ORIGINAL CONTRIBUTION

How Ultrasound First Came to New England

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Diagnostic ultrasound came to Yale in the 1960s and was first developed in Glasgow and London. This story tells us that ultrasound was well-established in the Department of Obstetrics and Gynecology at Yale University School of Medicine in the Yale-New Haven Hospital by 1970. By then it had caught up with the pioneers in New York, Denver, and even Glasgow.

Modern diagnostic ultrasound scanning was conceived and born in Glasgow, Scotland and Denver, Colorado. Echoes in the Scottish glens and among the Rockies! In the mid-1960s the search for a satisfactory clinically convenient and acceptable method of scanning patients had been ongoing for more than a decade. It was Professor Ian Donald (Figure 1) in Glasgow who conceived the idea of contact scanning, actually placing an ultrasound probe in contact with the patient’s skin [1]. At that time it was standard practice to immerse the patient in a water bath to obtain good ultrasound anatomic images of limbs. This approach became unnecessary when it was found that the ultrasound probe could be placed on a surface such as the abdomen, using olive oil or mineral oil as a coupling agent thereby producing satisfactory images. Ian Donald, John MacVicar and Tom Brown in Glasgow and Joseph Holmes, Horace Thompson and Kenneth Gottesfeld in Denver were the pioneers of this successful, clinically applicable, technique.

In 1965, a young gynecologist, Ernest Kohorn, was in need of obtaining a British credential called a “BTA” (Been To America), a prerequisite for the beginning of an academic career in the United Kingdom. Kohorn was then “Senior Resident Obstetric Surgeon” in the Obstetric Unit of University College Hospital in London. Residency training in England was much longer than the four or five years required in the United States, and this was a senior resident post that, however, carried the privilege of admitting patients and having one’s own beds in the hospital. The Chairman of the Department was Professor William C. W. Nixon, the second Chair of Obstetrics and Gynecology in England (Figure 2). He had been Chairman in Hong Kong prior to the Second World War and was in Istanbul during the war. During his time in Turkey, the instrument cabinet in his office swung

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aPresented to the Beaumont Medical Club in 1999, and as a Yale Medical School Historical Library Exhibit in 2003.
Figure 1. Professor Ian Donald of Glasgow, Scotland who first developed contact ultrasound scanning a patient using the Diasonograph, 1963.

away from the wall to reveal the receiver and transmitter for the British secret service. In Nixon’s London department Norman Smyth was investigating transmission ultrasound.

At this time Dr Charles Lee Buxton (Figure 3) was Chairman of Obstetrics and Gynecology at Yale, and both he and Nixon knew Ian Donald who had developed and was actively investigating contact diagnostic ultrasound in Glasgow. The apparatus was known as the “diosonograph,” initially developed by Donald and Brown of Kelvin Hughes Corporation in 1957. Donald had been interested in high intensity ultrasound as a means of treating cancer but conceived of the idea of its diagnostic use when he observed its flaw-
detecting ability when applied to metal sheeting.

Kohorn was sent from London to Glasgow to learn ultrasound scanning. At that time it was possible to image the fetal head and trunk using what was called “compound-B scanning.” The principle of this method is to reduce the vertical deflections caused by the sonic echo to a dot on the oscilloscope screen and then to move the contact probe so as to create multiple echoes thus outlining the object to be screened. This technique allowed precise imaging of the fetal head and its midline echo without the use of a water bath, and this facilitated the actual measurement of the fetal biparietal diameter by a method called “A-scanning.”

By serial examinations it was now possible to measure fetal growth in utero. The structure of the fetus in its amniotic fluid in the uterus was being visualized through the sonic window of the full bladder. It was possible to diagnose twins earlier than by X-ray (Figure 4). This is because radiology cannot visualize the fetus prior to about 18 weeks gestational age when the base of the skull and the ribs first calcify. By ultrasound scanning the fetus could, in 1965, definitely be seen by 12 weeks. At the time of Kohorn’s arrival in Glasgow, Donald was beginning to try to define the ultrasound appearance of the placenta. A patient who required manual removal of the placenta was moved to the operating room where a diasonograph was present, and while Kohorn performed the manual removal of the placenta, Professor Donald scanned the patient’s abdomen. The site of the placenta was identified on the ultrasound screen by Kohorn moving his fingers and that detectable motion outlined the placenta (Figure 5). For the first time it was possible to see the placenta in the posterior position. The anterior placenta’s position had been visualized by Gottesfeld, Thompson and Holmes in Denver. Because they had only a 1.5 megahertz probe, it did not give the penetration provided by the 5-megahertz probe available in Glasgow. By changing probes the anterior placenta could be defined with the 1.5 megahertz probe and the posterior placenta with the 5-megahertz probe (Figure 6). This technique was later refined by Kohorn for imaging placenta previa, particularly the posterior placenta previa (Figure 7).

Kohorn’s days in Glasgow were spent in performing ultrasound scans, while the evenings were devoted to helping build Professor Donald’s sailing boat; the weekends were spent sailing in half gales on Loch Fife. These outings were somewhat
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intimidating because Professor Donald had been defibrillated on a visit to Detroit only some three weeks previously; he was on his second artificial mitral-valve.

In August 1965, Kohorn arrived in New Haven. His appointment was that of Instructor for one year at a salary of $10,000 a year. Unfortunately, the promised dionograph compound “B” scanning machine was not forthcoming, and the only ultrasound machine available was an “A” scanner which allowed the imaging of deflections on an oscilloscope and so the measurement of fetal biparietal diameters but not two-dimensional scanning. In spite of this frustrating disappointment, Kohorn went to work and began serial weekly measurements of all babies in the prenatal clinic. The nature of the mid-line echo had not been ascertained. Dr. Edmund S. Crelin, Professor of Anatomy, provided a fetal skull (which was named Eric) and experiments were performed in water baths to try to ascertain what exactly the mid-line echo was; was it the falx, the medial aspect of the hemisphere, or the thalamus? This work became the first critical assessment of biparietal fetal cephalometry [2].

At that time there was still significant concern about the safety of diagnostic ultrasound and “volunteer” neonatal babies were submitted to ultrasound measurement of the head using a 5 megahertz probe with simultaneous performance of an electroencephalogram [3]. The difficulty in ascertaining the safety of diagnostic ultrasound was that the power of the ultrasound was so small that the energy could only be calculated rather than measured.

During that year in the United States, Kohorn visited Kenneth Gottesfeld and Dr. Holmes in Denver as well as Professor Louis Hellman at Downstate Medical Center in New York where Dr. Mitsunao Kobayashi, with the technical help of Mr. Felicity, were successfully using a dionograph, the same apparatus that was being used in Glasgow. The excitement of their research heightened Kohorn’s frustration because they had the apparatus he needed to go forward. The work at Downstate eventually resulted in the publication of Kobayashi’s classical atlas of sonography.

In July 1966, Kohorn returned to London and University College Hospital. To his great surprise he found a dionograph there. The British Ministry of Health had purchased three of these machines to determine whether the funny shadows that were being obtained in Glasgow had any significance and had elected Dr. John Hodson, Chief of

Figure 6. Posterior placenta previa demonstrated by ultrasound in 1966. a: anterior abdominal wall, h: fetal head, p: placenta. Line = amniotic fluid-placental interface.

Figure 7. Placenta Previa diagnosed by ultrasound scanning, 1966. Transverse scan through lower uterine segment.
Diagnostic Radiology at University College Hospital, to initiate and supervise this investigation. All three machines were lying fallow at London Teaching Hospitals. It turned out that Kohorn was the only individual in London, and even in all of England, who knew how to use this machine. Rowland Blackwell was the physicist assigned to help in that investigation. Kohorn and Blackwell got busy. They established both “A” scanning and compound “B” scanning at University College Hospital. They investigated fetal growth, defined the characteristic appearance of the placenta both anterior and posterior and were able to image placenta previa [4]. They began the study of the first trimester of pregnancy using ultrasound imaging. Prior to this time, visualization of the first trimester fetus and differentiating between a healthy fetus, an inevitable miscarriage or a hydatidiform mole was not possible. They were therefore able to distinguish a hydatidiform mole from twin gestation which had also first been achieved in Glasgow and Denver. Their paper on moles was the third published on that subject [5].

Radioactive isotope imaging was then being used to image the placenta, and in order to confirm that the two techniques gave similar results, technetium isotope scanning was compared with ultrasonography [6, 7]. Prior to the advent of ultrasound it was customary to diagnose twins or even triplets by X-ray, but ultrasound gradually replaced the radiological investigation of early pregnancy to confirm the presence of multiple pregnancy. By late 1966, a paper demonstrating the ultrasonic appearances of the posterior placenta was submitted for publication by Kohorn, Stewart Campbell, and Blackwell. Stewart Campbell, who had trained with Ian Donald, had come to the Institute of Obstetrics in London as senior lecturer, but had no ultrasound machine. He joined Blackwell and Kohorn at University College while arrangements were made to transfer one of the diasonographs from the teaching hospital, where it was gathering dust, to Queen Charlotte’s Hospital. This did not occur until early 1967. It is of note that Professor Stanley Clayton, then editor of the British Journal of Obstetrics and Gynaecology, delayed the publication of that paper to allow Professor Donald in Glasgow the courtesy of publishing his findings of placentography simultaneously to the report from University College Hospital so that these two papers were published back to back in April, 1967.

About this time, Kohorn received a call from the United States where Professor Edward Quilligan had succeeded Lee Buxton as Chairman of the Department of Obstetrics and Gynecology at Yale. He invited Kohorn to return to New Haven to establish a diagnostic ultrasound unit at Yale. “But I am really interested in pursuing a career in gynecologic oncology,” said Kohorn. “That’s fine,” said Quilligan, “just establish the unit of ultrasound and then you can do what you want.” Such was the climate of medicine in the United States in 1967. One was given quite sufficient rope to succeed or to hang oneself. Kohorn made the fateful decision to burn his British boats and to come to New Haven where he arrived in August 1968. This time a diasonograph was available. It must be realized that this was before the days of computer chips and the apparatus was equipped with electronic valves (U.S., vacuum tubes). Quite frequently it seemed the evening cleaners of the Radiology Department, where the apparatus was housed, flipped the switches during the night and readjustments had to be made the next morning. The machine was placed in a small room in the then Department of Radiology on the second floor of the Memorial Unit of Yale-New Haven Hospital. There was barely room for the large machine and the attached patient stretcher. Practical scanning began and all obstetricians in the New Haven area were invited to submit their obstetric and gynecological cases.
colonic cases for sonography. Given the limited electronics of the apparatus the pictures that were obtained must, even nowadays, be considered to be reasonably satisfactory. First-trimester fetuses were readily visualized (Figure 8). The Yale group learned about the "disappearing twin," that is to say that one fetus of a twin pregnancy dies and is absorbed. By scanning, one sees a double sack early on at four to six weeks gestational age and by eight weeks gestation one of these fetuses has disappeared! They learned that a placenta previa could not be diagnosed at six to 12 weeks and that as the uterus grows the placenta, gradually "moves" into the upper segment of the uterus. They began to scan gynecologic cases and could certainly, as was also happening in Denver and in Glasgow, diagnose ascites as well as beginning to differentiate malignancies from benign ovarian cysts.

There was great demand by other physicians to scan kidneys, livers, thyroids, and even hearts. Kohorn felt that unless he could confine his scanning to obstetric and gynecologic patients, the thrust of these early investigations would be diminished. An exception was made with thyroid scanning. Kohorn with Dr. Gerard Burrow, then an associate professor in the Department of Medicine, produced the earliest thyroid scans, certainly the first in the United States. These scans were presented at a meeting of the Ultrasound Society [8]. One could then clearly differentiate solid from cystic lesions of the thyroid and this has now, of course, become routine practice. One patient of Dr. Max Taffell, then Associate Chief of General Surgery, was of particular interest. The patient had a large mass extending in her left flank from the costal margin into the pelvis (Figure 9). Ultrasound scanning correctly diagnosed that this was cystic with no solid elements so reassuring the surgeon that it was most probably benign. Also this was the beginning of liver scanning; it appeared that one could differentiate malignancy in the liver.

By 1972, the ultrasound unit was well-established, and there was more confidence that those "funny shadows" that the fellow with a "foreign" accent had brought from Glasgow might in fact be useful. Ultrasound was now being used frequently and clinically profitably to diagnose abnormalities of early first trimester pregnancy. This investigation provided an M.D. thesis research project for one Yale medical student [9].

By then Dr. John Hobbins had returned to Yale after a stint of Army service. Dr. Hobbins had been the resident who had arranged for the babies for the ultrasound safety study in 1966 mentioned earlier. He was the person who was recruited by Dr. Quilligan to develop a modern clinical obstetric unit. Kohorn decided to go back to his first love of gynecologic oncology and surgery and, somewhat to the then chairman's surprise, offered to hand over the working ultrasound operation to the new high-risk obstetric unit. After all, it was difficult to do emergency ultrasound scans in the middle of a radical hysterectomy.

That is how ultrasound came to Yale and how ultrasound was first developed in London. This story tells us that ultrasound was well established in the Department of Obstetrics and Gynecology at Yale University School of Medicine in the Yale-New Haven Hospital by 1970 and had by then caught up with the pioneers in New York and Denver and even Glasgow. In the next few years computerized machines and multiple array machines began to appear so that scanning became significantly more precise and the apparatus

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This student subsequently became an ophthalmologist, somewhat analogous to Friedrich Kruckenberg (1871-1946) who, having described his three cases of Kruckenberg tumor of the ovary, then branched out also to become an ophthalmologist.
smaller and more clinically manageable. The stage was set for the revolutionary advances in fetal diagnosis that modern ultrasound has made in the first trimester and in being able to diagnose abnormalities of the fetus so precisely throughout pregnancy. This, of course, is quite apart from the revolutionary use of ultrasound in nephrology, thyroid disease, hepatology, cardiology, thromboembolic events, and the wider modern use of this fantastic diagnostic technique. The truism however remains that the results obtained with diagnostic ultrasound are just as good as the physician behind the machine. In the early days there were very few mistakes; Ian Donald hardly ever made a mistake. These pioneer ultrasonographic physicians took a history, made a diagnosis, examined the patient to confirm that diagnosis, and then used ultrasound to substantiate and confirm whether they were right or wrong. That is still the most appropriate way to use this and other imaging techniques.

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