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Obstetric US Imaging: The Past 40 Years[1]

Although diagnostic ultrasonography (US) was developing in the late 1940s and early 1950s, it was not until the 1960s, with the availability of commercial equipment, that its usefulness in obstetrics began to be realized fully by radiologists and obstetricians around the world. Advances from A-mode to bistable and then to gray-scale static imaging were followed by the introduction of automated compound imaging and real-time US. Also, the development and initial use of Doppler US for the detection of fetal heart motion and the eventual use of pulsed and color Doppler US for the evaluation of such fetal structures as the major vessels and heart chambers contributed to increasing the usefulness of US in obstetrics. The development of specialized transducers—in particular, endovaginal probes—resulted in images of the early fetus. At the present time, the development of multiplanar, three-dimensional imaging shows great promise for more complete imaging of the fetus. The importance of US in the examination of the pregnant patient and, in particular, of the fetus has led to its worldwide dominance as the imaging modality of choice. The contributions of obstetric US to improving maternal well-being and fetal health have been recognized as a key component in all countries around the world.

The beginnings of diagnostic ultrasonography (US) as we know it today were in the late 1940s and early 1950s, with pioneering researchers using sonar and ultrasonic flaw detector–based equipment that was developed as a result of the war effort. A key group in this country that participated in the development of equipment that was among the first to be used in obstetrics was directed by a radiologist, Douglas Howry, MD, at the University of Colorado in Denver, who in 1950 recorded the first cross-sectional images with US (1–4).

The other major research group was led by John Wild, MD, a surgeon who immigrated to the United States from England after World War II. He and his associates developed many of the basic concepts of US instruments as we know them today, which included a transducer that was placed within the rectum—a forerunner of endovaginal scanning. However, his group never emphasized the use of US in obstetrics (5,6). Dr Wild had an indirect influence on an obstetrician, Ian Donald, MD, from Scotland, in terms of introducing him to the potential usefulness of US in diagnosis in humans. Dr Donald, in the late 1950s and early 1960s, with his associates, started to explore the usefulness of US in obstetrics and gynecology (7–9). In the United States, Dr Howry and his engineering associates worked with obstetrician Horace Thompson, MD, and his younger associate, Kenneth Gottesfeld, MD, in using the instruments they developed to examine obstetric patients (Fig 1) (10,11).

It was not until the early 1960s that US equipment became available commercially. It was at that time (1963) that I graduated from the University of Pennsylvania Medical School, Philadelphia, and began an internship at the Albert Einstein Medical Center in Philadelphia, Pa. I had decided to pursue a career in obstetrics and gynecology and asked to be assigned to the obstetrics service during my first rotation. However, after several months I realized that this was not a pathway of interest for me. I explored other possibilities and paid a visit to the Department of Radiology at the Albert Einstein Medical Center and met with the chairman, Jacob Gershon-Cohen, MD, a pioneer in x-ray mammography. It was at this time that the field of radiology was growing with the introduction of invasive procedures, and this attracted me to the extent that I requested and received a residency position at Einstein; I started on July 1, 1964. Several months before I started the residency, Dr Gershon-Cohen purchased an US machine, which was produced by a subsidiary of the Smith, Kline and French pharmaceutical company in Philadelphia known as SmithKline Instruments. It was the third machine they had made (serial no. 0003). The machine was a

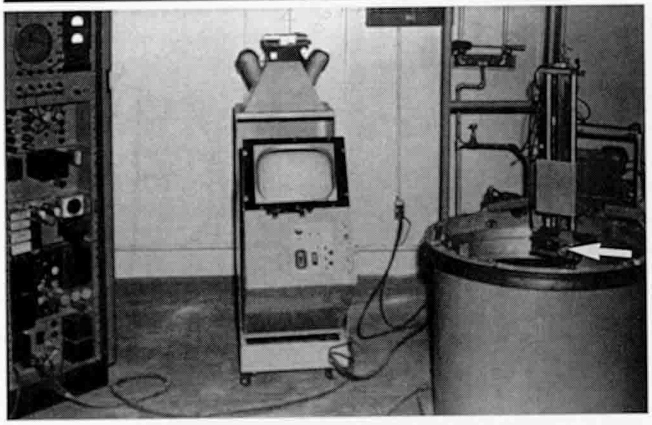

Figure 1. Photograph of Dr Howry's early water bath scanner (1953–1954), with the transducer (arrow) mounted on a ring within the water bath scanner so that it could be moved 360° around the patient. The electronic system is on the left and the display oscilloscope is in the center.

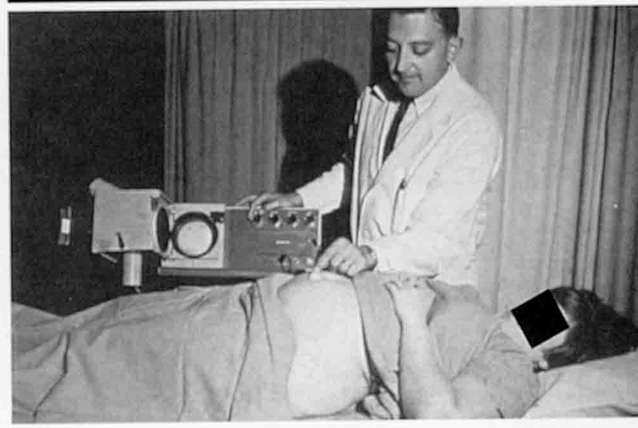

Figure 2. Photograph of SmithKline Instruments A-mode US machine being used by Dr Goldberg to examine a pregnant uterus.

simple A-mode US unit (Echoline 10) and had a Polaroid camera attached to it for recording the images from an oscilloscope (Fig 2). A second machine had been sold in Philadelphia to Temple University's Department of Radiology, where radiologists Mark Lapayowker, MD, and Renate Soulen, MD, were beginning to work within the areas of echoencephalography and echocardiology (12,13).

I remember starting the residency program and seeing a strange-looking machine in the hallway. It was no bigger than the proverbial bread box and was on a cart with wheels. I was familiar with the x-ray equipment available at that time through rotations during medical school, but I had never seen this type of x-ray machine. I remember asking Dr Gershon-Cohen what it was, and he told me that it was a new form of imaging called ultrasound and continued, "See what you can do with it." Having enjoyed conducting research in unrelated areas in medical school, I took up this challenge. I remember going to the library and carrying out a literature search on ultrasound. At that time there were fewer than 100 articles on the subject, and a vast majority of them were related to basic engineering and instruments, with certainly fewer than 50 having any relationship to the clinical usefulness of this new technology. By far the most common area under investigation was its use in echoencephalography; that is, the detection of the midline structures of the brain (one has to remember that at that time there was no computed tomography available). In obstetrics and gynecology, there were at most a dozen articles that referred to this subject in the English-language literature.

I can remember the first time I picked up the bell-shaped transducer that housed the piezoelectric crystal that produced the sound waves and placed it on my abdomen. I saw strange vertical reflections arising from a linear baseline (A-mode display) that had no relationship to any x-ray images I had seen.

Within a month, I had developed a program of research that entailed going to the autopsy room in the morning before work to see if there had been any deaths. At that time, it was much more common to perform an autopsy. I was able to examine the cadaver with the A-mode US transducer, which I placed over the liver, kidneys, pelvis, and heart, and to record reflections that arose at different depths. I placed long needles (up to a dozen) parallel to the ultrasound beam, exactly over where the transducer was placed, in one cadaver. The pathologist noted which structures were at which depths along the course of the needle. In this way, I was able to identify the relationships between the patterns I was seeing and the structures being traversed (14). It was obvious that this information was only one-dimensional, and one had to use one's mind to put together the entire picture.

During the working day, whenever patients were sent for x-ray studies prior to surgery for ovarian, uterine, or renal masses, I would place the US transducer over the area of interest as determined on the x-ray image or by means of palpation and obtain an A-mode US image that appeared to be characteristic of the mass. I then would go to the pathologist's laboratory, where the specimens usually were kept in the refrigerator, remove them, and place them in a water bath (a small fish tank that I had purchased and kept filled with isotonic saline). The specimen was placed within this liquid, and the transducer was placed on the surface. In this way, I was able to correlate the A-mode US patterns that I had seen in the intact body; then, with the help of the pathologist, the specimen was sliced, and photographs were obtained for comparison with the US recordings.

After work, my wife and I would often bring the US machine to the obstetrics department's delivery ward. At that time, it was very common to have labor inductions, and the women who had been admitted that afternoon would be receiving oxytocin drips to induce labor. I was able to obtain fetal biparietal diameter measurements whether the fetuses were in a vertex or breech presentation (Fig 3). Many of these women would have undergone radiography to confirm the position of the fetus and to determine the pelvic dimensions and evaluate for dystocia. My wife acted as my research coordinator, recording the patient information and the US measurements that I obtained in each patient. Next, we would go to the nursery to measure with calipers the biparietal diameter in the babies who had been delivered that morning. These data also were recorded and later were compared with the predelivery US measurements.

There was found to be an excellent correlation between the biparietal diameter measurements before and after delivery in the babies who had been in a breech presentation. However, in those who had been in a vertex presentation, the predelivery measurements tended to be smaller. This discrepancy was easily accounted for by the molding that took

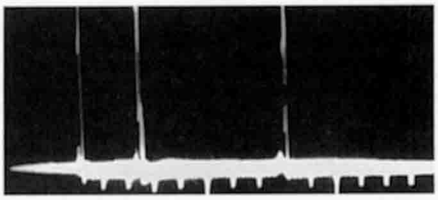

Figure 3. A-mode US image obtained in the fetal head. The first vertical deflection to the left is the maternal skin surface, with the two subsequent reflections arising from the fetal head.

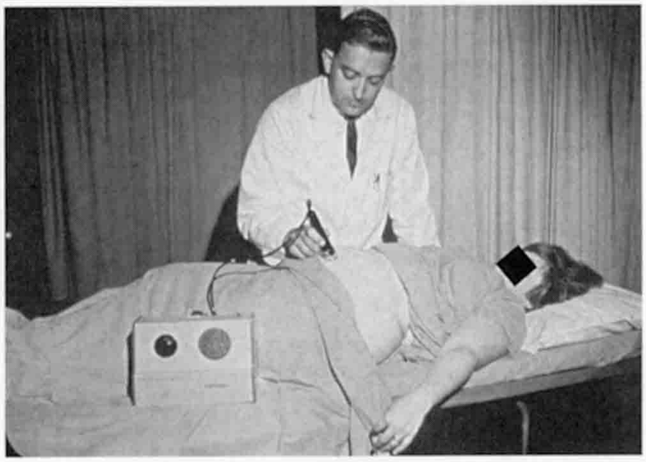

Figure 4. Photograph of a Doptone Doppler unit being used by Dr Goldberg to detect fetal heart motion.

place during the delivery; this was not the case with the breech-presentation babies, many of whom had been born by cesarean delivery. To confirm this, we repeated these measurements in the nursery over the next several days. With remolding of the heads, the vertex-presentation babies' delivery measurements correlated again with the predelivery biparietal US measurements (15).

I remember presenting my first paper at the 1965 Radiological Society of North America (RSNA) meeting. Many of you will recall that during that time, the entire RSNA meeting was held at the Palmer House hotel, Chicago, Ill, and the exhibits were all within the rooms of the hotel. The main meeting was held in the ballroom. It was not until the 75th anniversary meeting of the RSNA, at which there were individual plaques listing the accomplishments for each year of the meeting, that I learned that mine had been the first article on US ever presented at the RSNA. It was also at the 1965 meeting that I began to make contact with equipment manufacturers and learned about other ultrasound machines that were being developed. In 1965, there were only two ultrasound companies displaying their products: Picker X-ray and SmithKline Instruments.

In the department of radiology, as one might expect, there was no room available for the US equipment. The machine initially was kept in a hallway and then was moved into any available examining room to perform a study on a patient. It was during the end of my 2nd year of residency that I was able to obtain a room in which I could store the machine. A word of caution to me, however, was that this formerly was the closet in which the radium had been stored. During that period, the use of radium essentially had disappeared, and it was decided to get rid of the safe and the radium it contained. As you can imagine, I insisted on several Geiger counter readings of the area before I would go into it and store the machine.

Vivid in my memory is the smell of the coating that was used for the Polaroid film. The US machine was equipped with a Polaroid camera; each image was duly recorded, the film was pulled from the packet, and a special coating material was applied that was contained within a sponge in a plastic holder, although one inevitably got the coating on one's hands. Images not coated properly would rapidly turn brown. The images were stored in small envelopes, one for each of the cases, with the information recorded for each case. For presentations, the departmental photographer prepared the images on 3 × 4-inch glass slides.

I remember clearly during my residency a number of the staff physicians and other residents telling me that I was wasting my time, that US would go nowhere, that it was witchcraft compared with radiography, and that it was almost impossible to interpret the images and get reliable information. For whatever reasons, I ignored these naysayers and continued to gather data in many areas and to publish the results. It was just as important that I began to find compatriots within the United States and scattered around the world who were hearing similar negative statements but who were still fascinated by the potential usefulness of this new imaging modality.

Approximately 1 year after I started my residency, one of the salesmen from SmithKline Instruments approached me to evaluate a new advance, Doppler US, that was used to detect fetal heart motion and placental flow, as well as flow within peripheral vessels. This small instrument, known as the Doptone, contained two crystals within the transducer, one sending out a continuous sound wave and another receiving any reflections. Thus, I was able to expand my research in obstetrics by using Doppler US to detect fetal heart motion and the site of the placental attachment (Fig 4). This was a revolutionary approach, since the standard had been to use nuclear imaging to identify the placenta and, of course, to use a stethoscope for detecting the fetal heartbeat. With pulsed Doppler US, it was possible to detect fetal heart motion at a much earlier stage of fetal development.

In the middle of my residency, Dr Gershon-Cohen retired. He had been most supportive of my efforts and never disparaged them, since he had had extensive experience in pioneering work in mammography and knew the difficulties in developing a new technology. My next mentor, the new department of radiology chairman, Harold Isard, MD, also was supportive of my efforts. In fact, I was able to obtain the next model of the Echoline A-mode machine, which allowed the recording of motion (M-mode display) (16). This was most effective in the evaluation of the adult and pediatric heart, but I could also use it in the detection and recording of fetal heart motion.

By the end of my residency, there had been an upswing in the amount of literature available on all aspects of US from around the world. Pioneering works from many groups of both radiologists and obstetricians on the use of obstetric US began to appear with greater frequency. The first measurement charts for predicting gestational age by using the biparietal diameter were developed, and new equipment, including two-dimensional US, was becoming available commercially.

I became aware of other radiologists who were pioneers in US, including Don-

Figure 5. Photograph of compound water bath scanner, which was built by SmithKline Instruments and was located in Dr Lehman's laboratory at Hahnemann Hospital. The transducer could be moved in the water bath that was lowered over the patient's abdomen. The nurse is viewing the formed US image.

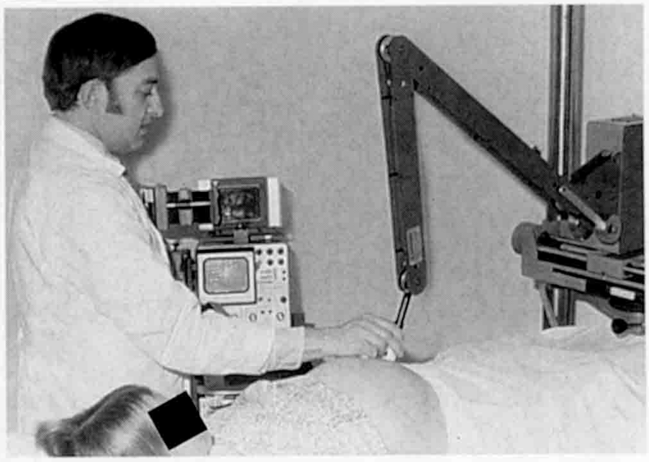

Figure 6. Photograph shows Dr Goldberg moving the transducer in a sagittal plane to obtain images of the fetus with a Picker bistable US machine.

ald King, MD, Frederick Winsberg, MD, Roger Sanders, MD, Michael Johnson, MD, Edward A. (Ted) Lyons, MD, and Arthur Fleischer, MD; all had a strong influence on the development of the obstetric and gynecologic applications of US. Other pioneers such as George Leopold, MD, and Atis Freimanis, MD, developed uses for US in the abdomen, while Raymond Gramiak, MD, concentrated on the use of US within the heart. It should be noted that one of the first fellows of Dr Freimanis was Roy Filly, MD, who has become a leader in the development of the use of obstetric US in the United States. Many others were to follow, including Jason Birnholtz, MD, whose fellow, Beryl Benaceraf, MD, also is recognized as a leading researcher in obstetric US. The same can be said of one of my first fellows, Alfred Kurtz, MD. These individuals and others they trained or influenced helped to make obstetric US an established part of imaging in radiology. At the same time, obstetrician-gynecologists who also were pioneers in obstetric US influenced many in their specialty to perform US. There is a division of obstetric cases between radiologists and obstetrician-gynecologists, with the predominance of obstetric US being performed in offices by obstetricians and within hospitals by radiologists (17).

After completion of my residency and 1 year on the staff at Einstein, I had the opportunity to move to the Department of Radiology at Hahnemann Medical College, Philadelphia, Pa, in 1968. At that time, a radiologist who was also chairman of the department, Jay Stauffer Lehman, MD, worked with radiologists George Evans, MD, and Marvin Ziskin, MD, to conduct research in US (18). They were working with SmithKline Instruments to develop a two-dimensional–US machine. Luther Brady, MD, was instrumental in bringing SmithKline together with Dr Lehman on this project. It was during this period that I was introduced to two-dimensional US equipment.

As with many of the early machines, the initial equipment used was a water bath in which an automated transducer was moved. This allowed for larger transducers that could be better focused to improve resolution. However, the water bath proved cumbersome for routine patient use (Fig 5) (19,20).

In 1970, an opportunity arose for me to move to Episcopal Hospital, Philadelphia, Pa, with a radiologist friend, Gerald Goodman, MD, and to work under the chairmanship of Howard Pollack, MD, a world-renowned urologic radiologist. As part of the agreement for my coming, the hospital obtained one of the early, commercially available, two-dimensional, bistable US machines made by Picker, which had bought the rights to the earlier developments of the Howry group in Denver from their company, known as Physionics. This allowed me to obtain two-dimensional images of the fetus (Figs 6, 7), as well as of other areas of the body.

My research continued with the development of specialized transducers that contained central lumina that allowed for the passage of needles into the body. This was particularly useful during amniocentesis, since it now was possible to demonstrate the best place for removing fluid with either A-mode (Fig 8) or B-scan transducers. When a needle was passed through the lumen, the tip of the needle could be identified clearly within the fluid, and such vital structures as the umbilical cord, the fetus, and the placenta could be avoided. This approach also was used for the aspiration of fluid-filled masses or collections and for the biopsy of masses (21,22).

At this point in the early 1970s, enough articles had been published in the literature, and even books had been written about US, that radiologists were becoming familiar with its use. US already was being included in many of the residency programs; this certainly was the case at Hahnemann and, once I arrived, at Episcopal, where all of the residents rotated through US. It was at this point that I had a small room for the equipment, although, if a patient came on a stretcher, in order to scan, either the head or the feet had to be outside in the hallway. Thus, I had progressed from storage of the earliest US machine in a former radium closet to a room that could hold the machine and half a stretcher or patient. At this time, I began expanding the use of US and, over the next 7 years, acquired additional US equipment, including some of the earliest two-dimensional gray-scale machines made by such companies as Unirad, which eventually was sold to Technicare, then to Johnson and Johnson, and finally to General Electric.

Two-dimensional gray-scale US came about as a result of the development during the Vietnam War of scan converters, which made it possible to display images in shades of gray. With this ad-

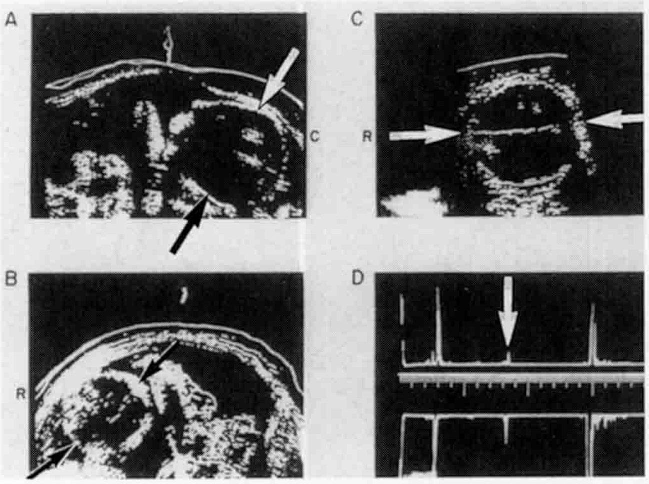

Figure 7. *A–C,* Static B-scan US images obtained with the Picker scanner show a fetal head (arrows in *A* and *C*) and a fetal body (arrows in *B*) within the uterus. *A,* Sagittal plane; *B, C,* transverse plane. *D,* Accompanying A-mode image shows the small central vertical deflection (arrow) obtained from the midline of the fetal brain.

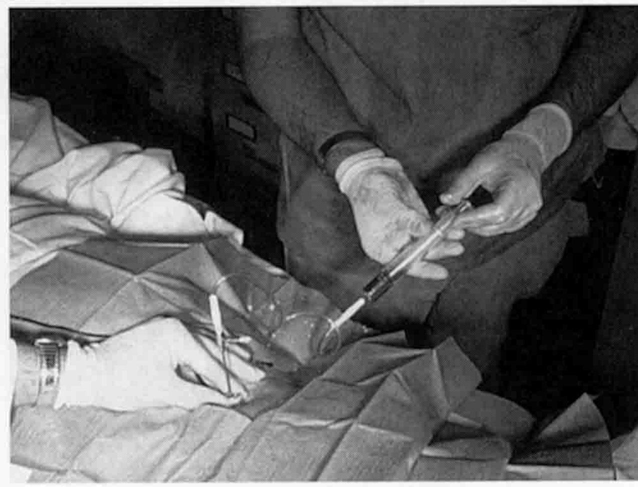

Figure 8. Photograph of A-mode transducer containing a central lumen that has been placed on the abdomen, anterior to the pregnant uterus. A needle has been inserted through the transducer lumen and into the amniotic fluid, which is being removed for analysis.

vance, it was also possible to introduce the concept of compound imaging. This required one to move the transducer in a sectorlike motion as it was advanced across the skin surface. The reason for this was that it increased the chances for the ultrasound beam to strike a reflector perpendicularly and thus increased the chances of recording more complete information from the region of interest. As a result, more detailed US images of the fetus and of other structures throughout the body became possible. This resulted in improved resolution, which made it easier to interpret both normal and abnormal structures. This same concept was incorporated in an automated water bath US machine (Octoson), which I had an opportunity to evaluate when I first arrived at Thomas Jefferson University Hospital, Philadelphia, Pa, in the late 1970s.

In the early 1970s, we still were using Polaroid cameras to record the information, but by the end of that decade, the first film cameras became available, which was important to obtain the best display of shades of gray. By this time, details of the fetus and measurements of all areas of the fetus were being published worldwide by both radiologists and obstetrician-gynecologists. It also was during this time that programs for the training of sonographers and physicians were being developed. In the early 1970s, I started teaching formal training courses and had the opportunity to invite some of the pioneers from around this country and the world to participate.

In the mid-1970s, I had the opportunity to evaluate one of the earliest real-time machines marketed by Siemens Ultrasound, known as the Vidoson (23). It was a large machine with the transducer housed within a liquid-filled bag that made contact with the skin and that produced images at 1–2 frames per second. The company had effectively marketed this machine throughout Europe and South America especially for use in the evaluation of the fetus and had given it to Dr Winsberg in Canada and to me in the United States for evaluation (Fig 9). However, the equipment was not selling in North America, and I was asked to go to Germany to speak to the engineers about why they were not having success here.

I remember meeting the key people within Siemens Ultrasound; they asked me one question: "Why are we not selling in America?" I explained that the machine was very awkward to use and that in the United States radiologists usually worked with technologists who performed the studies, and some found it difficult to maneuver the equipment. In addition, the radiologists tended to look at the static images on Polaroid film and lose the effectiveness of real time in the evaluation of the fetus. I also pointed out that in Europe and South America, physicians were performing the scanning and thus could more easily capture the real-time effectiveness of their product. I remember their response as follows: "You Americans will have to learn how to use our product." I then responded, "I don't think that will happen." Many years later, one of the key people who had been at the meeting came up to me and apologized for not listening. I think that was an important turning point for companies to learn to listen to the users of their equipment. One can have engineers who make excellent machines, but if the machines are not easy to use or are not meeting clinical needs, they will not be accepted. In more recent decades, I and others have worked with companies to make sure that products being developed met the needs of the US users.

Toward the end of the 1970s, the first successful real-time US machines were developed and were made available commercially. (Advanced Diagnostic Research later was purchased by Advanced Technology Laboratories). This revolutionized the use of US for obstetrics, since the fetus, which moves, could be visualized easily, and information about the fetal heart could also be obtained. In the 1980s, real-time, two-dimensional US essentially replaced the static gray-scale imaging machines. With each advance in transducers, equipment, and technology, the use of US to depict more details of the fetus led to its rapid acceptance throughout the radiology and obstetrics-gynecology community.

By the mid-1970s, with the rapid expansion of the uses of US and with its acceptance by the referring physicians, the volume of referred cases had increased to the point where we now had three B-scan gray-scale US machines, and I limited my radiologic practice to US.

Immediately after arriving at Thomas Jefferson University Hospital, I was asked

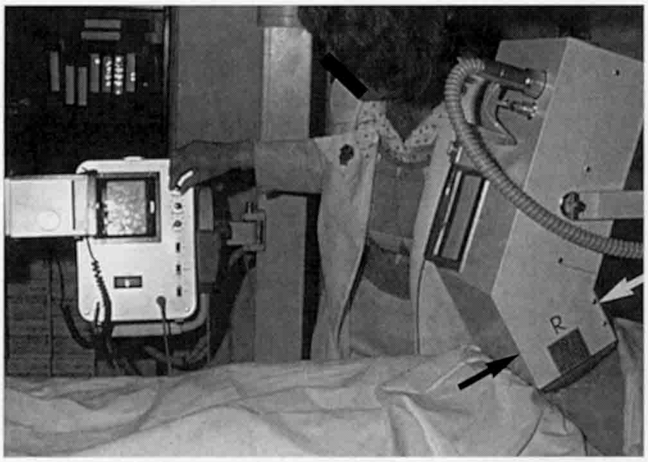

Figure 9. Photograph of a Siemens real-time US scanner positioned over a pregnant uterus. The transducer is housed within the water-filled container (arrows), and the images are being observed on the oscilloscope by the sonographer.

Figure 10. Photograph of an Octoson water bath system, with a pregnant patient lying over a water-filled tank that contains eight large transducers.

to evaluate an automated water-bath US machine (Octoson). It had been developed by a group of Australian engineers led by George Kossoff, DSc Eng, and was being commercialized by an Australian US company known as Ausonics (24–26). General Electric was considering marketing this equipment in the United States, and I was the first to have such a machine to evaluate. This instrument contained eight large transducers housed within a water tank, which could produce two-dimensional, gray-scale compound US scans automatically. The individual would lie on a large membrane that separated him or her from the transducers that moved within the water (Fig 10). While this equipment could image many areas, one of the more exciting uses was in evaluating the pregnant uterus and in producing gray-scale images of higher resolution than was possible with equipment available then (Fig 11). However, General Electric decided not to go ahead with the commercialization of this product, since the image quality of real-time US was improving rapidly. Both gray-scale static and real-time US equipment had advantages over the more complex and cumbersome large water bath approach that had been used by some of the early pioneers and then was reincarnated, with more sophisticated technology, by the Australian group. An automated machine with real-time capability would have been the best approach, but this pathway never was pursued.

Almost since the beginning of US, there was a concern that even though US was nonionizing, it was a form of mechanical pressure wave that vibrated tissues and thus might cause a problem. Many researchers, including those in my research group, have investigated this area. In some countries, particularly in Europe, regulations were passed to use US during every pregnancy. In the United States, a different approach was taken. This came about by a consensus conference called by the government in the 1980s to evaluate the safety of US, particularly in the developing fetus. This conference called together experts that included radiologists, obstetrician-gynecologists, scientists, government officials, and laypeople who were concerned about the developing fetus. As a result of this meeting, many areas were examined, including the competence of the individuals who performed the examinations, the responsibilities of manufacturers to provide safe equipment, and the current knowledge of any bioeffects in the literature.

At the end of the meeting, the consensus was that US was not cancer producing. However, it was thought that since nobody could guarantee that US was 100% safe, it should be used only when indicated clinically in the developing fetus (27). As a result, the government and the third parties who paid for the studies stated that US should be used only when indicated clinically. Nonetheless, the many advantages of US in the examination of the developing fetus have led to its use in more than 80% of all pregnancies.

In the 1980s, additional new technologies were developed and became widespread, including endovaginal US. Its development can be traced back to the beginnings of US and to the initial research of Dr Wild and his engineering associate, John Reid, PhD, and to their development of miniature transducers in the 1950s, as well as to Alfred Kratochwil, MD, in association with the Kretz Instrument Company in the 1960s (28). The development of real-time US, combined with advances in transducer technology, led to its widespread clinical use in the 1980s. It now was possible to examine the early developing fetus and to evaluate for ectopic pregnancy and other abnormalities of the pelvis. This further increased the usefulness of obstetric US and led to earlier diagnoses. By the late 1980s, it was possible to guide needles through the vaginal canal with direction from endovaginal transducers to perform chorionic villus biopsy and to retrieve eggs from stimulated follicles.

By the late 1980s, color Doppler US had been introduced and used in many areas of the body. It was not until the early 1990s that its usefulness in the fetus was fully developed and included the demonstration of placental and umbilical cord abnormalities. More recently, it has been used as a supplement to real-time gray-scale imaging in the evaluation of congenital cardiac abnormalities (29).

In the 1990s, the greatest advance was the development of three-dimensional gray-scale and color Doppler US imaging. Our center has had the opportunity to evaluate some of the earliest three-dimensional–US equipment, which can be used to obtain a volume of US data and display it in multiple planes and to produce reconstructed three-dimensional images (Fig 12). In the United States, Dolores Pretorius, MD, and Thomas Nelson, PhD, have been leaders in developing its uses in obstetrics, as well as in other areas in

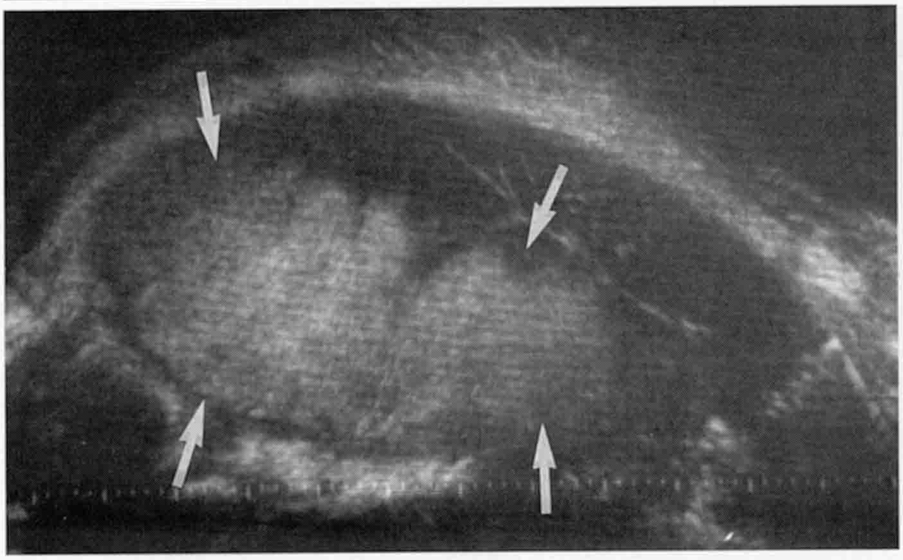

Figure 11. Sagittal, two-dimensional, gray-scale US image of an enlarged placenta (arrows), obtained by using the Octoson equipment.

Figure 12. Three-dimensional, reconstructed US image of the fetal face.

the body (30). My associate, Anna Lev-Toaff, MD, has taken the lead and has developed a technique—three-dimensional hysterosonography—for better defining the uterine cavity and for demonstrating causes of pregnancy failure, such as submucosal myomas and polyps (31). Three-dimensional US often provides additional information about the fetus and includes exquisite detail of the fetal face, limbs, and genitalia. Image reconstruction has improved considerably with advances in computer capabilities. Three-dimensional color imaging allows for the visualization of vessels in many areas of the body. While this is still of limited value in the fetus, one can predict that with improvement in reconstruction, as well as with the development of real-time capabilities, the advantages of displaying vessels and cardiac chambers in the fetus will become possible in the not-too-distant future.

Not only has US had an important effect on the clinical practice of obstetrics because of its use in imaging the developing fetus and in detecting a wide range of abnormalities, but also it has been used as an aid during surgical intervention and treatment. With US, it has been possible to guide needles for amniocentesis and for chorionic villus biopsy and to direct needles into the umbilical cord for fetal transfusions and into dilated fetal ventricles for the creation of shunts. In addition, it has been used as an aid during open intrauterine fetal surgery. It has provided eyes for physicians that enable them to look at the fetus as a patient. Thus, it is recognized that the diagnosis and management of fetal problems could not have occurred without US.

The contributions of radiologists, as well as of obstetrician-gynecologists, to the improvement of maternal well-being and fetal health have been recognized as a key component in all countries around the world. The World Health Organization has placed the importance of US second only to general x-ray imaging in helping to improve health care and the quality of life throughout the world (32). Radiologists in the past and in the present have played important roles in the development and evaluation of new US technology, which has led to improved diagnoses in the evaluation of the developing fetus.

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