

Medical ultrasound: Case Study

Today we take for granted the use of ultrasound for medical examination and diagnosis, but in the 1950s ultrasound was still an emerging technology. NHMRC supported ultrasound research in Australia from its early beginnings, and one of the first ultrasound scanners was developed by NHMRC-funded researchers. Co-developed with the Australasian Society for Ultrasound in Medicine (ASUM), this case study focuses on the work of the Ultrasonics Institute (UI) and of pioneering Australian doctors and sonographers who revolutionised the use of medical imaging.

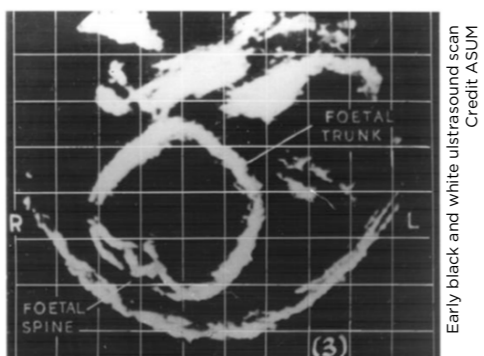


Background

At the beginning of the 20th century the only medical diagnostic imaging tool available to doctors was X-ray. Early X-ray machines had their shortcomings: patients might be required to stand completely still for several minutes of intense radiation exposure in order to obtain a useful image. Consequently, taking X-rays of pregnant women and infants was dangerous. A safer approach to medical imaging was needed.

In 1943, NHMRC established an Acoustic Testing Laboratory (ATL) in Sydney to undertake war-time research. The laboratory later became the Commonwealth Acoustic Laboratories (CAL) (1947). In 1975, the CAL's Ultrasonics Research Section became the Ultrasonics Institute (UI).

Directed by Norman Murray, the laboratory initially focused on hearing support for deafened veterans and children affected by the 1940-41 epidemic of maternal rubella. During the 1950s, Murray became interested in developments in ultrasound to treat Ménière's disease and Parkinson's disease, and the diagnostic use of reflected ultrasound to detect and determine the nature of breast tumours.



Development and Investment

NHMRC funded the establishment of the ATL and the salaries of its staff from 1943-46. In 1946, the Australian Government Department of Health (DoH) took over funding the laboratory. In 1955, NHMRC set up an Ultrasonics Committee, chaired by Murray, to inquire into the control and use of ultrasonic therapy apparatus and establish standards in the measurement of acoustic output.

In 1958, UK obstetrician Dr Ian Donald first used ultrasound in a clinical setting in Glasgow. Informed by this development, Murray sought to produce such a system in Australia and recommended to NHMRC that CAL employ a full-time scientist to undertake research into this new field of diagnostic medical ultrasound. George Kossoff joined CAL in 1959 as a research physicist and also became a member of NHMRC's Ultrasonics Committee, as did Dr William Garrett, an obstetrician at Sydney's Royal Hospital for Women (RHW). Kossoff headed the section, which was made up of technical experts working with a variety of medical specialists. By 1963, CAL had become world renowned for its research and development in the field of medical ultrasound.

Between 1970 and 1990, NHMRC funded CAL/UI researchers and others including:

- **Professor John McCaffrey:** for blood flow studies and to develop an ultrasonic computerised tomography system
- **Professor David Wilcken:** for multi-scanning echocardiography (using ultrasound to generate images of the heart)
- **Professor Brian Trudinger:** for Doppler ultrasound (blood flow volume and velocity studies) of the placenta and fetus
- **Professor Thomas Reeve:** for characterisation of breast tissue by ultrasound.

Research

Technology: In 1961, the first commercially practical Australian ultrasonic scanner (the CAL Echoscope) was built by Kossoff and Dr David Robinson. From 1970, CAL Echoscopes were modified to include greyscale scanning: a world first. This technology represented a significant improvement over the black and white imaging that was previously available. It produced clearer and more detailed images and could reveal soft tissues.

Obstetrics: In May 1962, the first ultrasound obstetrics examination was performed at the RHW by Robinson, Kossoff and Garrett. In the early 1970s, Garrett led the world in identifying fetal anatomy using ultrasound, and he and Robinson published an early textbook on ultrasound in clinical obstetrics. Professor Robert Gill, a researcher and developer of Doppler ultrasound techniques joined UI in 1975. In 1979, he published the first measurements of blood flow in the umbilical cord in pregnancies, paving the way for Doppler to be used in other studies.

Breast: In 1966, a dedicated breast scanner was installed at the Royal North Shore Hospital (RNSH). Reeve was the clinical consultant. Scientific support was provided by Dr Jack Jellins, and Kaye Griffiths made significant contributions to this work. From 1969, Reeve began developing a comprehensive range of diagnostic interpretative criteria.

Brain: In 1969, Kossoff and Robinson developed an Ultrasonic Neuroscope which produced clear images of the brain. Unlike the previously available methods, this form of imaging posed no risk to the infant. The team, working with Garrett, also used the device to create an atlas of the normal infant brain.

Heart: Wilcken collaborated on the very early development of echocardiography. He, along with Dr Ian McDonald, was one of the first to develop and promote its use in Australia.

Results and Translation

After greyscale became available, one of the early discoveries by Reeve was the different ultrasonic features in benign and malignant solid lesions in the breast. This led to more accurate cancer diagnoses.

The UI team continued to make technical improvements to their scanners. In 1975, Kossoff and Robinson developed the UI Octoson. Ausonics Pty Ltd was established to manufacture it in Sydney. Over the next five years nearly two hundred were sold worldwide.

In 1987, Trudinger and his team at The University of Sydney published results of the first randomised clinical trial showing the usefulness of umbilical artery Doppler ultrasound to assess fetal well-being in high-risk pregnancies. Much of this work remains in mainstream clinical practice today.

McCaffrey advanced the understanding and implementation of breast cancer screening and of the treatment of early breast cancer. He played a major role in the establishment of breast ultrasound in Australia and internationally.

Wilcken used echocardiography to visualise mitral valve prolapse (an abnormality of a heart valve) on which he became one of the world's leading experts. In 1977, he organised the first course in echocardiography. Echocardiography is now an essential part of routine cardiac assessment.

The skill required of sonographers (i.e. operators of ultrasound scanners) was recognised in Australia early on. The Australasian Society for Ultrasound in Medicine (ASUM) was formed in 1970 as use of ultrasound spread further than the UI. In 1976, Garrett helped set up the Diploma of Diagnostic Ultrasound for doctors and the Diploma of Medical Ultrasound for sonographers.

Health Outcomes and Impact

As technology advanced, the early ultrasound scanners were superseded by smaller, more portable, electronic, real-time scanners. But the use of ultrasound as an accepted clinical tool was firmly established, as was its excellent safety record.

In the late 1960s and early 1970s, cardiac diagnostics such as ultrasound, along with other factors, resulted in improved survival from chronic heart disease in Australia. By the mid 1990s, use of cardiac and vascular ultrasound was increasing significantly and that growth has continued up until the present time.

By 1995, ultrasound in pregnancy represented 20% of ultrasound services and was performed in 97% of pregnancies.

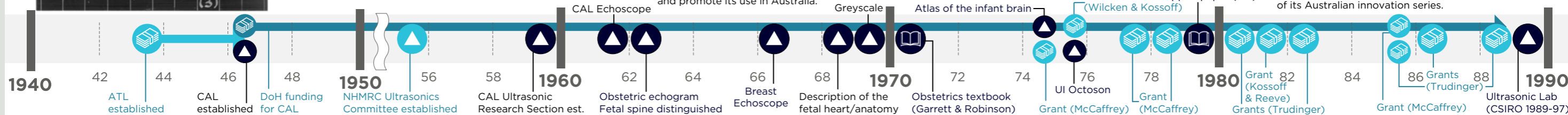
- Evidence from randomised trials during pregnancy had shown that a routine 16-18 week scan in pregnancy reduced perinatal mortality through the detection of fetal abnormalities.
- The use of Doppler ultrasound of the umbilical artery as a clinical guide to management of high-risk pregnancies had been shown to reduce the odds of perinatal death by 38%.

| | 1993/1994 ('000) | 2019/2020 ('000) |
|--------------------------|------------------|------------------|
| General | 1,100 | 4,100 |
| Musculoskeletal | 54 | 2,900 |
| Cardiac | 169 | 1,500 |
| Obstetrics & gynaecology | 401 | 1,300 |
| Vascular | 145 | 1,200 |

Source: Services Australia

Diagnostic imaging now plays a critical role in a world-class, 21st century health system.

UI was transferred to CSIRO in 1989, becoming its Ultrasonics Laboratory until 1997. In 2004, Australia Post issued a stamp highlighting ultrasound as part of its Australian innovation series.



Norman Murray

Norman Murray (d 1971) was a pioneer of acoustics research in Australia and the foundation Director of CAL (1947-1967). He chaired NHMRC's Ultrasonics Committee from 1955-63.

Dr George Kossoff AO

Dr George Kossoff designed the first Australian ultrasound scanner and later the scan converter that led to the clearest greyscale images seen at the time. He was foundation President of ASUM (1970-72) and President of the World Federation for Ultrasound in Medicine and Biology (1982-85). He was appointed an Officer of the Order of Australia in 1999.

Dr William Garrett AM

Dr William Garrett (1927-2015) was founding Medical Director of RHW's Department of Diagnostic Ultrasound and President of ASUM (1972-74). He was appointed a Member of the Order of Australia (AM) in 1985 for service to medicine, particularly the science of obstetric ultrasound.

Dr John McCaffrey

Dr John McCaffrey (1933-2000) was an oncological surgeon at the Royal Brisbane Hospital, where he founded the first public breast screening clinic in Australia. He was a founding member of ASUM and President of ASUM from 1982-83.

Professor David Wilcken

Professor David Wilcken (1927-2020) was a pioneering cardiologist at the Royal Prince Henry Hospital and one of the world's leading experts on mitral valve prolapse. His later research confirmed the link between smoking and the diseased arteries which lead to heart failure.

Professor Brian Trudinger

Professor Brian Trudinger was Professor of Obstetrics and Gynecology at Westmead Hospital, The University of Sydney. His ultrasound studies of placental blood flow and its effect on fetal physiology led to a new way of monitoring fetal wellbeing. In 2006, the International Society of Ultrasound in Obstetrics and Gynecology awarded him the Ian Donald Gold Medal.

Dr David Robinson AM

Dr David Robinson (1939-2010) built Australia's first ultrasound scanner and helped develop greyscale ultrasound scanners. He was President of ASUM (1974-76) and was appointed a Member of the Order of Australia in 2002. The Australasian College of Physical Scientists & Engineers in Medicine (ACPSEM) established a prize to commemorate his contributions to the field of biomedical engineering.

Professor Robert Gill

Professor Robert Gill is a pioneer in Doppler ultrasound technology. As well as scientific publications and papers on his research, he has authored four international patents. He was President of ASUM (1990-91).

Prof Thomas Reeve AC CBE

Professor Thomas Reeve was Surgical Research Fellow in the Unit of Clinical Investigation at RNSH and involved in clinical ultrasound during its early development for the study of the breast, and the thyroid and parathyroid glands. An expert in his field, Professor Reeve was appointed Commander of the Order of the British Empire in 1973, and a Companion of the Order of Australia in 1994.

Kaye Griffiths AM

Kaye Griffiths (1945-2017) was a research sonographer who pioneered two dimensional techniques to examine the brains of young children. She convened the First World Congress of Sonographers in Sydney in 1985. In 2002, she was appointed a Member of the Order of Australia.



References

This case study was developed in partnership with ASUM. The information and images from which impact case studies are produced may be obtained from a number of sources including our case study partner, NHMRC's internal records and publicly available materials.

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