



INCUBATOR PUBLICATIONS

1. **“Comparison of neonatal MRI examinations with and without an MR-compatible incubator: Advantages in examination feasibility and clinical decision-making”**

Z. Rona, K. Klebermass, F. Cardona, C.D. Czaba, P.C. Brugger, M.Weninger, A. Pollak, D. Prayer

European Journal of Paediatric Neurology 14 (2010) 410-417

Purpose: To assess the utility of an MRI-compatible incubator (INC) by comparing.

1. The frequency of MR examinations done in 18 months periods each in unstable newborns with suspect central-nervous system (CNS) problems,
2. The respective expenditure of time, and
3. The amount of necessary sedatives with and without the INC.

Methods: In a retrospective study, the clinical and radiological aspects of 129 neonatal MRI examinations during a 3 year period were analyzed. Routine protocols including fast spinecho T2-weighted (w) sequences, axial T1w, Gradient-echo, diffusion sequences, and 3D T1 gradient-echo sequences were performed routinely, angiography and spectroscopy were added in some cases. Diffusion-tensor imaging was done in 50% of the babies examined in the INC and 26% without INC. Sequences, adapted from fetal MR-protocols were done in infants younger than 32 gestational weeks. Benefit from MR-information with respect to further management was evaluated. Results: The number of the examinations increased (30e99), while the mean age (43e38, 8 weeks of gestational age) and weight (3308e2766 g) decreased significantly with the use of the MR-compatible incubator. The mean imaging time (34, 43e30, 29 min) decreased, with a mean of one additionally performed sequence in the INC group. All infants received sedatives according to our anaesthetic protocol preceding imaging, but a repeated dose was never necessary (10% without INC) using the INC. Regarding all cases, MR-based changes in clinical management were initiated in 58%, while in 57% of cases the initial ultrasound diagnosis was changed or further specified.

http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6WF2-502WG7Y-1&_user=10&_coverDate=09%2F30%2F2010&_rdoc=1&_fmt=high&_orig=search&_origin=search&_sort=d&_docanchor=&view=c&_searchStrId=1514005837&_rerunOrigin=google&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=7427b808c2d0c64f8e464a5fc533239e&searchtype=a

2. **“Advances in magnetic resonance neuroimaging techniques in the evaluation of neonatal encephalopathy”**

A. Panigrahy, S. Blüml

Top Magn Reson Imaging. 2007 Feb;18(1) :3-29.

Magnetic resonance (MR) imaging has become an essential tool in the evaluation of neonatal encephalopathy. Magnetic resonance-compatible neonatal incubators allow sick neonates to be transported to the MR scanner, and neonatal head coils can improve signal-to-noise ratio, critical for advanced MR imaging techniques. Refinement of conventional imaging techniques include the use of PROPELLER techniques for motion correction. Magnetic resonance spectroscopic imaging and diffusion tensor



imaging provide quantitative assessment of both brain development and brain injury in the newborn with respect to metabolite abnormalities and hypoxic-ischemic injury. Knowledge of normal developmental changes in MR spectroscopy metabolite concentration and diffusion tensor metrics is essential to interpret pathological cases. Perfusion MR and functional MR can provide additional physiological information. Both MR spectroscopy and diffusion tensor imaging can provide additional information in the differential of neonatal encephalopathy, including perinatal white matter injury, hypoxic-ischemic brain injury, metabolic disease, infection, and birth injury.

http://www.ncbi.nlm.nih.gov/pubmed/17607141?ordinalpos=6&itool=EntrezSystem2.PEntrez.Pubmed.Pubmed_ResultsPanel.Pubmed_RVDocSum

3. **“Magnetic resonance imaging of the neonatal brain”**

Ariel Prager, Sudipta Roychowdhury
Indian Journal of Pediatrics 2007 ;74 ;173-184

Neonatal magnetic resonance (MR) imaging is rapidly becoming the preferred modality for the evaluation of central nervous system disorders in the newborn. Recent literature supports the value of this imaging technique in diagnosing ischemic, hemorrhagic and infectious disease processes in the premature and full-term neonatal brain. Recent data in premature newborns with neurological injury also suggest a role for MR imaging in determining long-term neurodevelopmental outcomes. This review article provides a framework and overview on neonatal MR imaging techniques and examines the literature or radiological disease patterns and prognostic implications in common neurological disorders.

<http://www.springerlink.com/content/f401660158117375>

4. **“MRI scans in premature infants can predict future developmental delays”**

Beth Miller
New England Journal of Medicine 355;685-94. Aug. 17, 2006.

A Washington University pediatrician at St. Louis Children’s Hospital has found that performing MRI scans on pre-term infants’ brains assists dramatically in predicting the babies’ future developmental outcomes.

<http://news.wustl.edu/news/Pages/7500.aspx>

5. **“Ensuring Safety for Infants Undergoing Magnetic Resonance Imaging”**

Laura A. Stokowski, RN, MS et al.
Advances in Neonatal Care 2005, Vol. 5, No. 1; p 14-2

Magnetic resonance imaging (MRI) is a powerful and versatile diagnostic tool. Applications of MR technology are rapidly expanding for all patient populations, including infants receiving newborn intensive care. Millions of MR examinations have been conducted without incident or harm, yet rare accidents in the MR environment continue to occur. The infant is vulnerable to many of the potential hazards of MRI, including projectile accidents, radiofrequency electromagnetic field effects, noise



hazards, physiologic instability, and adverse effects of transport, positioning, handling, and sedation. The MRI-compatible incubator is a promising means for safe imaging of smaller and less stable infants than previously possible. Proper education of staff and meticulous attention to detail in preparing the infants for MR examinations are the keys to safety during neonatal MRI.

http://jerlab.psych.sc.edu/kidsMRIsite/mrisafety/abstracts_pdfs/articlepdfs/Stokowski_2005.pdf

6. **“MR Imaging of Newborns by Using a MR-Compatible Incubator with Integrated Radiofrequency Coils – Initial Experience”**

Stefan Blüml, Philippe Friedlich, Stephan Erberich, John C. Wood, Istvan Seri, Marvin D. Nelson

Radiology 2004; 231:594-601; © 2004 RSNA

To meet the needs of term and preterm neonates undergoing magnetic resonance (MR) imaging, an MR-compatible incubator with air, temperature, and humidity regulators and integrated radiofrequency coils was evaluated. Nine brain, two cardiac, and two pelvic examinations were performed by using a 1.5-T clinical MR imaging unit. The axillary temperature of the newborns varied by less than 0.8°C, their vital signs remained stable, and no complications were encountered. The diagnostic quality of images obtained with the MR-compatible incubator was superior to that of images obtained with the standard MR imaging equipment. The use of an MR-compatible incubator for examinations of ill neonates is feasible and safe and yields excellent MR images.

<http://radiology.rsna.org/content/231/2/594.full>

7. **“Newborns breathe easy in customized MR incubator”**

Merlina Trevino

Diagnostic Imaging Online July 7, 2004; © 1996 – 2004 CMP Media LLC, a United Business Media company

One size does not fit all when it comes to imaging newborns. Customized MR-compatible incubators with integrated head and body radio-frequency coils designed for neonates proved to be safe and provided higher quality images than standard imaging equipment, according to a study published in the May issue of *Radiology*. MR imaging for newborns has required lengthy, intensive preparations, and many systems come with RF coils designed for adults. Yet for many applications, in particular soft-tissue imaging, MR is simply the best tool, said lead researcher Stefan Blüml, Ph.D., an associate professor of radiology research at the University of Southern California Keck School of Medicine. Researchers used the incubator with 13 neonatal patients already scheduled for an MRI exam who ranged in age from four to 12 weeks. Exams included nine brain, two cardiac, and two pelvic. Patients undergoing brain imaging also had MR spectroscopy performed. All brain MRI and MRS images were compared to images of six age-matched controls performed with standard equipment.

<http://www.diagnosticimaging.com/dimag/legacy/dinews/2004070701.shtml>



8. **“MR Incubator Creates Safe Imaging Environment for Newborn”**

Laurie Volkin and Richard S. Dargan, Contributing Writers ASTR
Newswire May 05th, 2004

An incubator that is compatible with magnetic resonance is safe for examinations of ill newborns and yields excellent MR images, according to a new study.

MR imaging is the most desirable imaging test for many newborns because there is no exposure to radiation, according to researchers. However, many sick newborns cannot undergo MR because of concerns for their safety during transport and during the procedure.

9. **“MRI delineates complexities of preterm infant brain”**

Shalmali Pal
April 30th, 2004

Investigators have successfully used imaging on adults who survived preterm birth; neurological scans performed on infants, while they are still in the danger zone, is much trickier. MRI may offer the best way to effectively diagnose certain pathologies in these children.

MRI incubator: “There have been several attempts to overcome the problem of imaging the neonate, including dedicated scanners on neonatal intensive care units,” wrote Dr. Elspeth Whitby from the section of academic radiology at the University of Sheffield and the Royal Hallamshire Hospital, both in Seffield. “However, (these scanners) are not widely available and may be restricted in their image sequences.”

<http://www.auntminnie.com/index.asp?sec=ser&sub=def&pag=dis&ItemID=91829>

10. **“MRI-Compatible Incubator Allows High-Quality Neonatal Imaging”**

Laurie Barclay
Pediatrics. 2004;113:e150-e152

A magnetic resonance imaging (MRI)-compatible incubator affords safe and good- to excellent-quality MRI in neonates, according to the results of a study published in the February issue of *Pediatrics*. “MRI of the neonate is important clinically, because this group of patients often has complex and multiple problems due to prematurity and developmental abnormalities,” write Elspeth H. Whitby, FFDRCSI, from the University of Sheffield, and colleagues. “MRI usually involves moving neonates away from their controlled environment to the scanner.” (113:e150-e152)

<http://www.medscape.com/viewarticle/468948>

11. **“Ultrafast Magnetic Resonance Imaging of the Neonate in a Magnetic Resonance-Compatible Incubator with Built-in Coil”**

Elspeth H. Whitby, Paul D. Griffiths, PhD, Torsten Lonneker-Lammers, Ravi Srinivasan, PhD, Daniel J.A. Connolly, FRCR, David Capener, BSc, Martyn N.J. Paley, PhD



Pediatrics Vol. 113, No. 2, February 2004, pp. e150-e152.

Magnetic resonance (MR) imaging of the neonate is important clinically, because this group of patients often has complex and multiple problems due to prematurity and developmental abnormalities. MR imaging usually involves moving neonates away from their controlled environment to the scanner.

Objective. In this study we present the results of our initial experience with an MR-compatible incubator used on a 1.5-T system.

Methods. Seven neonates were imaged at 1.5 T without sedation or anesthesia. Images were obtained by using single-shot fast spin echo, 3-dimensional Fourier transfer gradient echo, and diffusion-weighted sequences. In 4 cases, time-of-flight angiography was performed.

Results. All 7 neonates were stable throughout the scan time (10-21 minutes). Experienced observers graded the images for quality, and all were graded excellent or good. In no case was the image quality poor.

Conclusion. Neonates can be imaged safely by using an MR-compatible incubator and fast image sequences. This method should allow neonates to be imaged by MR in sites at which a dedicated neonatal MR scanner is not available.

<http://pediatrics.aappublications.org/cgi/content/abstract/113/2/e150>

12. **“Functional MRI in neonates using neonatal head coil and MR compatible incubator”**

Stephan G Erberich, Philippe Friedlich, Istvan Seri, Marvin D Nelson Jr. and Stefan Blüml

NeuroImage 20, 2003: p 683-692; © 2003 Elsevier Inc.

Structural and functional magnetic resonance imaging of the newborn brain is a complex and challenging task. Term and preterm neonates require a controlled microenvironment and close monitoring during the MRI study to maintain respiratory and cardiovascular functions, body temperature, and fluid and electrolyte homeostasis. In addition, to minimize motion artifacts, most neonates also need to be sedated, which carries the risk of respiratory depression compromising the neonate's ability to maintain appropriate ventilation and oxygenation during the procedure. Finally, because of their small head size, the use of the standard MR head coils results in suboptimal picture quality in the neonate. Thus, these limitations affect our ability to obtain both high quality structural and functional MRI studies. To overcome these difficulties, we have utilized an MR compatible incubator with a built-in radiofrequency head coil optimized for the neonatal brain volume. In this study we demonstrate that functional MRI and high-resolution structural MRI of the newborn brain can be achieved with this novel design. The use of this equipment offers potential for studying the development of the preterm and term neonatal brain and obtaining state-of-the-art, high-resolution structural and functional imaging in this most vulnerable patient population.

http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6WNP-49MF08F-8&_user=10&_coverDate=10%2F31%2F2003&_rdoc=1&_fmt=high&_orig=search&_origin=search&_sort=d&_docanchor=&view=c&_searchStrId=1513929514&_rerunOrigin=google&_acct=C000050221&_version=1&_urlVersion=0&_userid=10&md5=48c496bfc0d95ea6b32995b706e0b978&searchtype=a



13. **“First Experiences with Magnetic Resonance Imaging of Neonates Using a Magnetic-Resonance-Compatible Incubator with a Built-in Coil”**
Rangmar Goelz, Eva Bültmann, Thomas Nägele

14. **“Comparison of neonatal MRI examinations with and without an MR-compatible incubator”**
Dr. Katrin Klebermass, Dr. Peter Brugger, Prof. Arnold Pollak,
Prof. Daniela Prayer, MD Zsófia Rona, Prof. Manfred Weninger