Objectives

1) To provide a brief introduction to the principals of ultrasonography.

2) To demonstrate transrectal ultrasonography to evaluate ovarian structures in the bovine.

3) To demonstrate how transrectal ultrasonography is used to detect, age, and sex the early developing bovine pregnancy.

What is ultrasonography?

1) Ultrasonography utilizes pulses of sound waves that are projected towards its intended structures and within seconds the echoes are returned to the source from which they originate.

2) Various body tissues conduct sound differently. Some tissues absorb sound waves while others reflect them. The density of the tissue dictates the speed at which the echoes return.

3) The transducer is responsible for sending and receiving the sound signals while the computer converts the sound signal into an electrical signal, which is ultimately viewed on a computer screen (Figure 1). Transducers come in two types: linear which produces a rectangular image and sector which produces an image similar to that of a “slice of pie”. Transducers come in several frequencies: a 7.5MHz transducer is used to produce great detail but will only image superficial structures, a 3.5MHz transducer can penetrate deeper structures but lacks detail, and a 5 MHz transducer is usually a good compromise in detail and penetration.

4) The picture that the ultrasound generates on the monitor is in different shades of white and grey, which is dictated by the echogenicity of tissues. Echogenicity of a tissue is described by how quickly sound waves are reflected back to the transducer from which they originate. Hence, the echogenicity of a tissue is related to the brightness of the image on the ultrasound monitor. Tissues and or fluids present two types of echogenic patterns:

   **Anechoic:** No echoes of sound; hence, black is visualized on the monitor (i.e., fluid).

   **Hyperechogenic:** Increased echoes of sound; hence, white is visualized on the monitor (i.e., bone).

**Appearance of ultrasound images** (Figures 2 - 6)

**Bone** Increased reflection of the sound so the image appears white on the screen. In the early developing fetus, this is usually cartilage with some bone.

**Connective tissue and fat** Moderate reflection of sound with a dull white image.

**Organ tissue** Medium gray appearance on the screen, which varies between organs. The corpus luteum of the ovary is a good example.

**Fluid** Appears black on the screen since there are few reflective surfaces. Follicles on the ovary are a good example and also blood vessels.

**Complex fluids** Cell clumps within fluid resulting in a black image with white speckles. A cystic follicle would be a good example.
Reproductive Ultrasonography

1) **Ovarian structures** (Figure 2)
   - Follicles are fluid-filled structures that appear black.
   - The corpus luteum is a heterogeneous tissue, which appears medium gray.
   - Abnormal ovaries may contain structures like luteal and/or follicular cysts.
   - Can also be used to aspirate dominant follicles at the initiation of a superovulation protocol. This is also known as “OPU”, or oocyte pickup.

2) **Uterus** (Figures 2 and 3)
   - Detect abnormal fluid buildup, which may be a sign of pyometria.
   - Pregnancy diagnosis by the detection of anatomical structures of the conceptus:
     - Amnionic cavity in early embryonic development is fluid-filled and it appears black while the amnionic membrane is bright white. The fetus, which is inside the amnion, is outlined in medium white and shades of grey.

3) **Fetus** (Figures 2 - 6)
   - Fetal viability
     - Presence of the fetal heartbeat can be seen by day 25 of gestation in the bovine.
     - Fetal heartbeat and integrity of the conceptus and its associated membranes can be evaluated during the first 60 days. Fetal viability can also be determined in horses by a similar method.
   - Fetal aging (Figure 3 and 4)
     - Accurately age fetus between days 25 to 60 of gestation by measuring the size of the fetus. Age and size for 30 (10mm), 35 (15 mm), 40 (25 mm), 45 (35 mm), 50 (40 mm), 55 (50 mm) and 60 (65 mm) day old fetuses. There are significant fetal landmarks that appear as the bovine fetus develops (Figure 4). Similar types of ages and landmarks can be used in the horse. However, they will be different since the equine fetus develops at a different rate than the bovine.
   - Fetal number
     - Typically done in sheep to determine nutritional strategies of ewes carrying single vs. multiple fetuses during gestation. Fetal number is also easily determined in cats, dogs, and horses.
   - Fetal sexing (Figure 5 and 6)
     - Between days 55 - 70 of gestation in cattle by identifying the fetal genital structures:
       - Male - scrotal swelling, fetal prepuce against umbilicus.
       - Female - lack of male structures and appearance of a vulva under the tail.
     - In the equine, a similar set of fetal landmarks is used to determine fetal sex at a similar stage of gestation as the bovine.

4) **Detecting pregnancy in other animals** (Table 1)
   - Ultrasound can be used in all farm animals as well as companion animals to detect pregnancy with the transducer placed either transabdominal or transrectal. Transrectal ultrasound provides a clearer and more detailed picture than transabdominal because the transducer is closer to the reproductive tract. Pregnancy is typically detected by the presence of fluid in the amnionic vesicle, fetal heartbeat, and (or) presence of the fetus in many animal species.
Figure 1.

A) Basic components of an ultrasound scanner: a pulse generator, transducer, a scan converter, and a video display.

B) The development of a 60-day bovine fetus by transrectal ultrasonography. Note the white image projected by the cartilage of the early developing skeleton. (Image adapted from O.J. Ginther, “Ultrasonic Imaging and Animal Reproduction: Cattle” and Pierson et al., 1988, Theriogenology, 29:3-20).

Figure 2. Ultrasound images of the bovine reproductive tract. A) Day 14 corpus luteum (CL), note the dark gray color of the CL and luteal cavity filled with fluid. B) Dominant follicle (14 mm) filled with fluid. C) Uterine fluid - day 30 of pregnancy.
Figure 3. Ultrasound images of bovine pregnancy. **A)** Day 30, note the small size of the fetus which is approximately 10 mm in length and the presence of fluid in the uterine horns. **B)** Day 47, note the development of the limb buds; the fetus is approximately 35 mm in length. **C)** Day 51, the upper right arrow above the head is the amnion, middle arrow is lower jaw, and note the presence of the umbilical cord; fetus is approximately 40 mm in length. **D)** Day 60 fetus, note the cranial image and the cervical and thoracic vertebrae; fetus is approximately 70 mm in length. **E and F)** Placentomes from day 30 (E) and day 60 pregnancies (F) as indicated by the arrows. (Images C, D, E, and F adapted from O.J. Ginther, “Ultrasonic Imaging and Animal Reproduction: Cattle”).
Figure 4. Embryo length and anatomical highlights of the early developing bovine conceptus. (Adapted from Curran et al., 1986; J. Amer. Vet. Med. Assoc. 189:1295-1302).

Table 1. Utilization of ultrasound to detect pregnancy and the earliest stage of gestation pregnancy can be detected with 95 – 100% accuracy in several species

<table>
<thead>
<tr>
<th>Species</th>
<th>Transducer Placement</th>
<th>Earliest days from mating</th>
<th>Diagnostic Criteria</th>
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</thead>
<tbody>
<tr>
<td>Horses</td>
<td>Transrectal</td>
<td>15</td>
<td>Embryonic vesicle</td>
</tr>
<tr>
<td>Cattle</td>
<td>Transrectal</td>
<td>25</td>
<td>Embryonic vesicle</td>
</tr>
<tr>
<td>Sheep/Goats</td>
<td>Transabdominal</td>
<td>45-50</td>
<td>Fetus (es), placentomes</td>
</tr>
<tr>
<td>Sheep/Goats</td>
<td>Transrectal</td>
<td>30</td>
<td>Fetal fluids</td>
</tr>
<tr>
<td>Swine</td>
<td>Transabdominal</td>
<td>30</td>
<td>Allantoic Fluid</td>
</tr>
<tr>
<td>Dogs</td>
<td>Transabdominal</td>
<td>25</td>
<td>Fetal Heart beat</td>
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</tbody>
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Figure 5. Female fetuses (A and B) with swollen genital tubercle (GT) or vulva. Ultrasounds pictures (C and D) show the swollen GT anterior to tail (T) and posterior to hind legs (HL). Figure 5C shows lack of swollen GT anterior to umbilical cord; hence, not a male. (Images adapted from O.J. Ginther, “Ultrasonic Imaging and Animal Reproduction: Cattle”).

Figure 6. Male fetuses (A and B) with swollen genital tubercle (GT) or prepuce posterior to the umbilical cord (UC). Ultrasounds pictures (C and D) show the swollen GT anterior to tail (T) and posterior to umbilical cord (UC). In both figures C and D note the lack of swollen GT or vulva anterior to tail; hence, not a female. (Images adapted from O.J. Ginther, “Ultrasonic Imaging and Animal Reproduction: Cattle”).