Australian Government

Department of Health and Ageing

Australia and New Zealand Horizon Scanning Network

ANZHSN

AN INITIATIVE OF THE NATIONAL, STATE AND TERRITORY GOVERNMENTS OF AUSTRALIA AND THE GOVERNMENT OF NEW ZEALAND

Horizon Scanning Technology Prioritising Summary

MRI-safe incubator for premature infants

March 2010

AHTA

Adelaide Health Technology Assessment

ISBN
Publications Approval Number:

Electronic copies can be obtained from http://www.horizonscanning.gov.au

Enquiries about the content of the report should be directed to:

HealthPACT Secretariat
Department of Health and Ageing
MDP 106
GPO Box 9848
Canberra ACT 2606
AUSTRALIA

DISCLAIMER: This report is based on information available at the time of research cannot be expected to cover any developments arising from subsequent improvements health technologies. This report is based on a limited literature search and is not a definitive statement on the safety, effectiveness or cost-effectiveness of the health technology covered.

The Commonwealth does not guarantee the accuracy, currency or completeness of the information in this report. This report is not intended to be used as medical advice and intended to be used to diagnose, treat, cure or prevent any disease, nor should it be used therapeutic purposes or as a substitute for a health professional's advice. The Commonwealth does not accept any liability for any injury, loss or damage incurred by use of or reliance the information.

The production of this Horizon scanning prioritising summary was overseen by the Health Policy Advisory Committee on Technology (HealthPACT). HealthPACT comprises representatives from departments in all states and territories, the Australia and New Zealand governments; and ASERNIP-S. The Australian Health Ministers' Advisory Council (AHMAC) supports HealthPACT through funding.

This Horizon scanning prioritising summary was prepared by Linda Mundy and Professor Janet Hiller from the National Horizon Scanning Unit, Adelaide Health Technology Assessment, Discipline of Public Health, School of Population Health and Clinical Practice, Mail Drop DX 650 545, University of Adelaide, Adelaide, SA, 5005.

PRIORITISING SUMMARY

REGISTER ID: **000072**

NAME OF TECHNOLOGY: **MRI-SAFE INCUBATOR FOR PREMATURE INFANTS**

PURPOSE AND TARGET GROUP: **SAFE IMAGING OF PREMATURE INFANTS**

STAGE OF DEVELOPMENT (IN AUSTRALIA):

☐	Yet to emerge	☐	Established
☐	Experimental	☐	Established *but* changed indication or modification of technique
☒	Investigational	☐	Should be taken out of use
☐	Nearly established		

AUSTRALIAN THERAPEUTIC GOODS ADMINISTRATION APPROVAL

☒	Yes	ARTG number	168064
☐	No		
☐	Not applicable		

INTERNATIONAL UTILISATION:

COUNTRY	LEVEL OF USE		
	Trials Underway or Completed	Limited Use	Widely Diffused
United States	✓		
United Kingdom	✓		

IMPACT SUMMARY:

One company manufactures a MRI-safe neonatal incubator with the aim of providing the safe MRI assessment of pre-term infants. LMT Lammers Medical Technology GmbH (Germany) provides the LMT nomag IC 1.5, which is sponsored in Australia by Imaging Solutions Pty Ltd (ARTG number 168064). Advanced Healthcare Technology Ltd manufactures a MRI compatible neonate capsule, which is distributed by Endocorp Pty Ltd (ARTG number 16073). However this carbon fibre capsule is not electrically equipped and is designed to provide protection to the infant whilst travelling or undergoing MRI. The technology is available through specialist children's hospitals for critically ill neonates being treated in an intensive care environment.

BACKGROUND

Magnetic resonance imaging is considered a safe imaging technology for infants as unlike X-rays or computed tomography, MRI does not utilise ionising radiation. MRI

is ideal for obtaining functional images of the brain and other soft tissues and is especially useful in diagnosing: the cause of neonatal seizures; the presence of neonatal stroke; the pattern of tissue injury in neonatal encephalopathy, deformities of the cerebellum and metabolic disorders originating in the central nervous system. However, MRI scanners tend to be large and extremely noisy and usually located long distances away from neonatal intensive care wards, requiring the infant to be transported to the scanner (Stokowski 2005).

Lammers Medical Technology manufactures two MRI-compatible incubators, the LMT nomag IC 1.5 and the IC 3.0 (Figure 1). Both have a MRI-compatible chassis with an independent power and gas supply. The unit sits on a trolley which facilitates intra and inter-hospital transportation of the infant. The incubator has hand ports so that the infant can be positioned correctly prior to imaging by medical staff. Custom made head and body coils may be purchased. With the use of a MRI-compatible incubator, the infant may be transported to the MRI scanner while remaining connected to ventilation, respirator tubes, endotracheal tubes and infusion pumps. Vital signs including heart rate, pulse and oxygen saturation (SpO_2) can be monitored. In addition, the air temperature and humidity levels of the incubator can set by medical staff. Patient preparation or transfer time into the incubator is approximately 45 minutes (LMT Lammers Medical Technology GmbH 2008). A video demonstrating the use of the MRI safe incubator may be viewed via the following link.

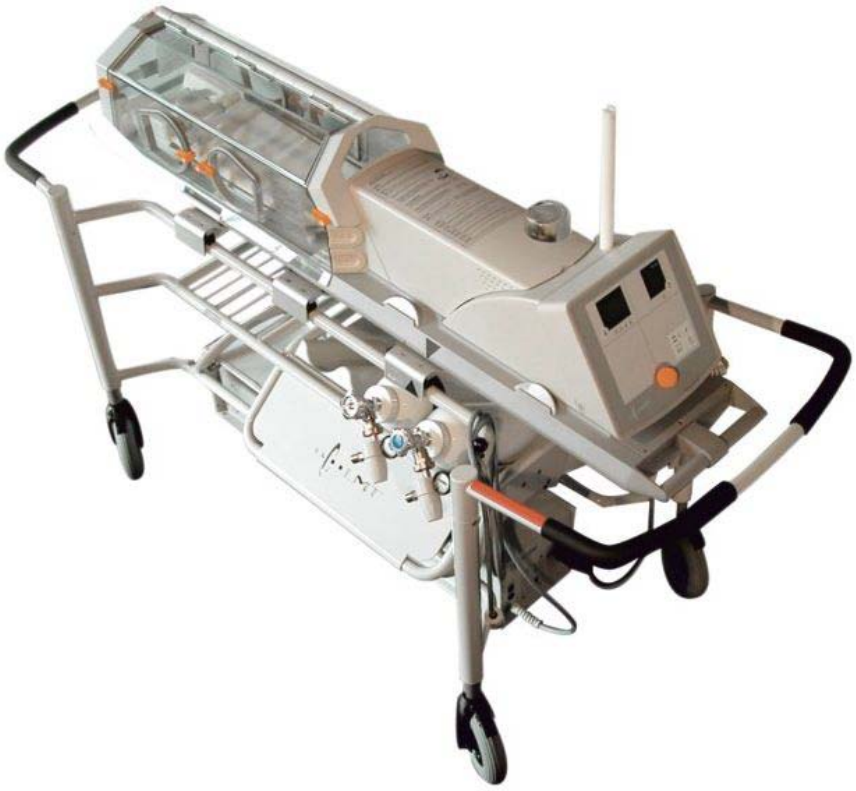

Figure 1 The LMT nomag IC 1.5 MRI-safe incubator (LMT Lammers Medical Technology GmbH 2008)

The use of a MRI-compatible incubator reduces the need to sedate infants prior to imaging and exposes the infant to fewer fluctuations in temperature and environment, so that stress levels of the infant are decreased and overall comfort to the infant is increased (Stokowski 2005). Hospital MRI scanning rooms are usually maintained at a moderate temperature (22°C) and low humidity, whereas neonate incubators are usually maintained at 36-37°C with a humidity ranging between 40-90 per cent depending on infant need. The MRI environment outside the neonate incubator would be considered hostile and detrimental to the infant. If imaged outside the environment of an incubator, infants may develop hypothermia and as a result heart rate, stroke volume and minute ventilation may increase, which may in turn affect cerebral blood flow and oxygenation. In addition, infants experiencing a drop in body temperature will respond by moving in an attempt to keep warm. All of these factors may affect the quality of the MR images (Erberich et al 2003).

CLINICAL NEED AND BURDEN OF DISEASE

The National Perinatal Data Collection defines a live birth to be at least 20 weeks gestation or at least 400 grams birth weight. In Australia in 2007 there were 292,027 live births. During the same period, the mean gestational age for all babies born was 38.8 weeks with 90.9 per cent of babies being born at term (37-41 weeks gestation). Preterm births were classified according to the criteria of the WHO into groups of 20–27 weeks, 28–31 weeks and 32–36 weeks. In 2007 there were a total 22,194 pre-term births (20-36 weeks) representing 8.1 per cent of all babies, live and still births. The majority of pre-term live births occurred in the gestational age bracket of 32-36 weeks (6.4%) with 0.45 and 0.74 per cent of live pre-term births at 20-27 weeks and 28-31 weeks, respectively. Although pre-term birth is associated with significant morbidity and mortality birth weight is also a key factor. Low birth weight babies may be at risk of developing significant disabilities and may require longer periods of hospitalisation and care than larger babies. Pre-term babies tend to be smaller, however low birth weight may be a result of intrauterine growth retardation or factors including mother's nutritional status, smoking and alcohol intake during pregnancy, age of mother, size of parents and socioeconomic status of parents. The average birth weight for babies born in 2007 was 3,374 grams. In the same period there were 17,976 (6.2%) live born babies of low birth weight (<2,500 grams). Of these, 2,956 (1.0%) were considered to be of very low birth weight (<1,500 grams) babies and 1,288 (0.4%) were extremely low birth weight babies (<1,000 grams) (Laws & Sullivan 2009).

In New Zealand during 2004, the National Minimum Dataset (NMDS) reported that 54,875 women gave birth in hospital to 55,654 babies, of which 55,213 were live born, accounting for 94 per cent of all live births (home and hospital). The majority of live births (91.6%) in 2004 were full term (>37 weeks' gestation). Preterm babies (<37 weeks' gestation) accounted for 7.1 per cent of the live babies. Babies born to European and Māori mothers were more likely to be preterm (7.4% and 7.3%,

respectively). The average birth weight of babies born in New Zealand during this period was 3.43kg. There were 236 (0.4%) live babies with an extremely low birth weight babies (<1,000 grams), 325 (0.6%) with a very low birth weight (<1,500 grams) and 2,808 (5.0%) with a low birth weight (<2,500 grams). Of the 51,223 full-term babies (>37 weeks gestation) born in 2004, two per cent had a low birth weight. Mothers aged under 16 or 40 years and over or who lived in the most deprived areas (NZDep quintile 5) were more likely to have full-term babies with a low birth weight (2.8%, 2.6% and 2.4%, respectively) (New Zealand Health Information Service 2007).

DIFFUSION

The Australian newspaper reported in November 2009 that the University of Queensland's Centre for Clinical Research (Perinatal Research) had purchased a MRI-safe incubator in conjunction with the Royal Brisbane and Women's Hospital and the Royal Children's Hospital. It is likely that several large teaching hospitals in Australia and New Zealand will acquire this technology over time.

COMPARATORS

Cranial ultrasonography would be considered the most suitable tool for the non-invasive imaging of the neonatal brain for the detection of congenital or acquired brain anomalies and for the assessment of brain maturation in both preterm and full term neonates. It is considered to be safe, relatively inexpensive, can be performed at the bedside with little disturbance to the infant, can be initiated at an early stage and can be repeated on several occasions (Steggerda et al 2009).

SAFETY AND EFFECTIVENESS ISSUES

Although the following papers are several years old and may be considered past the horizon, this technology has been assessed as it has not diffused into the Australian health system.

In the early proof-of-concept study conducted by Erberich et al (2003), seven pre-term neonates were referred from intensive care (ICU) for MR brain imaging. Mean gestational age of the infants was 28.6 weeks (range (24-39 weeks) and postnatal age ranged from 4-12 weeks. The mean birth weight of the infants was 1230 grams and ranged between 701 and 2636 grams. The mean weight at time of imaging was 2702 grams and ranged between 1.2 to 4.6 kg. Infants were sedated in the ICU and transported to the MRI scanner in a standard transport incubator, where they were transferred to the pre-warmed MRI-safe incubator. Standard clinical images were acquired in addition to conducting three functional MRI studies (fMRI). The fMRI studies were designed to detect early brain activation from passive stimuli.

Total imaging time was 20-35 minutes. All infants were successfully imaged and when compared to images acquired by conventional brain imaging of age-matched

infants, appeared to be of superior quality. No diagnostic outcomes for these images were reported. During imaging the air temperature and humidity of the incubator remained constant with variations of 0.4 ± 0.4°C and 2.4 ± 1.3 per cent, respectively. There was no difference in the mean body temperature of the infants before and after imaging and variations in skin temperature were less than 0.5°C for all infants. Variations in blood oxygenation levels were less than three per cent.

During the fMRI studies stimulation of the right hand stimulated activity in the left hemisphere in three infants. A decreased signal was noted in the contralateral hemisphere of five infants during stimulation of the left or right hand resulted, however bilateral stimulation was found in one infant. Brain stem activation was noted in the least developed infant (Erberich et al 2003).

In another proof-of-concept study Whitby et al (2004) examined seven neonates ranging in gestational age from 24 weeks to full term with a postnatal age ranging from two days to four months (level IV diagnostic evidence). All infants were considered to be stable and were imaged prior to discharge. Infants were imaged with a 1.5 T MRI using fast imaging techniques.

No infants were sedated during imaging and scan time ranged from 10-21 minutes. Pulse oximetry and vital signs were monitored throughout scanning and all infants remained stable for the duration of the scan. T1 and T2 weighted images were examined by two neuro-radiologists and one neonatal radiologist and considered to be of good or excellent quality. Three of the infants were diagnosed as normal, three had a subdural haematoma and one infant had a germinal matrix haemorrhage. The incubator used in this early study was not capable of monitoring oxygen saturation and electrocardiographic activity, however later models have addressed these concerns. In addition, the authors felt that visualisation of the infant was difficult from the imaging control room and therefore placed a staff member in the MRI room while scans were conducted (Whitby et al 2004). This issue can also be addressed in newer models with the purchase of a MRI compatible camera with a remote monitor for continuous surveillance of the infant during scanning (Stokowski 2005).

Bluml et al (2004) conducted MRI on 13 infants. Gestational ages of the infants ranged from 24 to 41 weeks and postnatal age at time of scanning ranged from four to 12-weeks. At time of scanning the infants weighed between 1.2 and 4.5 kg. Infants were sedated in the ICU and transported to the MRI scanner in a standard transport incubator, where they were transferred to the pre-warmed MRI-safe incubator and reconnected to ventilators, oxygen, infusion pumps and vital sign monitoring equipment as needed. Infants were imaged with a 1.5 T MRI and brain (n=9), cardiac (n=2) and pelvic (n=2) MRI examinations were conducted. In addition, MR spectroscopy was conducted on the nine infants scheduled for brain MRI. Brain images were compared to brain images obtained with conventional imaging from age-matched infants. Images were interpreted by a blinded paediatric neuroradiologist.

The mean length of time that infants spent in the MRI-safe incubator was 47 ± 14 minutes. During imaging the air temperature and humidity of the incubator remained constant with variations of 0.4 ± 0.4°C and 2.4 ± 1.3 per cent, respectively. Throughout imaging blood oxygen saturation levels of the infants varied by less than 23 per cent and the pulse rate remained normal (120-150 bpm). Blood pressure and electrocardiographic status also remained normal. The skin temperature of most infants did not vary during scanning with the exception of two infants. The skin temperature of one infant increased by 1.2°C over the hour long course of a cardiac scan. Another infant experienced a rapid 0.8°C decrease in skin temperature 10 minutes after commencement of scanning. After the MRI was stopped and the infant examined it was found that the temperature sensor was loose. The signal-to-noise ratio and the quality of the MR images taken of infants in the MRI-safe incubator was increased compared to the images acquired from infants with standard MRI (Bluml et al 2004).

COST IMPACT

The approximate cost of the incubator, including a number of specialised coils required for successful MRI imaging of infants is A$960,000 (personal communication Imaging Solutions Pty Ltd, Queensland). The cost of conducting a MRI would be the same cost of conducting a conventional MRI once the infant has been placed in the specialised incubator.

ETHICAL, CULTURAL OR RELIGIOUS CONSIDERATIONS

No issues were identified/raised in the sources examined.

OTHER ISSUES

One of the authors (Lonnecker-Lammers) on the Whitby et al (2004) paper was a director of Lammers Medical Technology, the manufacturer of the incubator and another author (Srinivasan) was the director of Advanced Imaging Research, the manufacturer of the magnetic coil.

SUMMARY OF FINDINGS

The studies included for assessment in this summary were non-comparative, proof-of-concept studies and as such were a low level of evidence. These studies were conducted on infants considered to be stable and no studies were identified which conducted MRI on unstable or critically ill infants, where additional diagnostic evidence may have affected their treatment pathway. All studies reported that MR imaging was possible using the MRI-safe incubator and that good quality images were produced. Vital signs of infants undergoing MRI remained stable for the duration of the scan. The incubator appears to be capable of providing anatomical information of a vulnerable neonatal population.

HealthPACT action:

As one incubator is currently in use in Australia, HealthPACT have advised that it would be prudent to await outcome data from its use in this institution. With increased use for critically ill infants it is likely that routine scanning will identify any relevant studies published in the future, therefore no further review by HealthPACT on this technology is currently required.

Number of included Studies

Total number of studies	3
Level IV diagnostic accuracy evidence	3

References:

Bluml, S., Friedlich, P. et al (2004). 'MR imaging of newborns by using an MR-compatible incubator with integrated radiofrequency coils: initial experience', *Radiology*, 231 (2), 594-601.

Erberich, S. G., Friedlich, P. et al (2003). 'Functional MRI in neonates using neonatal head coil and MR compatible incubator', *Neuroimage*, 20 (2), 683-692.

Laws, P. & Sullivan, E. A. (2009). *Australia's mothers and babies 2007*, AIHW National Perinatal Statistics Unit, Canberra. Available from: http://www.aihw.gov.au/publications/per/per-48-10972/per-48-10972.pdf

LMT Lammers Medical Technology GmbH (2008). *MR Diagnostics Incubator* [Internet]. Available from: http://lammersmedical.com/e/media/nomag_pdfs/nomag-en.pdf [Accessed 18th January].

New Zealand Health Information Service (2007). *Report on Maternity: Maternal and Newborn Information 2004*, New Zealand Ministry of Health, Wellington. Available from:

Steggerda, S. J., Leijser, L. M. et al (2009). 'Neonatal cranial ultrasonography: how to optimize its performance', *Early Hum Dev*, 85 (2), 93-99.

Stokowski, L. A. (2005). 'Ensuring safety for infants undergoing magnetic resonance imaging', *Adv Neonatal Care*, 5 (1), 14-27; quiz 52-14.

Whitby, E. H., Griffiths, P. D. et al (2004). 'Ultrafast magnetic resonance imaging of the neonate in a magnetic resonance-compatible incubator with a built-in coil', *Pediatrics*, 113 (2), e150-152.

Search Criteria to be used:

Brain Diseases/*diagnosis/pathology
Brain Injuries/*diagnosis/pathology
Brain/anatomy & histology/*pathology
Cerebral Hemorrhage/diagnosis
Hypoxia-Ischemia, Brain/metabolism/*pathology
Incubators, Infant
Infant, Newborn
Infant, Premature
Magnetic Resonance Imaging