ecogenicidad, vascularización y edema de la pared y acúmulo de fluidos en el interior. La ecogenicidad de la pared aumenta en los animales en estro debido a la contracción de las paredes uterinas. La vascularización y edema se caracterizan como zonas anecogénicas dentro de la pared uterina, y son típicas de fases donde predominan los estrógenos.

El oviducto es una estructura que normalmente es difícil detectar en estados fisiológicos; sin embargo, cuando presenta patologías se detectan acúmulo de fluido de tipo anecogénico que indican que hay una alteración en la evacuación permitiendo el diagnóstico de obstrucción de oviducto. Los abscesos u otras tumoraciones (tuberculosis, linfosarcomas) se detectan como estructuras ecogénicas que también pueden llevar al acúmulo de fluidos alrededor de la tumoración.

La involución uterina posparto también ha sido evaluada por US y permite al clínico detectar si ésta se está llevando a cabo normalmente o por el contrario presenta patología. En general se busca evaluar el grosor y la ecogenicidad de la pared así como la ecogenicidad del contenido (loquios). A nivel investigativo, se pueden seguir los cambios ya mencionados durante el proceso de involución (Tabla 8).

TABLA 8. Grosor de la pared uterina (cm) durante las primeras ocho semanas de un posparto normal (Kamimura, 1993).

Semanas posparto	1	2	4	6	8
Área del endometrio	1.12	0.92	0.77	0.70	0.70

Antes de los 15 días posparto el útero se ve ligeramente anecogénico debido al edema presente en la pared y se detectan los loquios también anecogénicos con puntos ecogénicos reflejando el material celular(apariencia de nieve). Hacia el día 18 posparto el grosor del útero disminuye y la pared aumenta en ecogenicidad. Los loquios siguen

presentes en menor cantidad y si el proceso es normal, en este momento deben ser generalmente anecogénicos.
A nivel pragmático, es tal vez mas importante evaluar la ecogenicidad del contenido y de la pared para detectar endometritis ya que una sola medición de grosor no genera información diagnóstica (deberia ser seriada).

La endometritis es una patología frecuente en las vacas posparto. Los diversos sistemas diagnóstico incluyen palpación rectal, vaginoscopia, historia de repetición de calores, biopsia uterina, citologías y cultivos de fluidos uterinos. Cuando la endometritis es severa, hasta la sola palpación rectal permite el diagnóstico. Sin embargo, en muchas ocasiones ni siquiera la vaginoscopia nos permite su identificación, lo cual resalta que no todas las endometritis se identifican por la presencia de fluidos (vaginoscopía) o por el grosor y contenido del útero (palpación). Es indiscutible que lo importante en el diagnóstico de esta patología, es que se realice lo mas rápido posible para retornar a la vaca a servicio.

Para diagnosticar endometritis por US, se debe evaluar el grosor de la pared uterina y por la detección de fluidos en el lumen uterino cuya grado de ecogenicidad indica la mayor o menor presencia de material purulento. El fluido uterino se detectará como material anecogénico correspondiente a grados variables de cantidad de moco uterino, entremezclado con material ecogénico que corresponde al material purulento. Como es bien sabido, a mayor presencia de material purulento (mayor grado de ecogenicidad) la endometritis es mas severa. Igualmente, a medida que se involucra la pared uterina (metritis), la misma se torna mas ecogénica y a veces se hace difícil diferenciar el fluido de la pared. Una estrategia que ayuda a diferenciar un poco estas dos estructuras, es que por US se puede detectar el movimiento de los fluidos.

3. APLICACIONES DEL ULTRASONIDO EN PROPEDEUTICA

El utrasonido se ha utilizado para hacer seguimientos de tratamientos tales como la sincronización del ciclo estral, tratamientos de quistes ováricos y tratamientos de superovulación.

a. Tratamientos para la enfermedad quística ovárica: con respecto a estos tratamientos, Jeffcoate y Ayliffe (1995) reportan que tratamientos realizados con GnRH para tratar QF, incrementan el grosor de la pared del quiste en 2-6mm en un transcurso de 14 días post tratamiento. Esta aplicación es interesante ya que muchas veces es difícil determinar si el tratamiento ha logrado luteinizar el quiste folicular para lograr ser tratado como uno de tipo luteal o si por el contrario el QF persiste. Es indiscutible que este tipo de diferenciación logra disminuir errores en el tratamiento y por ende disminuir costos al productor.

b. Tratamientos con progestágenos para sincronización: En los últimos años, los profesionales han incrementado la utilización de los progestágenos en la inducción de un celo de referencia para transplante de embriones así como en la inducción de celo en vacas en anestro. Esto es sin duda debido a que el efecto sincronizador es mas eficiente que el de las prostaglandinas. Sin embargo, es bien sabido que la fertilidad del celo inducido con progesterona (P4) no es adecuada.

Los estudios realizados, con US, en este campo muestran que la P4 sola, sin estrógenos, ocasiona que el folículo dominante se retenga por todo el tratamiento y que cuando la P4 es retirada, este mismo folículo ovula, liberando un oocito de poca capacidad de desarrollo. Por el contrario, el tratamiento conjunto de estrógenos y P4 ocasiona atresia del folículo dominante y reiniciación de una nueva onda folicular con posterior ovulación de un folículo de calidad superior (Sawyer et al., 1995).

Los progestágenos también se han utilizado a la par con el tratamiento superovulatorio. En estos casos, varios estudios han concluido que el día que se inicia el tratamiento con progestágenos es crítico para obtener una respuesta superovulatoria adecuada. Un ejemplo de lo mencionado, es el trabajo de Sawyer et al. (1995). En dicho trabajo se demuestra que iniciar el tratamiento con PRID al día 7 posterior al celo es mas benéfico que al día 14. Se observa que el tamaño del segundo folículo dominante es menor, lo cual permite que haya un menor efecto negativo sobre los otros folículos en desarrollo. Igualmente, dicho efecto se ve en el tamaño de los folículos al momento del estro, donde se observa que los folículos estimulados son mas homogéneos y de un mayor tamaño. Estos efectos benéficos se ven reflejados en el número de embriones viables al momento de la colecta (Tabla 9).

TABLA 9. Efecto del PRID (dispositivo intravaginal liberador de P4) en dos diferentes días del ciclo estral sobre la respuesta superovulatoria de la eCG (gonadotropina coriónica equina) (Sawyer et al., 1995).

	PRID 7	PRID 14
Duración primera	7 d	6d
Tamaño segundo FD	7.1 mm	9.6mm
X Tamaño folicular al estro	10.0mm	8.7mm
# embriones viables	42/51	19/52
Desarrollo folicular	Uniforme	Desigual

4. EL ULTRASONIDO EN LA BIOTECNOLOGÍA DE LA REPRODUCCIÓN

El profesional que se dedica a realizar transplante de embriones, sin duda encontrará múltiples razones para justificar la adquisición del ecógrafo. Ya vimos lo crítico que puede ser el inicio del tratamiento sincronizador así como el superovulatorio. Vimos que la presencia de un folículo dominante puede disminuir la respuesta superovulatoria y por ende el ultrasonido permitirá en un momento dado detener el inicio de tratamiento si se detecta un folículo dominante. Igualmente, el US permitirá evaluar la respuesta superovulatoria al momento del estro, detectar quistes anovulatorios y establecer la relación entre éstos y la cantidad de cuerpos lúteos, para así determinar si se realiza o no el lavado para la obtención de embriones.

Es importante tener en cuenta que el US permitirá evaluar la cantidad de folículos superovulados y posteriormente la cantidad de CL de una manera mas precisa que la palpación rectal, pero de ninguna manera se puede decir que es exacto en este tipo de diagnóstico y que el margen de error es mayor o menor dependiendo de la destreza del operador. ie. es posible que inicialmente el usuario del ecógrafo tenga mas experiencia para diagnosticar CL por palpación rectal que por US.

Las receptoras para transplante de embriones, juegan un papel crítico en el éxito del mismo, particularmente en cuanto a sincronización con la donadora se refiere. Esta sincronización implica además que la receptora presente un adecuado CL el día de la transferencia. En estos casos, no siempre la donadora, particularmente si es media sangre con cebú, permite la adecuada detección del CL (CL internos). EL ultrasonido vuelve a jugar una papel crítico en estos casos, además de su utilización para el diagnóstico de preñez hacia el día 21 posterior al transplante

Una de las últimas aplicaciones del US en la biotecnología de la reproducción, es la **obtención de oocitos por aspirado folicular** con la ayuda del ecógrafo por vía trasvaginal. A pesar de que este tipo de tecnologías no está ampliamente difundida actualmente, es sin duda una alternativa de obtención de embriones por técnicas in vitro, particularmente para el caso de vacas que por alguna razón no superovulan adecuadamente o no producen embriones por patologías de oviducto.

La aspiración folicular se ha utilizado en vacas ciclantes donde se realizan aspiraciones de folículos de mas de 3 mm. El experimento de Pieterse et al., 1991 nos ilustra las posibilidades de esta nueva tecnología (Tabla 10).

TABLA 10. Obtención de oocitos por aspiración transvaginal guiada por ultrasonido (Pieterse et al., 1991).

Número de vacas	21
Tamaño de folículos puncionados	> 3mm
Frecuencia	3 veces por semana
Duración del experimento	Tres meses
Total de punciones	541
# Folículos puncionados por ciclo	12.6±0.3
Tasa de recuperación de oocitos	55%
Embriones transferibles	18
Duración de ciclo estral	22.2

Días de la punción	% recuperación
3-4	59%
9-10	55%
15-16	4%

Se observa que la punción de folículos provenientes de la primera onda folicular da un mayor porcentaje de recuperación de oocitos que los de las ondas subsecuentes. Igualmente, se observa que la duración del ciclo estral no se afecta y que según el reporte, la formación de adherencias fue nula aunque no se reporta la fertilidad de las vacas posterior al procedimiento.

Es indudable que estos trabajos son de tipo experimental y que se generan preguntas tales como que posibilidad existe de generar adherencias y qué efectos detrimentales tiene sobre la fertilidad de la vaca. Obviamente que cuando estos trabajos se realicen sobre vacas infértiles dichas preguntas no tendrían mayor importancia, pero para el caso de realizarlos en vacas fértiles si la tiene.

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