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 from Australia’s 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 Ultrasounds 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. 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 Auditory, Tactile and Visual Laboratory (ATL) in Sydney to undertake war-time research. The laboratory later became the Commonwealth Auditory Laboratories (CAL) (1947). In 1975, the CAL’s Ultrasound Research Section became the Ultrasounds 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.

Research

Technology: In 1961, the first commercially practical Australian ultrasonic scanner (the CAL Echoscope) was built by Murray and David Hopkins. In 1970, CAL Echoscopes were modified to include greyscale scanning capability and Doppler.

Obstetrics: In May 1962, the first ultrasound obstetric examination was performed by Dr William Garrett at the Royal North Shore Hospital (RNSH) in Sydney. Over the next five years nearly two thousand women were scanned in the first randomised clinical trial showing the usefulness of umbilical Doppler ultrasound to detect fetal well-being in high-risk pregnancies. This work continues in mainstream clinical practice today.

Results and Translation

After greyscale became available, one of the early discoveries by Reeve was the different ultrasound appearances of malignant and non-malignant tissues in the breast. This led to more accurate cancer diagnoses.

Health Outcomes and Impact

As technology advanced, the early ultrasound scanners were superseded by smaller, more portable, electronic, resolutions scanners. 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%.

Number of diagnostic ultrasound in Australia

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of ultrasounds performed</th>
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<tbody>
<tr>
<td>1960</td>
<td>14,000</td>
</tr>
<tr>
<td>1970</td>
<td>150,000</td>
</tr>
<tr>
<td>1980</td>
<td>1,000,000</td>
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<tr>
<td>1990</td>
<td>10,000,000</td>
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<tr>
<td>2000</td>
<td>20,000,000</td>
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<tr>
<td>2010</td>
<td>40,000,000</td>
</tr>
<tr>
<td>2020</td>
<td>80,000,000</td>
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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 Laboratories until 1997. In 2004, Australia Post issued a stamp highlighting ultrasound as part of its Australian innovation series.

NHMRC funded the establishment of the ATL and the salaries of its staff from 1943-46. In 1946, the Australian Government Department of Health 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 into this new field of diagnostic medical ultrasound. George Kossoff joined CAL in 1958 as a research scientist and also became a member of NHMRC’s Ultrasound Committees, 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 renowned for its research and development in the field of medical ultrasound.

Between 1970 and 1990, NHMRC funded CAL’s 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 echography (using ultrasound to generate greyscale images in various dimensions)
- **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

Development and Investment

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Research

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Obstetrics: In May 1962, the first ultrasound obstetric examination was performed at the RHW by Dr. Garrett and Kossoff. Garrett led the world in identifying fetal anatomy using ultrasound and 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 Jelles, and Kaye Griffiths made significant contributions to this work. From 1969, Reeve began developing a comprehensive range of diagnostic interpretive 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 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.

Kossoff 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 during its early development for the study of the disorders of childbirth and disease.

Post issued a stamp highlighting ultrasound as part of its Australian innovation series.

Dr William Garrett (1927–2015) was founding Medical Director of the Ultrasounds Institute (UI) and President of ASUM from 1982.

Dr David Wilcken: Helped establish the AAPSEM in 1976, and played a critical role in Australian Ultrasound standards and training.

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**Professor Thomas Reeve**: for characterisation of breast tissue by ultrasound

**Grant (Kossoff & Reeve)**

**Robert Gill**: for echocardiography

**Grant (McCaffrey)**

**Trudinger (McCaffrey)**

**Roach (Garrett & Robinson)**

**Kaye Griffiths AM**: a research sonographer who pioneered two dimensional techniques to examine the brain and carried out the first echocardiographic studies on the heart.
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**