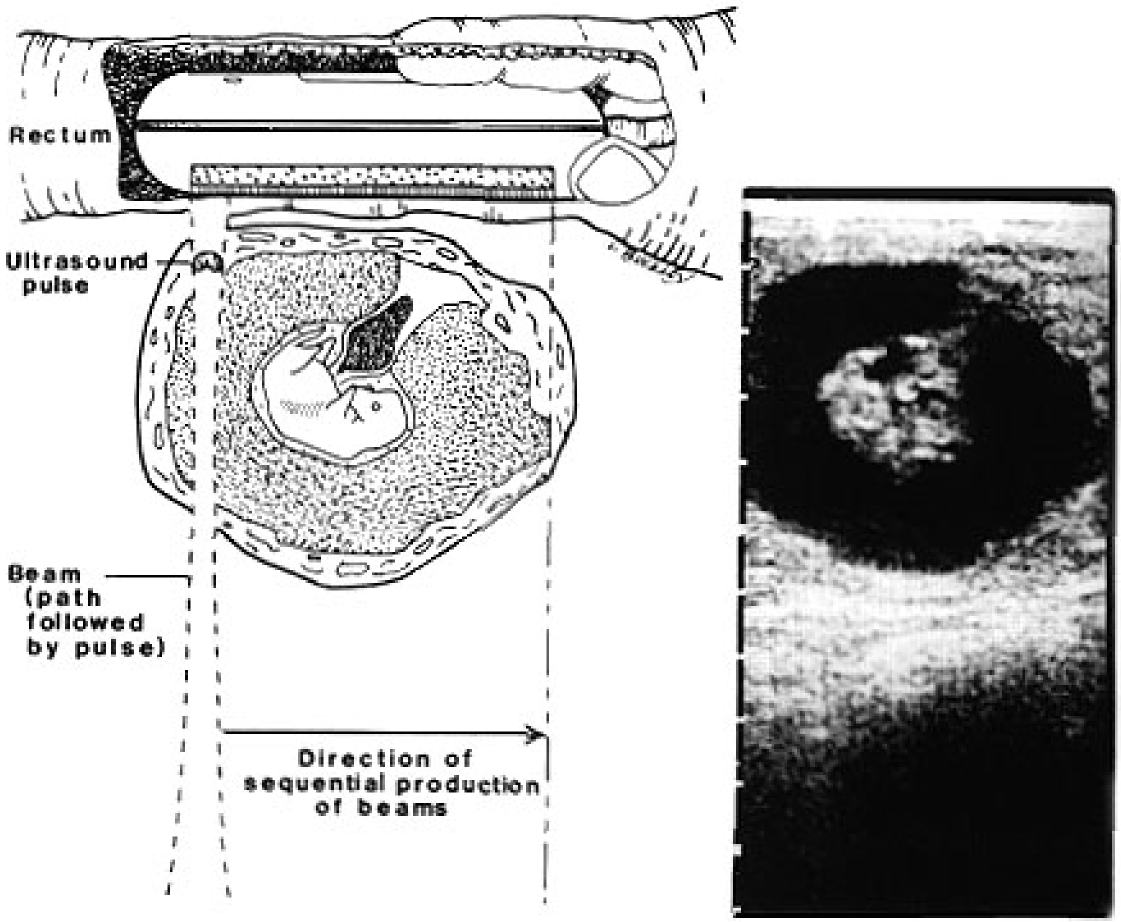
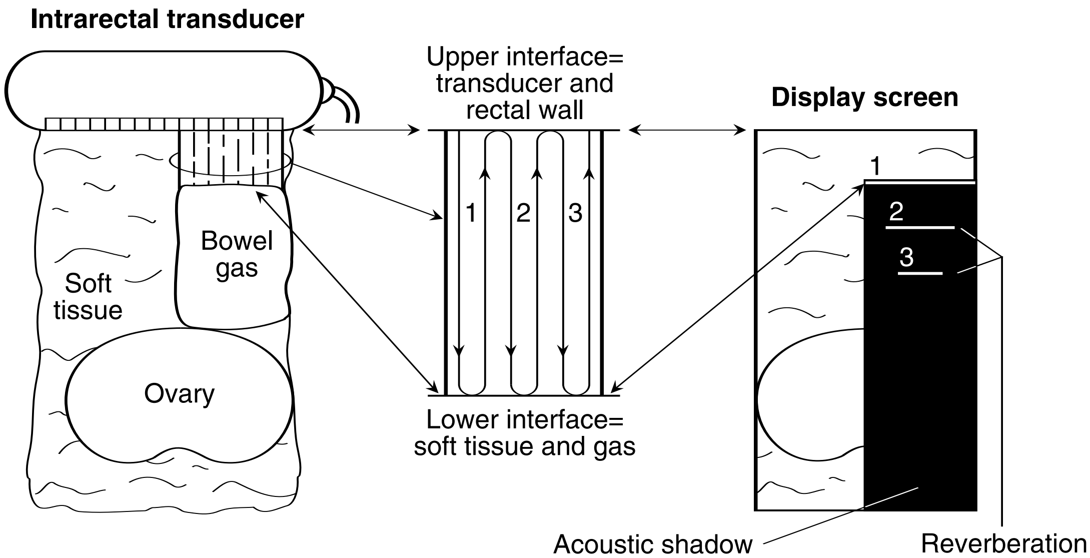
The Net Result



Development of an image of a 45-day equine fetus. A 64-element linear-array transducer is held in the rectum over a uterine horn. An ultrasound pulse is generated by firing a cluster of elements. The resulting pulse follows the confines of the imaginary focused beam, and echo signals are returned to the same elements. After completion of echo-gathering data, the cluster moves down the array and a second pulse is fired, producing a second beam. This sequential, segmental firing of clusters of elements moves along the array, completing 30 passes per second. The resulting echo signals are processed, resulting in a displayed image. Each picture element (pixel) corresponds to a location of a tissue reflector, and the brightness of each pixel corresponds to the density (echo-producing ability) of the tissue reflector. The information from

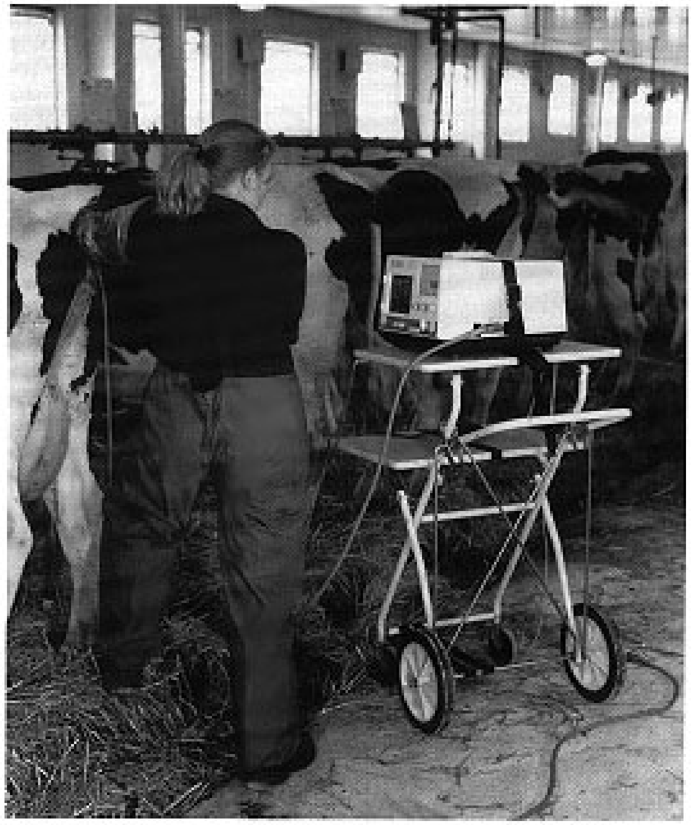
Reverberation Artifacts



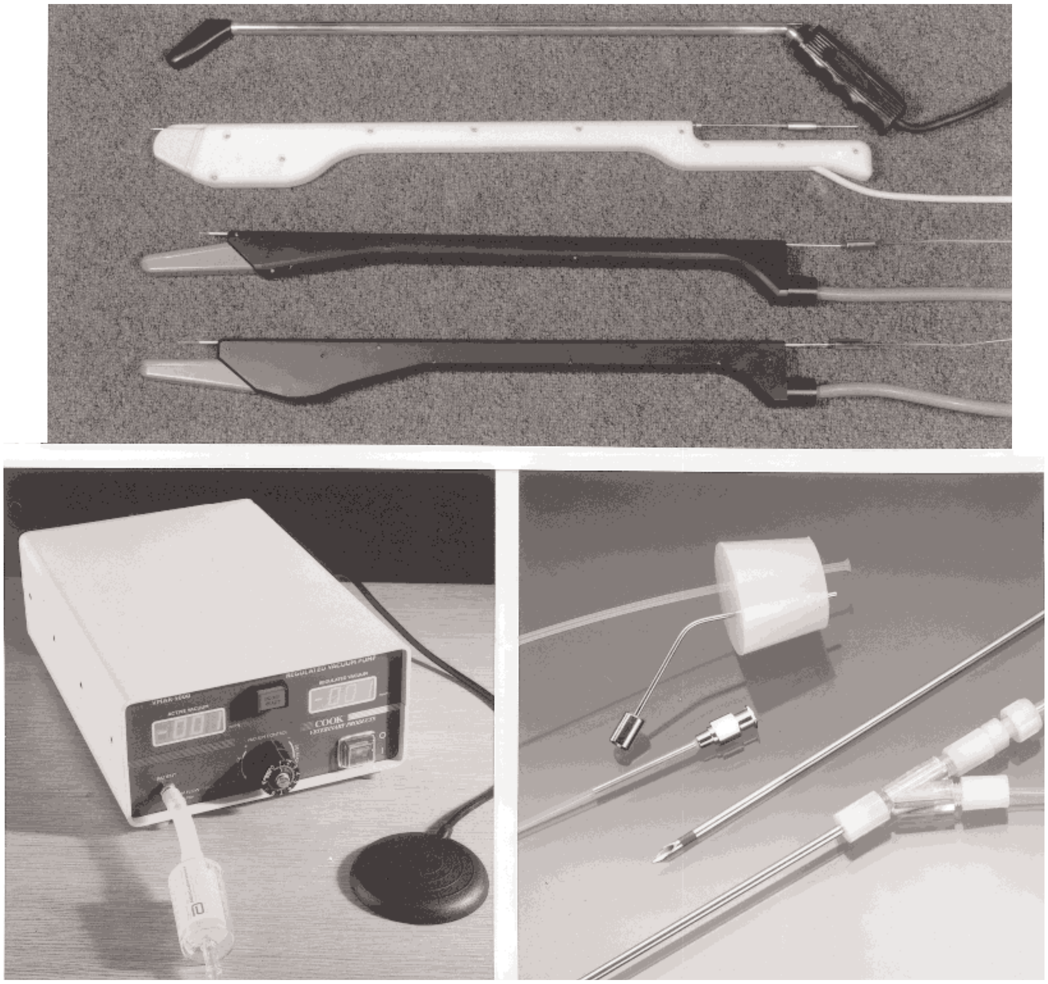
Origin of reverberation artifacts. Reverberation is a process wherein an echo bounces between two strong interfaces until the ultrasound pulses are exhausted by attenuation. The illustration shows the origin of reverberation artifacts on the display screen as a result of the sound waves bouncing between a soft tissue-gas interface and the interface consisting of the transducer and rectal wall. The pulse is shown making three round trips between interfaces. Round trip number l results in a legitimate echo on the display screen (echo l). The second and third trips, however, result in false or reverberation marks on the screen. At the completion of the first round trip, the echo strikes the transducer crystals and produces a small voltage, which in turn results in an echo at the appropriate pixel on the screen. However, much of the sound energy is reflected back into the tissue, because the transducer-rectal wall interface represents a profound acoustic impedance mismatch and therefore a very effective ultrasonic reflector. On the second return trip, the pulse again strikes the crystals, resulting in another echo on the screen (echo 2). This time, however, the scan converter assigns an address that is twice as far from the top of the screen (representing the transducer face) as for the legitimate echo; the second trip resulted in a doubling of the interval from the time the pulse originally left the transducer (trip l) until the echo struck the transducer after trip 2. In addition, the amplitude of the second echo is weaker because of additional attenuation. Therefore the resulting echo on the screen is

Freeze Control

Side-by-side freezing of two images. The images are of a Day-29 corpus luteum and the corresponding embryonic vesicle. Modern scanners have a provision for freezing an image, allowing study or photography. The control button may be located on the console or in a remote box. We prefer to have the control button on the console because we normally have the console close to the operator and certainly within arm's length (pg 132); under these optimized circumstances, a remote control box can be a nuisance. Freezing is done through an image-storage function known as freeze-frame memory. In some scanners, especially the older models, the freeze-frame memory may involve only one sweep of beams across the transducer. Therefore, only every other scan line is seen and the resulting image is of low quality. This problem also may occur when attempting to freeze a videotaped image for detailed study or for still photography. In some scanners, several images may be frozen simultaneously and recalled as needed. The side-by-side provision on some scanners, shown above, allows the operator to freeze an image and then to continue scanning by means of an adjacent image. This provision is especially useful for comparing areas or to select the most desirable image for photography. In addition, a structure too wide for one screen can be photographed on two contiguous screens. The images from digital scan converters will remain in storage until released from the memory or until the scanner is turned off. However, images from analog scan converters begin to deteriorate slightly after approximately 10 minutes.



Scanning animals secured in rows or stalls. Dairy cattle are commonly held in stanchions or tie stalls. If an efficient centralized area is not available, the scanner can be moved from animal to animal. If properly designed, this approach can rival or exceed the efficiency of a centralized chute. Many distributors of portable scanners sell carts for this purpose (source information: pg 195). Some features of carts to consider are the following: 1) platform height that will bring the scanner screen closer to eye-level; 2) large, wide-based rear wheels so that the stand is stable and easy to move even over rough floors or ground; 3) good collapsibility for easy transportation or storage; 4) a second shelf for record books, towels, bucket, gloves, gel, etc; and 5) provisions for strapping the scanner to the cart. A professional cart is a small investment ($300 to $400) when measured against the value of the equipment that it holds and protects. A long extension cord (e.g., 15 meters) can be unrolled as the cart is moved. The cord of the scanner (not the extension cord) should be fastened to the cart so that the electric connection does not fall in water and so that the cord will disconnect if accidentally pulled. Conventional utility carts that are not designed for this purpose should not be used routinely, especially under barn conditions.



Paraphernalia for transvaginal ultrasonic guiding. Transvaginal aspiration of cattle and horse follicular oocytes for in vitro fertilization is becoming commonplace. Specialized convex and sector transducers and devices for encasing conventional linear-array transducers are being marketed (top to bottom: Pie Medical, Aloka, Tokyo Keiki, Tokyo Keiki; source information: pg 191). An aspiration pump and needles with adapters are also shown (Cook; source information: pg 195). Note the ultrasound etch mark near the needle's point. Increasing the reflectivity of the needle may be done by roughening the surface to increase the number of acoustic interfaces or by incorporating an air-containing notch near the needle tip. Such needles can be purchased, or a needle tip can be scarified with a fine file *(8)*. Another approach involves a simulated needle path on the ultrasound screen. Linear-array transducers or transducers that produce a longitudinal field of view display a clear image of the longitudinal aspects of the needle *(26)*: needles as small as 25 gauge were imaged within the follicular fluid.

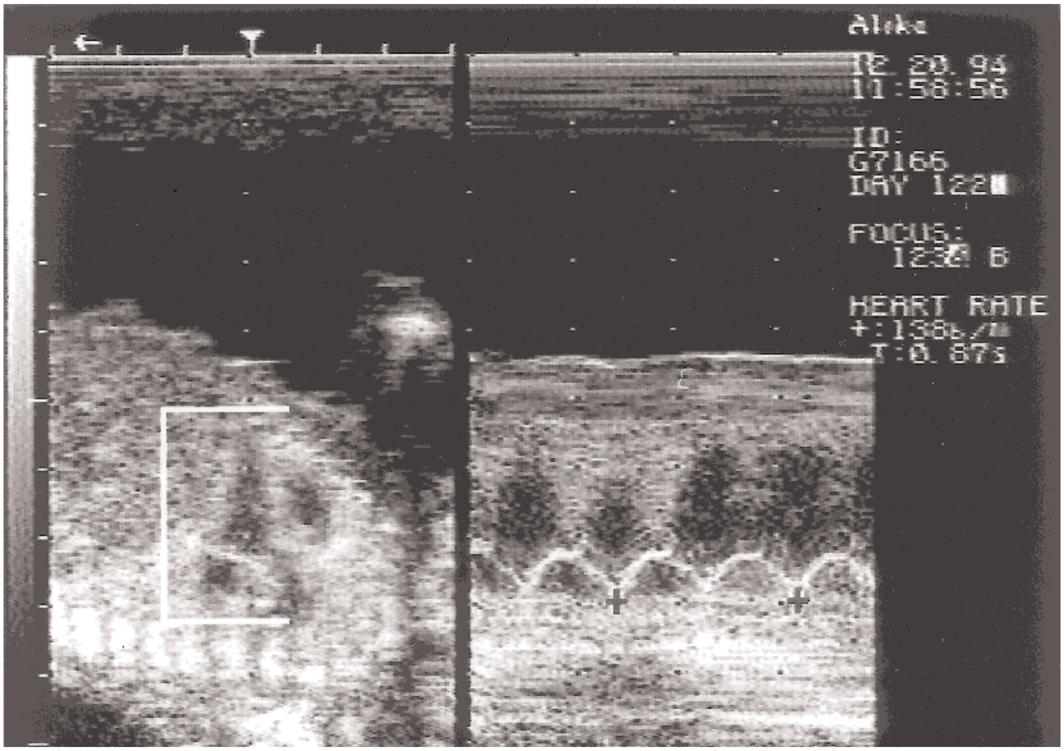
Ultrasonic Reference and End Points

Advantages of ovulation versus estrus as a reference point:

1. Readily and objectively detected
2. Encompasses a narrow time span
3. Represents a profound and central endocrinologic event
4. Detection requires little additional time, if the study involves ultrasonic examinations for other reasons

Ovulation as an ultrasonic reference point. Farm-animal biologists have traditionally used estrus as a primary reference point. Paradoxically, many researchers, even though they determine the day of ovulation ultrasonically, continue to report, for example, profiles of changing hormonal concentrations and follicular development using estrus as the reference or starting point. Behavioral criteria, as used for defining estrus, are difficult to standardize among and within laboratories, experiments, and investigators, whereas ultrasonically determined ovulation is objective. Moreover, ovulation can be confirmed by the development of a corpus luteum. The time of ovulation, in contrast to varying estrous lengths among animals and species, can be narrowly defined by ultrasound, limited only by the frequency of examinations. Furthermore, consideration can be given to multiple ovulations occurring at different times. Another advantage of ovulation as a reference point involves its partitioning of markedly different hormonal environments. The time required for determination of ovulation is minimal if efficient facilities are available (pgs 132 to 135). A program can be developed to decrease the need for daily examinations. For example, in mares, daily examinations need not begin until a follicle has reached 25 mm. If behavioral checks are replaced by ultrasonic monitoring for ovulation, the true length of the estrous cycle will be unknown. The length of the interovulatory interval can be used instead.

Other ovarian reference and end points that have become available solely through ultrasonography include the following: 1) day of emergence of a follicular wave, 2) day of divergence of follicles into dominant and subordinate categories, 3) beginning of regression of an anovulatory dominant follicle, and 4) beginning of morphologic luteolysis. Each of these characteristics will require a firm definition as part of the experimental protocol.



M-Mode display of fetal heartbeats. In this example, the B-mode image of an equine fetal heart at Day 122 is shown on the left; the heart is indicated by the bracket. An M-mode cursor line was placed over the beating heart on the real-time B-mode image and is depicted by the vertical row of dots. The cursor line represents the slice that will be sampled for the M-mode image (right panel). The vertical axis of the M-mode sonogram represents depth and the horizontal axis represents time. The time interval between each vertical row of dots is 0.5 seconds. The changing depths resulting from the beating heart are represented by the rhythmic lines on the M-mode image. Note the echogenic undulating line from the division between heart chambers, the alternating anechoic and echogenic areas resulting from an open and closed beating ventricle (above the undulating echogenic line) and images from the atrium (below the line). The heart rate is calculated by the scanner's computer system based on the distance (time) between two heart cycles or beats; two cursor marks (black crosses) have been placed on the image to identify two cycles. The measured time interval (0.87 seconds) and the computed heart rate (138 beats/minute) are displayed.