

# The baby MRI—shrinking tech to help save newborn lives

January 24 2017, by Michael Regnier

---

There's a picture of our first daughter that my wife can't bear to see. It was taken on Easter Sunday, 2008, the day she was born. Although it was the start of spring, it was snowing in London. Meanwhile, our daughter, just a few hours old, lay on a white blanket in an incubator in a neonatal intensive care unit (NICU), tubes and wires sprouting out of her.

We'd done everything right – or so we thought. Sophie had gone into labour naturally a week or two before her due date. When we got to the hospital the following morning, a doctor was soon listening to the heartbeats of mother and baby. Something was wrong. The baby's heartbeat was too slow.

In my memory, the doctor hit a big red button on the wall above the bed. That seems unlikely now, but the effect was the same. Suddenly I was being told to change into scrubs while nurses streamed into the room and started preparing Sophie for an emergency C-section. I was still pulling on the thin blue trousers when they wheeled her bed out of the room and down the hall. A nurse pointed me towards the double doors of the operating theatre. The knot in my stomach got tighter.

Minutes later, Edith was born. She didn't cry, as [babies](#) are supposed to when their first breath fills their lungs. In silence, she was placed on a table under a warming lamp, medical staff around her, blocking our view. At last, she managed a squawk. Someone held her up for us to see her cross little face and then she was whisked away. By the time I went home that evening, Sophie was in the maternity ward recovering from

surgery and Edith was in the NICU. Our first night as a family and the three of us all sleeping in different places.

At just 2.1 kg (4 lb 10 oz), Edith was significantly underweight for a baby who wasn't particularly premature, so she went to the NICU for observation and to make sure her brain hadn't suffered from lack of oxygen when her heart was beating slowly. With no evident issues appearing, she was there for only four days. It was long enough to adjust to the dim lighting, the continual beeping of monitors, the collective anxiety and the stab of fear that accompanied anything out of the ordinary. But four days is nothing compared with the weeks and months that some babies and their parents spend in the NICU.

Most babies in a NICU are seriously ill, having had very premature or traumatic births. Around 70 per cent are at risk of brain damage. Predicting how they will fare is notoriously hard, and despite the best available specialist care, often it's still a matter of waiting to see whether they will survive and with what, if any, impairments. And although an adult patient would go for an MRI scan as soon as brain damage was on the cards, many of these babies don't ever get to have that basic test.

Magnetic resonance imaging machines are huge and noisy and they weigh a ton. Or more like 10 tons. They fill a sizeable room, and need more space beyond that for computers and an operator outside the strong magnetic field, but they're also acutely sensitive to vibration. This means they are usually installed on the ground floor of a hospital or in the basement. NICUs, on the other hand, like maternity wards, are often placed upstairs, out of the way, safe and secure. But the most delicate babies can't risk journeys through the hospital, up and down in lifts, through corridors, past visitors, patients and staff who might be carrying infections, getting ever further from the expert care they'd need should anything start to go wrong on the way. So although a scan would be entirely safe, MRI is quite literally out of bounds. Ultrasound is used

instead, which is much cheaper, more portable and convenient, but does not give as clear a picture as MRI.

If the baby can't come to the MRI, can the MRI come to the baby? Knowing something of life inside the NICU, I was intrigued to discover that GE Healthcare was developing a prototype MRI system specifically for newborns. Could they really make a scanner small and safe enough to fit in the average NICU? If they could, it had the potential to transform healthcare for these most vulnerable patients.

§

The next time I set foot in a NICU is in 2014, in the Jessop Wing of the Royal Hallamshire Hospital in Sheffield. The same noises punctuate the hush that I remember from our experience in London, and I feel uncomfortable walking through as an observer. These parents don't need an audience when they're dealing with the anxious boredom of the place. I know that all they really want is to be able to take their babies home.

Julie Bathie is a special care coordinator here. Her job involves looking after babies who are leaving the NICU. "Sometimes I send them home with maybe not many weeks to live, or that uncertainty, but it's still nice to send the babies home, regardless of how long it will be," she says. "But the majority of the time, I'm sending my babies home to have a life, to just grow, get fat – and come back and see me to say hello."

Bathie has dark hair, a chatty personality and the professional nurse's air of compassionate efficiency. She has five children of her own, all of whom spent time on a neonatal unit, so she can empathise with the parents she works with. "I don't often say what I've been through, but I can say I know what you're feeling because I have actually been through it myself," she says. "It's scary and I don't think sometimes we appreciate how scared parents are."

Fear is fuelled by uncertainty, and if having better access to MRI scans could reduce that uncertainty, it would help staff, parents and babies alike. At the moment, there are two options for getting an MRI scan here, both of which involve putting a tiny baby in a big machine designed for adults. If the baby is relatively stable, they can be taken over to the main hospital. This involves making an appointment with the radiology department, making sure the nurse caring for that baby can be spared for an hour, and requesting a porter to take them across. "Very rarely do we go, 'MRI,' and it's the same day," says Bathie.

It's more complicated if the baby is on a ventilator, breathing air or oxygen through a tube. The adult radiology department doesn't have the equipment or expertise to manage a ventilated baby. Instead a trip to the Children's Hospital, just a few hundred metres down the road, is required, as Helen Cowan, another coordinator in the NICU, explains.

"I've got a baby that's going to MRI tomorrow," she says. "Because he's a ventilated baby, he needs to go on an anaesthetic list to be looked after airway-wise by an anaesthetist over at the Children's Hospital. So what I've done this morning is referred the baby to our transport service, referred the baby to the Children's to have a set of notes made up. Tomorrow morning, the transport service will come, pick the baby up, move the baby into their incubator, onto their ventilator, using their equipment, using their team, will take the baby in an ambulance to the Children's Hospital, which admittedly is not very far but whether it's half a mile or 20 miles the same service is required. Baby will have his MRI over there and will come back here."

Many babies are too ill to go through the stress of that procedure, so they can't get an MRI until they are stronger, by which time it may not be so useful. Having a dedicated scanner in the NICU would change all that. "They'll be able to scan sick babies at an opportune moment rather than

waiting," says Bathie.

Cowan agrees: "There are definitely occasions where we want an MRI and we have to go with what's available and that would be next week or whatever time. We accept that because that's the only choice we had." But with a scanner on site, "I'm not taking a member of staff off the unit for however many hours, it's not a big deal for the families waving their baby off in an ambulance. It will be just wheeling the baby down the corridor."

This is not wishful thinking. Jessop Wing is getting ready to receive one of the first prototype NICU scanners in the world. Responsible for it coming is Paul Griffiths, professor of radiology at the University of Sheffield. He's been trying to give more babies access to MRI for over a decade. He and his colleagues even built a low-strength baby scanner, although the images it produced were not good enough for clinical use so it could only be used for research.

In his office, adorned with a poster for an early Joy Division gig, academic certificates, football match tickets (he supports Crewe Alexandra) and a picture of the mythical Sybil about to make a prophecy, Griffiths sets out the challenge and the potential of the new prototype: "It's obviously about scanning newborn babies and trying to diagnose what's wrong with their brain accurately," he says. "The concern is that ultrasound doesn't show all of the problems with the accuracy that other tests might, and MR has always been seen as the next port of call.

"The problem has always been the safety aspects of trying to get that MR scan done. Inevitably, the baby has to be transferred out of the neonatal care, and of course you've got the issue of physically having to handle the baby, and that is actually the most dangerous bit."

Faced with this problem, you could build a new NICU with enough space for a full-sized MRI scanner, but that option really is out of reach for all but the wealthiest hospitals. Or you could do no MRI scans at all and rely solely on ultrasound. Or, as in Sheffield, you can constantly weigh the potential benefits of a more accurate scan against the risks of taking the baby out of the NICU.

"They select their cases where perhaps the clinical situation doesn't fit what they've seen on the ultrasound. If the baby is not thought to be under undue risk, they will get it down to an MR scan," explains Griffiths. "Whereas a little 27- or 28-week premature baby that stops breathing when you look at them still doesn't get the scan."

Griffiths, along with a Sheffield physicist and a collaborator at GE, had been awarded funding from the Wellcome Trust in 2011 to develop a new scanner for newborns. As there were others at GE and elsewhere who had also been talking about making a full-strength baby scanner for years, they got together and decided they could achieve more in partnership.

Project Firefly, as it was named, had been conceived. The aim: to build a small but powerful scanner, tailored to newborns, that could be put in an average NICU. The prototype in Sheffield would test the concept. Ultimately, they would discover whether giving more vulnerable babies access to MRI really does translate into a better understanding of their conditions, better treatment, and better health as a result.

§

By April 2014, Edith has turned six, and although she is still rather small for her age, there have been no health issues resulting from her traumatic birth. She's at home with her two-year-old sister (another eventful birth but no NICU required this time) and Sophie, while I am 4,000 miles

away in Milwaukee, Wisconsin. I've only been away a day or so, but already I'm struggling to picture them – I've always been bad with faces, so I'm grateful for all the photos I can fit on my phone. But it's no substitute for the real thing, and I'm missing my family.

Despite being the start of spring, it's still freezing here. There's ice on the Menomonee river and my fingertips are numb, no matter how far I shove them into my pockets. Milwaukee is an industrial town, home to Harley-Davidson motorbikes, to Miller beer and to GE Healthcare, which has an MRI facility in the suburb of Waukesha. This is where the Project Firefly prototypes are coming into being.

In the Project Firefly office, there is a full-scale mock-up of the new scanner. It certainly is compact compared with a normal full-body scanner, where an adult lies on a table and slides into a 70-cm diameter bore. This one is about as tall as me but there is no built-in table to lie on and the bore of the magnet is 18 cm, just big enough for a large baby's head. Or an orange, as I am about to see.

I'm taken along to engineering bay 3, where the first ever working version of the new design is sitting. I suppose that makes this the delivery suite for the prototypes, but it has been a long gestation and prone to complications.

At the heart of every MRI machine is a massive magnetic doughnut, which uses a magnetic field about 100,000 times as strong as the Earth's. It works by forcing the protons in the water of tissues to align with that field; special coils then stimulate the protons by emitting bursts of radio waves, and the MRI sensors detect differences in the way they respond when the current is switched off. This reveals the distinction between different types of tissue and creates a three-dimensional image.

By 2011, GE had a newly developed small magnet that was capable, with

a bit of tweaking, of generating a 3 Tesla magnetic field – the same strength as a standard adult machine. It had been designed for scanning arms and legs, so it was about the right size for babies, too, but it had to be adapted to work with brains rather than simple limbs. Adding a new gradient coil for focusing the magnetic field and surface coils to boost the radiofrequency signals was relatively straightforward, although it meant splicing together components from different MRI systems, but more unexpected issues kept cropping up. It turned out that they needed to put much more thought into exactly how these babies would get to the scanner in the first place.

Some of the solutions were delightfully low-tech. To manage lines – the monitor leads and the tubes connected to drips – they just cut a notch in the side of the doorway to the scan room. The lines sit in the notch and the door can be closed without ever having to disconnect the baby. More ingenious was a special swaddle and sling to lift the baby from its incubator and transfer it to a small table that slides into the scanner. But when they tested it with nurses, they were told that the noise of undoing the Velcro strap securing the babies was liable to upset them.

It was something of a novelty for the nursing staff to be consulted by a company like GE on the design of kit like this. Julie Bathie remembers getting the chance to plead for hard-wearing materials and for as much as possible to be disposable or else very easy to clean, otherwise it wouldn't get used. The sling now has a disposable inner lining along with a stronger outer layer, tightly wrapping the baby to help keep it still during the scan and held in place with a special, quieter Velcro headband. There are new attachments to help bundle wires and lines neatly together. The nurses are highly satisfied with the updated design.

There were also a number of more technical challenges. First, the noise. No one having an MRI scan is supposed to experience more than 99 decibels but these machines can easily go above that, especially if you're



trying to scan a wriggly and sensitive baby as quickly as possible. The babies, therefore, need ear defenders and silicone ear plugs to keep the noise within limits.

Then there was ventilation. The team weren't sure whether carbon dioxide would build up in the bore of their scanner when there was a baby in it. A baby's head takes up much more of the space inside the magnet than an adult (or, indeed, a baby) does in a full-body scanner. Their solution was to pump air through to prevent any build-up of toxic CO<sub>2</sub> – except that they couldn't blow air too quickly or it could make the baby cold or dry. Having adapted ventilation components used in bigger machines, they now need to wait until babies are being scanned to know for sure how well it works.

Given that you can't use actual newborn babies to test a baby scanner in development, it turns out that citrus fruit is a really good substitute. An orange, for example, is about the same size as the head of a fetus at 26 weeks and has lots of water like a newborn's brain. Plus it has internal structures – segments and juice vesicles and a central column – that show how good the resolution is.

Jessica Buzek, GE's global marketing manager for clinical applications, puts an orange inside the bore of the machine in bay 3 and raises it to the right height with a few paper napkins. The scanner goes through its finely controlled sequence of beeps, whines and whirrs, and soon I can see slices of the (unpeeled and intact) orange in incredible detail on the computer screen. It's obvious how a baby's brain, its eyes, or even the optic nerves could be examined with such a scan. Nerves usually sit around fluid, so they really pop out as a black line, I'm told, thanks to the contrast between fluid and structure in the brain. You could easily check for a rupture or a tear in a way that just wouldn't be possible with an ultrasound.

"Would you like to see anything else?" Buzek asks.

"No," I reply. "I'm very impressed by the orange."

"She was going to have it for lunch," someone else jokes.

"Right," says Buzek. "It looks healthy enough to eat!"

After lunch, we visit engineering bay 7B to see the first prototypes. On the floor, yellow tape marks out the exact shape of the room in Sheffield where it's going to be installed, while a dashed orange tape marks the edge of the 5 gauss field – that's the line you don't want to cross without removing any metal objects first. Already the machine is emitting a steady hum, and the hiss of the helium compressor signals that the magnet is cold and at full strength.

§

I've been in a number of NICUs in the UK and the US now, each with dimly lit rooms full of incubators and the familiar sounds of babies crying, monitors beeping, machines whirring and ventilators pumping. Doctors in charge of newborn intensive care have told me many things they think could become possible with a baby MRI machine.

Very premature babies are not just smaller versions of full-term newborns: they have a different physiology and that can make life in the NICU deeply uncertain. You can't just try to recreate conditions inside their mother's womb, either, because their needs aren't the same as a fetus's: they need to stay warm, breathe for themselves and do other things that a fetus doesn't. No one really knows what the optimum nutrition is for a very premature baby, for instance, so being able to assess nutrition based on regular brain imaging rather than simply measuring the size of the baby's head could make a big difference.

Other ideas range from general monitoring of brain activity, sedation and pain relief, to uses for specific conditions I've never heard of: paraoesophageal atresia, meaning a piece of the gullet which leads from mouth to stomach is missing. Post-haemorrhagic hydrocephalus, a build-up of pressure in the brain following internal bleeding. Necrotising enterocolitis, when an infection punches a hole in the gut wall. It's also common for babies who suffered trauma during birth to have their bodies deliberately cooled to reduce the risk of brain injury – they get rewarmed after three days but there's currently no way to measure whether one of them might need more or less time at low temperature.

In all these cases, doctors can see a role for MRI – if it were on the unit, that is, where decisions are being made, and not in another part of the hospital. And the benefits of developing better treatment and care in the NICU would be enormous: most of the babies survive, so in every case a whole lifetime is at stake.

Despite the optimism, it's not absolutely certain that more MRI will always mean better care. Dominic Wilkinson is a consultant neonatologist at John Radcliffe Hospital in Oxford and director of medical ethics at the Oxford Uehiro Centre. While he recognises a number of reasons to be positive about MRI becoming more accessible, he also thinks it raises some important concerns. For example, if more scans can be done, generating more information, there is a risk that all this extra information will increase uncertainty in the NICU rather than resolve it.

There is something seductive about the images an MRI scanner can produce. But, like photos of my daughters, an MRI picture is not the real thing. It's a multitude of data points, taken apart, processed and put back together to look like a brain. That it manages to be so lifelike – of an organ most of us will never see alive – is miraculous. However, it might be misleading if doctors or parents are tempted to give MRI results too

much weight compared with ultrasound or other tests when it comes to making decisions.

"A picture of a brain with a big hole or a huge blood clot or areas of the brain lighting up – it's powerful for clinicians and parents," Wilkinson tells me. "It may be appropriate where images indicate very poor outcome, but if you see a change on the MRI with a very premature baby, does that mean it would be unreasonable to continue intensive care treatment?"

If Edith had had a brain MRI that Easter Sunday in 2008, she might have been able to come home sooner. Or we might have seen something unusual on that image that would have compelled us to make harder decisions about her immediate future. These are not reasons not to go ahead with a baby scanner, but the transition from research to clinical practice needs to be undertaken carefully.

§

After years of development and delays, setbacks and solutions, the first baby was scanned in the prototype system in Sheffield on 22 March 2016. Now, in January 2017, I've come back to the Jessop Wing NICU to see a baby being scanned myself.

Alice-Rose Westbrook was born in early November at just 24 weeks' gestation. Things are touch and go for babies born so prematurely. But after nearly two-and-a-half months on the NICU (though still a few weeks before she would have reached full term and still weighing less than 3 lb), she is now stable enough to move to a ward in the nearby Children's Hospital. Before she goes, her parents, Rachael and Shaun, have agreed to let her be scanned in the prototype MRI machine.

Lying in her incubator in the NICU's high dependency unit, she is settled

into the custom-made swaddle and sling. The Velcro is fastened and ear defenders put on, but before she moves to the scanner, she's given a feed to help her relax, maybe even make her a little sleepy while the scan is taking place.

When she's quite finished sucking milk from her narrow feeding tube, she's lifted out, placed securely on a special trolley and wheeled out of the room. Two nurses push the trolley between them, walking slowly down the corridor. They leave the NICU, and the MRI is just across the hall.

The trolley fits snugly against the scanner, and the top slides with Alice-Rose into the bore of the machine. It is a close fit but she seems happy enough. Mum Rachael is with her, as well as one of the NICU nurses, who gently pats her through the swaddling. It's a little cold in the scan room, so they raise the temperature by a couple of degrees. Then the rasping buzz of the machine begins, taking scans in 22 seconds each time. Grey-scale images appear on the operator's screen and we are looking at Alice-Rose's tiny brain.

From many scans like this, the prototypes can be evaluated for safety, accuracy and clinical relevance. If the results are positive, it could spur a company like GE to develop a new product: a scanner that transforms the way premature and sick newborns are cared for and treated in the NICU.

Until the evidence starts coming through, however, it's still baby steps for Project Firefly and the baby MRI.

"Is it better? I'll say in all honesty, I don't know," admits Paul Griffiths. "I think it will show more things with higher certainty, but I'm not entirely sure whether it will manifest into real changes in management and outcome. That's why it's research: if I knew, I wouldn't ask the

question."

*This [article](#) first appeared on [Mosaic](#) and is republished here under a Creative Commons licence.*

Provided by Mosaic

Citation: The baby MRI—shrinking tech to help save newborn lives (2017, January 24) retrieved 23 April 2024 from <https://medicalxpress.com/news/2017-01-baby-mrshrinking-tech-newborn.html>

This document is subject to copyright. Apart from any fair dealing for the purpose of private study or research, no part may be reproduced without the written permission. The content is provided for information purposes only.