Curriculum Units by Fellows of the Yale-New Haven Teachers Institute
1983 Volume VII: Medical Imaging

Imaging the Human Body with Ultrasound

Curriculum Unit 83.07.06
by Elisabet O. Orville

Ultrasound imaging has become part of our lives in the last decade. We are now all familiar with the blurry black and white sonograms (ultrasound pictures) that show the unborn baby inside the mother's uterus. Although it may take a little imagination on our part to understand that a round circle is the baby's head, that does not prevent a proud mother-to-be from showing off her first baby picture. See sonogram below.

Thirty four week fetus

(figure available in print form)
Reprinted by permission of Dr. K.J.W. Taylor, from " *Atlas of Gray Scale Ultrasonography* ", (c) 1978 by Churchill Livingstone.

This unit emphasizes the medical applications of ultrasound. An important part of the unit is a collection of slides depicting ultrasound scans of various organs, showing both the normal condition as well as various pathological states. There are drawings that accompany and clarify many of these sonograms, because ultrasound pictures can be very difficult to understand without explanations. These slides are available by calling me at Polly T. McCabe Center (787-8758).

This unit is designed primarily for biology, ninth-grade physical science, health and human physiology classes in high school, but could be easily adapted as well for the middle school level.

It is strongly advised that this unit emphasizing the medical aspects of ultrasound be used in conjunction with Beverly Stern's unit in the same volume called " *The Basic Concepts of Ultrasound* ". Explained in her unit is the physical basis of ultrasound including:the nature of sound waves;equipment such as the transducer crystal which both emits sound waves and then receives the returning echoes; acoustic impedance and reflectivity; as well as an explanation of B-mode scanning, real-time and gray-scale.

Perhaps only a teacher of ninth-grade physical science or technology would wish to put equal emphasis on both our units, but we feel that since all our lives are becoming increasingly dependent on technology and that is where the jobs will be, students should be exposed to both the biological and technical aspects of ultrasound.

It has been exciting for us to learn about this dynamic , new method of imaging the human body. We participated in Dr. Ronald Ablow's seminar on Medical Imaging during the spring and summer of 1983 and as well as learning about ultrasound, we explored other modalities of imaging such as CT scanning, Nuclear Magnetic Resonance, and Nuclear Medicine. To supplement our theoretical knowledge we visited the Ultrasound Lab at Yale-New Haven Hospital where Paula Jacobsen and staff demonstrated the actual procedures and cheerfully offered themselves as guinea pigs to allow us to get some sonograms.

I am also grateful to Dr. Kenneth J.W. Taylor, Professor of Diagnostic Imaging at Yale, who allowed me to reproduce many of the sonograms from his book, “ *Atlas of Gray-Scale Ultrasonography* ”, 1978; as well as to Dr. John Hobbins, Professor of Obstetrics and Gynecology at Yale, who discussed recent uses of ultrasound in obstetrics with me. Many of the slides are reproduced with permission from his book,” *Ultrasonography in Obstetrics and Gynecology* ”, 1983.

I especially want to thank our seminar leader, Dr. Ronald Ablow, Professor of Diagnostic Radiology and Pediatrics, who initiated us into the mysteries of medical imaging, and patiently and with good humor helped us to learn the concepts and language of a field that was new to most of us.

Introduction to Ultrasound and Echolocation :.

The use of soundwaves in order to “see” is a new and strange concept for students. It might help your classes to get a proper perspective on the subject if they can first understand the phenomenon of echolocation in animals.

Before I continue, I need to define some terms that are used

in the study of sound. HERTZ is the number of sound waves per second. KILOHERTZ is 1000 waves/second and is abbreviated KHz. MEGAHERTZ (MHz) is one million waves/second. ULTRASOUND is sound with a frequency too high for the human ear to hear (over 20 KHz). ECHOLOCATION is the ability of certain animals to produce pulses of sound (either audible or ultrasonic) and then to receive the returning echoes which are processed by the brain to give information about prey or obstacles.

Many animals are adapted to niches where vision is not a particularly useful sense. Some of these animals live in the depths of the ocean or in dark caves, whereas others are nocturnal. Many of these species have evolved the ability to echolocate. For instance, dolphins and all the other species of toothed whales, such as the sperm whale and narwhale,use ultrasound to locate schools of fish at depths where little light penetrates. Oil birds of tropical South America give off audible clicks of sound to avoid flying into the walls of the caves where they live, and shrews echolocate when they are exploring for food.

The best known animal echolocator is of course the bat. There are more than 600 species of bats who use ultrasound in order to catch flying insects at night and to avoid obstacles. By rapidly vibrating their vocal cords they can emit short pulses of ultrasound at a frequency of up to 120KHz. These beams of ultrasound are beamed directionally into the darkness by means of the lips or noseflaps. If a moth happens to be cruising by, the sound waves are reflected from its body and return to the bat’s ears as echoes. When his brain has processed this information, he knows the size of the insect and its speed and direction and thus can swoop in on his prey in the darkness with great accuracy. (An interesting side note is that certain moths have evolved the ability to detect the ultrasound pulses of the bat, and to emit their own soundwaves with the same frequency as those of the bat. This confuses the bat who abruptly stops his attack.)

Just as a bat “sees” in the dark by emitting pulses of soundwaves, so the sonographer (ultrasound technologist) can “see” our insides by aiming high-frequency soundwaves, produced by a crystal with very special properties. There are a few differences of course. The frequencies used in medical ultrasound are much higher (from 1 to 5 MHz) whereas the maximum frequency for bats is 120 KHz.Another major difference is that the bat uses one organ to send sound (the vocal cords) and another to receive the echoes (the ears). In diagnostic ultrasonography the same crystal in the transducer both emits soundwaves *and* receives the returning echoes as well. See Beverly Stern's unit for a fuller explanation.

How ultrasound scans are made

There are many advantages to imaging the body with ultrasound. Most importantly, there is no ionizing radiation as with X-rays, so that ultrasound is used extensively during pregnancy. (More on the safety of ultrasound later in the unit.) Furthermore, soft tissues, such as the liver, spleen, kidneys and pancreas can be imaged directly without the injection of any sort of radio-opaque substances or isotopes to make them visible. In addition, the entire abdomen and pelvis can be rapidly scanned while the patient is lying on the table and photographs can be made of the area in question.

What are the drawbacks to ultrasound? Probably the most serious is the fact that sound is not able to travel through certain organs; their surfaces reflect almost 100% of soundwaves, so that the interiors of these organs and those lying directly beneath them cannot be imaged. Organs filled with air such as the lungs, stomach and intestines are opaque to sound as are hard tissues such as bone. (Acoustic impedance is explained in Beverly Stern's unit.)

However, an organ like the liver is ideal for the sonographer to work with. It is a very large homogeneous soft organ that permits sound pulses to move through with only small amounts of reflection so that the spleen, pancreas or kidney which lie beneath the liver can be imaged as well. For this reason, the liver is called an "acoustic window".

Formerly it was almost impossible to view the cervix and lower uterus because they lay under the air-filled intestines which reflected most of the sound. Then doctors discovered that they could create an ideal acoustic window if they had the patient drink 32 ounces of fluid one hour before an ultrasound exam. The distended bladder pushed the air-filled intestines out of the way and permitted sound to reach the reproductive organs in the lower pelvis.

Another barrier to sound is the air layer between the patient's skin and the transducer. In order to overcome the reflections at this level, the sonographer liberally smears mineral oil (or another lubricant) on the patient's skin before she begins the scanning. If this sounds like a messy exam consider the set-up of ultrasound machines in the 1950's where the patient had to be immersed in a water bath:.

To understand how scanning is done and sonograms produced, we will follow the examination of a patient who is to have a liver scan. He lies on a table with his abdomen liberally covered with mineral oil. Next to him is a large console with a television screen at the top, and connected to this is a hinged arm with a transducer at the end. This transducer contains the crystal which both emits sound waves and then listens for the returning echoes. These echoes are converted into electric signals which are sent to the console and form a picture on the screen. See diagram below.

Ultrasound Equipment with Patient

(figure available in print form)

The sonographer asks the patient to take a deep breath and hold it. This brings the top of the liver out from under the ribs. Then the transducer is either moved in a straight line in a longitudinal or transverse direction, or else rocked back and forth in one place. Either procedure will produce a two-dimensional scan on the screen. The sonographer scans the rest of the liver and takes pictures of areas of interest.

According to Dr. Kenneth Taylor, at Yale-New Haven Hospital ultrasound technicians are trained for 12 months on the job. They must be able to read the scan immediately to decide whether whether the patient needs to have more pictures taken. [1]

It may be difficult for high school students to understand the orientation of the sonograms that they are shown. First they have to realize that sonograms are two-dimensional sections cut through three-dimensional organs. The relationship of the organs in space will probably not make much sense to students unless they have either dissected frogs or studied three-dimensional models of the human body. In Lessons I and II (at the back of the unit) students are given exercises in visualizing how the internal organs would look if the human body were cut at different levels, both in longitudinal and transverse sections. Once they understand this they can be told that, conventionally, longitudinal sonograms are oriented with the patient's head at the left and feet at the right, whereas transverse sonograms are viewed from the patient's feet so that left and right sides are reversed. (See diagram above.)

Imaging various abdominal organs by ultrasound

The following section will explore ultrasound imaging of organs such as the liver, gallbladder and kidneys.

The science of ultrasound is constantly improving. Before the early 1970's ultrasound machines were able to record only the strong echoes arising from the outlines of an organ, and not any low-level echoes from the internal structure. Therefore liver scans, for instance, did not show possible carcinomas or other pathological states.

In 1972 a refined imaging mode was introduced called gray-scale display. This was a huge step forward because the internal texture of many organs became visible. In gray-scale display, low-level echoes are amplified and recorded as well as the higher-level ones, giving many degrees of brightness. Because of this, ultrasound (along with radionuclide scans) are now the most useful method of imaging the liver.

The following picture is a longitudinal sonogram through a normal liver with its characteristic homogeneous texture. The echoes represent the fibrous structure (collagen) of the liver. The diaphragm shows up clearly on the left (towards the patient's head) and the gallbladder is the dark structure on the right. Remember that this is a two-dimensional section through three-dimensional organs.

Longitudinal section through the liver

(figure available in print form)

Reprinted by permission of Dr. K.J. W. Taylor , from " *Atlas of Gray-Scale Ultrasonography* ", © 1978 by Churchill Livingstone.

Cirrhosis of the liver produces very different echoes from those of the normal liver. Excessive alcohol intake causes destruction of normal parenchyma cells which are then replaced by fibrous tissues. These scarred areas produce many distinct echoes and also keep soundwaves from traveling deeper. Characteristically this attenuation (weakening) of sound means that the lower part of the cirrhotic liver does not show up on sonograms.

Ultrasound is also very useful in diagnosing gallstones. The patient is asked to fast before the exam so that the lumen of the bladder will be filled with bile, and hence be more easily visualized. If gallstones are present and the scan happens to traverse them, a very interesting phenomenon can be observed. Gallstones are sonoopaque; that is, they reflect almost all soundwaves so that in a sonogram there will be a dark shadow below each stone. See picture below.

Longitudinal section through two gallstones

(figure available in print form)
Reprinted by permission of Dr. K.J.W. Taylor, from “Atlas of Gray-Scale Ultrasonography”, © 1978 by Churchill Livingstone.

The kidneys have a very characteristic appearance in sonograms. They look like doughnuts in cross-section and are oval with a light interior and dark exterior in a longitudinal view. The light interior represents the renal collecting system and the dark exterior is the renal cortex and medulla. Ultrasound can determine the size and location of the kidneys. In addition, masses or tumors in the kidneys can be imaged. See sonogram below.

Longitudinal section through liver and kidney

(figure available in print form)
Sonogram courtesy of the Yale-New Haven Hospital Ultrasound Lab.

Imaging the female reproductive system by ultrasound

The female reproductive system becomes visible in its entirety when the filled urinary bladder is used as an acoustic window to push aside the air-filled bowels. Vagina, cervix, uterus and ovaries show up clearly. See sonogram below.

Transverse section through the female reproductive system

(figure available in print form)
Reprinted by permission of Dr. K.J.W. Taylor, from “Atlas of Gray-Scale Ultrasonography”, © 1978 by Churchill Livingstone

It is even possible sometimes to see the uterine endometrial layer developing during the menstrual cycle; this layer returns especially strong echoes when it reaches its greatest thickness just before menstruation. According to Dr. John Hobbins, Professor of Obstetrics and Gynecology at Yale, in the future we may be able to use ultrasound to detect precancerous or cancerous changes of the endometrium. Not much work is being done on this aspect of ultrasound presently however. [2]

Ultrasound is useful for showing various abnormalities in non-pregnant women For instance, fibroids(benign tumors of the uterus) are clearly visualized. Occasionally an IUD gets lost, which is, of course, a cause of great concern. The material in an IUD, whether plastic or metal, is opaque to sound, so that these devices return strong echoes on sonograms. By the location of these echoes the gynecologist will be able to tell whether the

IUD is in its proper place (but without the string) or whether it has imbedded itself in the uterine wall. See sonogram below.

Lippes loop—courtesy Dr. K.J.W. Taylor

(figure available in print form)

During the last few years ultrasound has been used to study the development of normal ovarian follicles. This application has great promise in the treatment of infertility.

By constant ultrasonic monitoring, ovarian follicles have been observed to grow in diameter at the rate of approximately 3 mm per day during a normal woman's cycle, until they reach an average diameter of 2.0 to 2.5 cm at the time of ovulation. At the same time the follicle is developing,the woman's estradiol (hormone) levels also rise. Then 28 to 35 hours before ovulation there is a sudden spurt of Luteinizing Hormone (LH) as well. [3] Using all these indications a doctor would know fairly exactly when the woman was about to ovulate. This knowledge would be crucial for the timing of artificial insemination if a couple were infertile.

In vitro fertilization (commonly known as test tube babies) is a procedure that is done at Yale-New Haven Hospital as well as at many other medical centers around the world. A woman who is a candidate for this procedure usually produces normal ovarian follicles with eggs but because her fallopian tubes are blocked or missing, the egg is unable to descend to the uterus.

She is first given hormone treatments to stimulate the development of several follicles at once. These follicles are carefully monitored by ultrasound until they reach their maximal size just before ovulation. Previously the woman would be admitted to the hospital at this point and a procedure called laparoscopy would be performed. That is, two small incisions would be made in her abdomen and the eggs would be gently sucked out of all the large follicles.

Now at Yale the procedure has advanced to the point that the woman can be admitted on an out-patient basis and goes home the same day. Instead of making incisions in her abdomen, doctors can insert the aspirating needle through the urethra and bladder, watching continuously on real-time ultrasound (ultrasound that shows motion). When the follicles are located, the needle is pushed directly through the bladder wall into the ovary. As many eggs as possible are aspirated and placed in a petri dish with the husband's sperm to be fertilized. ("Test tube babies" are not started in test tubes.) When the fertilized eggs reach the 8-cell stage they are placed in the woman's uterus where, hopefully, one of them will develop to maturity.

Ultrasound and Pregnancy

Ultrasound is the only widely used imaging modality that appears to be safe during pregnancy, and it has been estimated that it is currently used in 20% of pregnancies in the U.S.

Ultrasound can diagnose pregnancy at least as early as urine tests and certainly is more accurate. At four to five weeks after the last menstrual period (LMP) a tiny so-called gestational sac appears in the uterus. This hollow fluid-filled ball which looks like a lima bean which is approximately eight mm long, represents the embryonic membrane. The embryo inside is still so minute that it is below the resolving power of the sound waves. (Actually the embryo is really only two to three weeks old at this stage because fertilization occurs at about two weeks after the onset of the last menstrual period.

By six weeks LMP the embryo has grown enough to begin to give off echoes. By the use of real-time ultrasound it can be seen moving in the gestational sac. At seven weeks a beating heart can be detected.

An important use of ultrasound is to detect ectopic (tubal) pregnancies. These pregnancies, which of course can never come to term, are dangerous to the mother because they will rupture the fallopian tube if not detected. If a woman has a positive urine test but ultrasound does not demonstrate a gestational sac in the uterus, then the diagnosis of tubal pregnancy is fairly assured.

Ultrasound is most commonly used during pregnancy to determine the due date of the baby. This might not seem like a particularly crucial reason, but according to Van Bergen, " . . . there is a fourfold increase in perinatal mortality in pregnancies with uncertain dates." [5] Pregnant teenagers whose periods are very irregular may be especially unsure of their expected delivery dates, and therefore constitute a high-risk population. The obstetrician needs to know the age of the fetus for several reasons. For instance, if a caesarean has to be done the doctor has to be sure that he/she does not deliver the baby before its lungs are mature enough to breathe on its own. Or if labor should start spontaneously the doctor must know whether it is premature and therefore should be stopped if possible.

The method used to determine the age of the fetus is as follows: by use of ultrasound the fetal skull is located and then with electronic calipers the transverse diameter is measured on the screen. This measurement is called the biparietal diameter (BPD). The doctor then uses a chart of BPD measurements to correlate the fetal head diameter with its age. For instance BPD measurement of the fetus in the sonogram below was 2.4 cm. On the basis of this (and also of the measurement of the femur) the baby's age was put at 13 weeks.

13 week old fetus

(figure available in print form)
Sonogram courtesy of the Yale-New Haven Hospital Ultrasound Lab

Biparietal diameter charts , which are based on thousands of measurements, have such a high degree of reliability because of the fact that babies' heads all seem to grow at the same rate in *utero* , regardless of race, ethnic origin or size of parents. Even intrauterine starvation of a fetus usually does not slow down the growth of the head, although the rest of the body may be gaunt. One reservation must be noted however. The use of BPD measurements to determine age is much more accurate early in pregnancy than later; after 30 weeks the range of variations is so great that the measurement is not useful.

When a patient comes in to the lab for a BPD measurement to determine her due date, the ultrasound technician routinely checks the organs of the fetus to make sure that everything is normal. It is amazing to realize that ultrasound can even image the soft organs of a fetus inside its mothers uterus:

According to the ultrasound technicians at Yale they check the following fetal organs: kidneys and bladder for obstructions; the heart (which can be seen beating); the spine for a condition known as spina bifida; the head for possible hydrocephaly (enlargement of the brain due to excess pressure); the stomach and the limbs.

Occasionally these routine exams can lead to dramatic results. A few fetuses who were diagnosed as being hydrocephalic during ultrasound viewing have actually had shunts placed in their heads, in *utero* , in order to drain off the fluid which caused pressure on the brain. In another case, a male fetus was seen to have an enlarged bladder caused by a urethral obstruction. Again a shunt was placed *in utero* in order to relieve pressure and future organ destruction.

Those are the dramatic cases that involve invasive procedures, but babies' lives are sometimes saved in less sensational and dangerous ways. Three fetuses at Yale-New Haven Hospital were found during ultrasound exams to have abnormal and potential lethal heart rhythm disturbances. The mothers were subsequently given digitalis, a powerful heart regulator, and the dysrhythmias were corrected without any surgery. [6]

Longitudinal view through heart chambers of fetus

(figure available in print form)
Reprinted by permission of Dr. K.J.W. Taylor, from *"Atlas of GrayScale Ultrasonography* ", © 1978 by Churchill Livingstone

Ultrasound is also used to determine multiple births. The diagnosis of twins, for instance, is regarded as positive when the sonographer can locate two skulls in the same plane. The task becomes much more difficult when there are more than two fetuses.

The position of the fetus can also be imaged on ultrasound. Before 28 weeks the fetus can move around fairly freely in the uterus but after that it assumes its fetal lie. The normal position is cephalic presentation (head down) but occasionally the baby is in a breech position (buttocks down) or transverse position (lying at a 90' angle to the cervix). It is necessary for the obstetrician to be aware of these presentations so that a caesarean can be performed if indicated.

In addition to the position of the fetus, the location of the placenta can also be visualized. This is important, especially in the case of placenta previa, a condition where the placenta covers the opening to the cervix . In this situation, the woman would hemorrhage during a vaginal delivery, so if ultrasound does show placenta previa at term then a caesarean would be indicated.

The doctor also needs to know the location of the placenta and fetus when amniocentesis is required. This procedure is routinely offered to pregnant women who are over 35 and who are therefore at greater risk for bearing a child with Down's Syndrome. A baby with this condition has 47 chromosomes instead of the normal 46. The procedure which is done when the fetus is approximately 16 weeks old, involves the insertion of a hollow needle through the woman's abdomen into the amniotic sac to obtain a sample of fluid with fetal cells. These cells are then cultured and examined for the extra chromosome. The accuracy and safety of amniocentesis procedures depends on the use of ultrasound.

A particularly fascinating aspect of ultrasound is that it allows us to watch the movements of the fetus inside its mother's uterus. It can be seen sucking its thumb, hiccuping and even making breathing movements after 20 weeks. This "breathing" is probably just practice for the outside world since the fetus is well supplied with oxygen through the umbilical cord.

According to Dr. Hobbins the fetus at term normally spends about 70% of its time in a REM (rapid eye movement) state of sleep. (When we adults dream during sleep, we normally exhibit REM.) Ultrasound actually allows the viewer to watch the movement of the lenses inside the fetus' closed eyes. If however, the fetus is stressed there is no REM sleep and its absence at term is an indication of trouble. [7]

The safety of ultrasound

As stated previously it has been estimated by several writers that ultrasonic imaging is now used in 20% of pregnancies in the United States. Some doctors feel that in the future it nay well be used routinely in all pregnancies to check for abnormalities. A few people would even go so far as to say that universal imaging would be desirable because it would help the mother bond to her child when she sees it moving on the screen. I feel that this would be going much too far, both because of the expense and also because of the worrisome issue of the biological safety of ultrasound.

In 1979 the American Institute of Ultrasound in Medicine published a booklet titled, " *Who's Afraid of a Hundred Milliwatts Per Square Centimeter* ?" The conclusion of this publication was that no deleterious biological effects have ever been measured at less than 100 milliwatts per cm^2 of tissue. Present ultrasound machines deliver less than 100 mW cm^2, and many go as low as 40 mW/cm2.

A conference in 1982 on the safety of ultrasound was co-sponsored by the March of Dimes and the Pediatrics Department of Columbia University's College of Physicians and Surgeons. Most of the studies presented indicated that there was no increase in birth defects or cancer in children who received ultrasound *in utero* . However, as reported by the popular press, experiments *in vitro* were less reassuring. [8] Several of these investigations seemed to indicate that there might be biological damage to cells at diagnostic levels of ultrasound. For instance, one experiment suggested that there was an effect on chromatid exchanges in human white blood cells. However, a basic dictum of science is that a scientist's work must be reproducible by other scientists before an experiment is valid. The results of this experiment , as well as several others, could not be confirmed by other investigators.

Despite these reassuring negative results, it is still good to be cautious when using a new modality. Many of us can remember when the danger from X-rays was considered to be so minimal that irradiation was a standard treatment for swollen tonsils and acne.

The following quote sums up the current status of the question of safety of ultrasound:

> In terms of identifiable hazards, obstetric ultrasound receives a clean bill of health. In addition to the substantial literature relating specifically to the fetus, we find no study in the entire body of biomedical ultrasound which clearly demonstrates that there is any effect on the mammalian fetus from pulse-echo ultrasound.
>
> However, a responsible and vigorous scientific community will continue the search for effects. [9]

Lesson Plan I: Two-dimensional sections through three-dimensional objects

Purpose To familiarize students with the appearance of two dimensional slices through a three-dimensional object. This sort of visualizing is necessary in order for them to begin to understand that ultrasound pictures really represent thin slices through the body.
Lesson Plan I will utilize common classroom and household objects and will be presented as a game to flex students' imaginations.

Procedure

1. Look carefully at your pen or pencil.
   a. Draw a transverse section (cross-section).
   b. Draw a longitudinal section. (encourage them to draw the lead or ink cartridge as well.)
2. Continue the exercise by having them draw both longitudinal and transverse slices through some of the following objects: coffee mug with handle, pack of cigarettes, onion etc.
3. Now turn it into a guessing game. You draw sections of familiar objects on the board and have your students guess the object. For instance, apple, teapot, book, beaker etc.
4. Homework. Have your students look around their homes to find other objects that they can draw sections through, then bring the drawings to class and let the other students guess what they represent.

Lesson Plan II: Sections through the human body

Purpose This lesson plan builds on the previous one. It teaches students about planes of the body and then goes on to have them identify the organs in both a transverse and sagittal (longitudinal) section. The final step is to look at slides of sonograms and to identify the organs.

Procedure

1. Draw the indicated sections through these two figures.

Transverse planes

(figure available in print form)

Longitudinal planes (Sagittal)

(figure available in print form)

2. Identifying two-dimensional views of the body organs. It is recommended that students have dissected frogs or at least looked at a three dimensional model of the human body first.
   a. *Transverse section* . (This view is seen looking upward from the feet of a supine patient (lying on back). Therefore the

(figure available in print form)

Labels :

1. Liver
2. stomach
3. pancreas
4. rgt kidney
5. Left kidney
6. spleen
7. spine
8. inferior vene cava
9. aorta

b. *Longitudinal* Section. (This view is seen with the patient's feet at the right and his head at the left).

(figure available in print form)

Labels:

1. rib
2. Liver
3. gallbladder
4. kidney
5. intestines (small)

Lesson Plan III: Ultrasound videotapes and slides

Purpose To make the whole field of ultrasound come alive for students by showing them both slides and real-time ultrasound videotapes.

Procedure The slides which are at McCabe Center (787-8758) have a written guide accompanying them. They begin with pictures of ultrasound equipment followed by sonograms of the upper abdomen, reproductive organs and various stages of pregnancy.

The videotape (at the Yale New Haven Teachers Institute436-3316) shows several modalities such as nuclear medicine, fluoroscopy. The real-time ultrasound segment shows the organs of the upper abdomen as well as the reproductive organs. ***NOTES***

1. Kenneth J.W. Taylor, *Atlas of Gray-Scale Ultrasonography;* New York: Churchill Livingstone, 1978, p. 39
2. John C. Hobbins, personal communication, July 21, 1983.
3. John C. Hobbins, et. al., Ultrasonography in Obstetrics and Gynecology; Baltimore: Williams and Wilkins, 1983, p. 211.
4. John C. Hobbins, personal communication, July 21, 1983.
5. W.S. Van Bergen, *Obstetric Ultrasound: Applications and Principles* ; Menlo Park: Addison-Wesley , 1980, p. 7.
6. Hobbins, pp. 136-137
7. John C. Hobbins, personal communication, July 21, 1983.
8. Joan Arehart-Treichel, Fetal Ultrasound:How Safe?, *Science News* , v. 121, June 12, 1982, p. 396
9. *The Effects of Ultrasound on the Fetus* , The University of Rochester, College of Engineering and Applied Science, Rochester, N.Y. May 1983., p. 19.

BIBLIOGRAPHY

Note: There are very few books about ultrasound for the general public whether adults or teenagers. In fact there are none. Most of the information in my unit comes from reading medical texts or speaking with specialists at Yale-New Haven Hospital.

1. Bartrum, Royal J. Jr., and Crow, Harte C., *Real-Time Ultrasound* . Philadelphia: W.B. Saunders Co., 1983. This text was one of best that I used. The authors have a great sense of humor.

2. Callen, Peter W., *Ultrasonography in Obstetrics and Gynecology.* New York: W.B. Saunders Co., 1983. Very complete with many different authors contributing chapters.

3. Devey, Gilbert B. and Wells, Peter N. T., *Ultrasound in Medical Diagnosis* . Scientific American, 238 (5) 1978. If a student wants to do more reading on the subject this would be the best article.

4. Hobbins, John, C. Winston, Fred and Berkowitz, Richard L., *Ultra-* sonography in Obstetrics and Gynecology. Baltimore: Williams and Wilkins, 1983. This book contained the most recent information on the subject.

5. Leen, Nina and Novick, Alvin, *The World of Bats* . New York: Holt, Rinehart and Winston, 1970. wonderful book with many photos. The last section covers echolocation.

6. Powledge, Tabitha M., "Windows on the Womb", *Psychology Today* , 17 (5), 1983. An interesting article about amniocentesis and ultrasound.

7. Small Miracles of Love and Science, *Life Magazine* , November, 1982. Students would enjoy this article about *in vitro* fertilization and, incidentally, ultrasound.

8. Taylor, Kenneth, J. W., *Atlas of Gray Scale Ultrasonography* . New York: Churchill Livingstone, 1978. Most of the pictures in my unit are taken from this book. It is very clearly written.

9. VanBergen, W. S. ed., *Obstetric Ultrasound: Applications and* P *rinciples* . Menlo Park: Addison-Wesley. 1980.