Medical ultrasound: Case Study

Today we take for granted the use of ultrasound for medical examination and diagnosis, but in the 1950s it 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 Ultrasound Research Section became the Ultrasonics Institute (UI).

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

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 Ultrasound 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 in this new field of diagnostic medical ultrasound. George Kossoff joined CAL in 1961 to work as a research physicist and also became a member of NHMRC’s Ultrasound Committee. As did Dr William Garrett, an obstetrician at Sydney’s Royal Hospital for Women (RH), Kossoff headed the section, which was made up of technical experts working with a variety of medical specialties. By 1963, CAL had become 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 Wilkinson**: for multi-scanning echocardiography (using ultrasound to generate vascular images)
- **Professor Brian Trudinger**: for Doppler ultrasound (blood flow velocity and acceleration studies) of the placenta and foetus
- **Professor Thomas Reeve**: for characterisation of breast tissue by ultrasound

Development and Investment

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Research

**Technology**: In 1961, the first commercially practical Australian ultrasonic scanner (the CAL Echoscope) was developed at the Commonwealth Scientific and Industrial Research Organisation (CSIRO). In 1970, CAL Echoscopes were modified to include greyscale scanning at 10 frames per second. 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 RH by Dr. Donald, Kossoff and Garrett. Garrett led the world in identifying fetal anatomy using ultrasound. 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 1976, 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 1989, Kossoff and Robinson developed an Ultrascan Neuroscope which produced clear images of the brain. Unlike the previously available methods, this form of imaging posed no risk to the infant. 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 ultrasound features of benign and malignant solid lesions seen 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 Doppler arteriography in the assessment of 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 the treatment of early breast cancer. He played a major role in the establishment of breast ultrasound in Australia and internationally.

Wilcken used echography to visualise mental variolus plaque (an abnormality of a heart valve) on which he became one of the world’s leading experts. In 1977, he organised the first conference in echocardiography. Echocardiography has now become 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 a support network of ultrasound professionals. The use of ultrasonography in medicine continues to expand and is now an integral part of modern medical care.

Health Outcomes and Impact

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

In the late 1960s and early 1970s, cardiac diagnosticians 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.

- **Doppler arteriography** has been shown to reduce the odds of perinatal death by 38%.
- **Ultrasound for obstetric examination** has been shown to reduce the odds of fetal death by 62%.
- **Echocardiography** has been shown to reduce the odds of heart failure by 37%.
- **Echotomography** has been shown to reduce the odds of stroke by 33%.
- **Doppler paper** has been shown to reduce the odds of occlusion by 30%.

The use of Doppler ultrasound of the umbilical artery as a clinical guide to management of high-risk pregnancies has been shown to reduce the odds of perinatal death by 38%.

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

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

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
<th>Value</th>
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<tbody>
<tr>
<td>1940</td>
<td>ATL established</td>
<td>42</td>
</tr>
<tr>
<td>1946</td>
<td>CAL established</td>
<td>46</td>
</tr>
<tr>
<td>1950</td>
<td>NHMRC Ultrasound Committee established</td>
<td>48</td>
</tr>
<tr>
<td>1956</td>
<td>CAL Ultrasound Research Section established</td>
<td>60</td>
</tr>
<tr>
<td>1960</td>
<td>Obstetric/atheroma, fetal spine distinguishment</td>
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<td>1963</td>
<td>Description of the fetal heart/anatomy</td>
<td>04</td>
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<td>Obstetrics textbook (Garrett &amp; Robinson)</td>
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<td>1980</td>
<td>Atlas of the infant brain (Wilkens &amp; Kossoff)</td>
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<td>1985</td>
<td>Doppler paper (Gill)</td>
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<tr>
<td>1987</td>
<td>Grant (McCaflrey)</td>
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</tr>
<tr>
<td>1990</td>
<td>Ultrasonic Lab (CSIR)</td>
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### Prof Thomas Reeve AC CBE

Professor Thomas Reeve was Surgical Research Fellow in the Department of Cardiothoracic Surgery at the Royal Prince Alfred Hospital and part of a team which developed the first successful valve replacement for 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 conference in echocardiography. Echocardiography has now become an essential part of routine cardiac assessment.

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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.

The following sources were used for this case study:

**ASUM Bulletins**

**Ultrasonics Institute**

**Other**