

# WHAT DO THE EXPERTS SAY?



We have talked to four outstanding experts, those who perform fetal CMR already for a long period of time.

## What is your motivation to perform fetal CMR today?

**Malenka:** Cardiac MRI is a valuable tool for the diagnosis and management of patients with CHD throughout their lifespan, but its application in fetal life has so far been limited. Fetal CMR has the potential to provide crucial and complementary information in some cases of fetal CHD. Pregnancies complicated by fetal CHD are challenging for parents due to the persistent uncertainty about the prognosis and treatment options. Fetal CMR can assist in reducing this uncertainty and in predicting the postnatal outcomes and need for surgical interventions for the affected fetuses, thus offering significant benefits for parents and our future patients.

**David:** Our primary motivation has always been to understand the value that fetal CMR can bring to patients with fetal CHD. I see this value not just in terms of improving clinical diagnosis, but also in furthering our understanding of the effects (and even causes) of CHD in the context of the fetal circulation. Our service and approach have continually evolved to meet these needs, and I'm very proud of how much we have

achieved so far. I'm sure there will also be much more to learn in the future!

**Alex:** Our ultimate motivation for researching fetal CMR is to enhance the care of our fetal patients with suspected CHD. While our focus is on improving patient care, we are also keenly interested in developing and exploring the technology's potential to extend beyond fetal applications.

## How does fetal CMR fit into your clinical workflow?

**Malenka:** Our fetal cardiologist usually refer for fetal CMR after the 28 week check up. For the final monitoring visit at around 32-34 weeks, we streamline the process for our patients, many of whom travel long distances, by scheduling a joint fetal clinic and fetal CMR appointment. This helps ensure efficient care.

Following the fetal CMR, we promptly send a clinical report back to the referring clinician.

While most of the time, fetal CMR results align closely with echo results, if there are significant different findings, our fetal cardiology team arranges an additional appointment to discuss it with the patient. We have a clear protocol in place to address such cases.

*"The most rewarding thing about doing fetal CMR is to have the privilege to show our parents to be - who often really have a tough pregnancy - their baby on the screen and sending them a 3D reconstruction of their unborn baby. It brings some happiness and bonding and reminds parents that they are about to bring new life into the world. It's not just a heart problem, there's a real baby behind it."*

## What is your procedure in terms of referrals?

**David:** As a result of our early experiences with fetal CMR, particularly the engagement and support from our clinical colleagues in fetal cardiology, we were able to start a clinical fetal CMR service in 2019. This means our patients can now effectively be referred for fetal CMR as they would for any other imaging investigation. We are fortunate to have experienced clinical (Evelina London Children's Hospital) and research (King's College London) teams co-located on the same site St Thomas' Hospital, and in practice



**Malenka Bissell, M.D.,**  
Pediatric Cardiologist  
at Leeds teaching hospitals and clinical lecturer at University of Leeds

Use of smart-sync since summer 2021

a lot of the administration of the scans is still split between both. The vast majority of our clinical patients consent for research at the time of their MRI which really supports the ongoing development of the programme. Of course, running the programme as a clinical service means we also need robust processes for data management, reporting, managing incidental findings etc. This has taken a lot of time and effort to put in place, but works pretty seamlessly now.

**Alex:** In the early days it was crucial to build trust and closely involve our maternal-fetal care team in our development process. My colleague Dr. Lorna Browne, a pediatric radiologist, took the initiative to personally discuss each case with the maternal-fetal care team, particularly the fetal cardiologists, surgeons and obstetricians. This involved extra effort when we were starting up to share and educate the team on what the capabilities of the technology were. As a result, there has been an increase in referrals for both research exams (to

explore diagnostic capability under IRB approval) and to integrate the cardiac examination into clinically-indicated standard fetal MRIs for diagnostic insight. We've reached a point where we are no longer actively seeking referrals; instead, colleagues are referring patients to us.

## How did the cooperation between the teams (gyn, card, rad) change since you apply fetal CMR?

**Eleanor:** There is a strong collaboration between the teams, with perinatologists and cardiologists conducting monthly case reviews together. The determination of specific objectives for each scan is a collective discussion, but the final decisions are ultimately made by me.

**Malenka:** I now collaborate much more closely with my radiology colleagues compared to before, primarily because our fetal CMR also generate a fetal body report. This has led to significantly increased communication and collaboration with the radiology department compared to the past.

**David:** Since the beginning of our programme we have consistently maintained a strong partnership with our clinical colleagues in fetal cardiology. This means working together to establish what needs they have in terms of cardiac imaging, and developing sequences and post-processing methods to complement those needs. In practice this often means engaging proactively with the referring clinicians, for example via one-on-one discussions where we can present and discuss imaging results directly, participating in multi-disciplinary meetings, and engaging with other specialities involved with patient care.

It's important to remember that just

because we are imaging the fetal heart we still have to consider broader health needs of the patient and their unborn baby. In my view, it's essential when embarking on a clinical fetal CMR program to establish strong connections with professionals involved in maternal care – for example fetal medicine, obstetrics, radiology – who can assist in interpreting imaging data related from the mother as well as the fetal cardiac brain, body, and lungs.

From the reporting perspective, our fetal CMR team generate a cardiac report while radiology colleagues formally assess and report the fetal brain and body. We have robust local protocols both for disseminating these reports and for handling maternal or fetal incidental findings, all of which have been agreed with the relevant specialists locally.

**Alex:** The process involved building trust, learning how to collaborate effectively and fostering relationships for easy communication. We made sure to advertise our capabilities, even though there's no formal structure currently in place.

Dr. Browne and Dr. Richard Friesen were and are integral members of our family meetings, where the care implications of a suspected or confirmed diagnosis are discussed with the family members. This is also where the care team has seen the capabilities of this new technology.

*“smart-sync has proven to be a really valuable tool acquiring gated sequences, such as phase-contrast flows.”*

For other sites or hospitals looking to start a similar initiative, the key is to take the plunge and start the process. It will be a lengthy journey to identify key stakeholders in multiple departments who believe in the approach. Having invested experts within those departments is crucial; it's not just about doing the imaging, but also a commitment to demonstrating value of the approach to the care team.

## Did fetal CMR change your diagnostic impact? And how?



**David F. A. Lloyd, MBChB MRCPCH PhD,**  
Paediatric and Fetal Cardiology at  
Evelina London Children's Hospital  
and Senior Research Fellow  
at King's College London

David has been doing research on fetal CMR since 2015. He has gained lots of experience with the motion correction technology and has already integrated that tool into clinical practice at St Thomas' Hospital in London. In this interview he told us about his experience with fetal CMR and some the advantages brought by using *smart-sync*.

Between 3-4 scans/week

**Malenka:** In cases involving Transposition of the Great Arteries (TGAs), fetal CMR can help to confirm or strengthen the suspicion of a restrictive atrial septum. There was for example a specific case where the atrial septal flow looked sufficient on the echocardiography, but fetal CMR indicated a high suspicion of restriction, and indeed, saturations post-delivery were critically low and the baby required emergency septostomy. In other, especially complex cases, fetal CMR can serve as a valuable piece in the diagnosis puzzle, offering additional certainty and contributing to the diagnostic process.

**David:** Yes, absolutely! Congenital heart disease represents a wide range of conditions, so naturally fetal CMR will also have a range of impacts depending on the underlying diagnosis. But yes we have certainly seen many cases where fetal CMR has unequivocally identified associated features in a fetus – cardiac or extra-cardiac – that have had an important impact on counseling and the overall management of the patient. We have also had cases where we have detected less severe (but still important) incidental findings, or simply served to confirm the accuracy of initial impressions from fetal echocardiography. I think fetal CMR can serve an important role in all of these scenarios.

**Alex:** When prioritizing congenital heart disease indications, we particularly focus on Coarctation of the Aorta (CoA) as it has significant implications for delivery planning and postnatal care.

By combining structural information with 4D flow CMR analysis, we feel we have built up enough (soon to be published) evidence to improve the rate of true positives and false positives in cases of suspected CoA. This has had an impact on the diagnostic confidence among the care team for these patients. Of course, this is all said with the caveat that it is still very early days and all cases



**Eleanor Lehnert Schuchardt, M.D.,**  
Cardiologist  
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*"I love taking care of fetal patients and using all available tools to guide expectations through the perinatal period."*

require a holistic approach in which fetal CMR is only one part of the puzzle.

Beyond our efforts with CoA, a particularly memorable case was a large pericardial teratoma that contributed to 5% of the baby's overall weight. Using dynamic fetal CMR images, we were better able to delineate how much of the tumor was compressing the heart. This is important because it helped inform whether to perform something called the Ex-utero intrapartum (EXIT) procedure. This is a very invasive procedure in which the baby is partially delivered to operate on it, all while maintaining a connection to the placenta. After review of the fetal CMR results it was decided that the tumor did not severely compress the heart and that information, combined with echo, directly impacted the care of the patient, where it was decided to delay the procedure because the tumor was not severely limiting the function of the heart.

### **Have the therapy options changed since the application of fetal CMR?**

**Alex:** Yes, but it's crucial to reemphasize that our approach is holistic, which means that we don't rely solely on one piece of information to guide patient care. Instead, all available data is taken into consideration, including CMR, ultrasound, echo, and more, to make well-informed decisions. This comprehensive approach informs surgical planning, enhancing our confidence in deciding whether to perform invasive procedures, plan postnatal care, or simply monitor with 'watchful waiting'.

### **How did you manage to get the examinations reimbursed (in case you get it at all)?**

**Eleanor:** We currently need prior authorization for cases, but our team has not encountered denials so far. After completing the exam and ensuring it meets billable quality standards, we use fetal MRI CPT codes (74712 for singleton pregnancies). Looking ahead, I have plans to seek the creation of a new CPT Code within the U.S. medical system specifically for billing clinical fetal CMRs. This new code would enable cardiologists to receive separate payment for fetal CMRs, distinguishing them from fetal CMRs of the brain and body, similar to the distinction between hest MRI and traditional CMR procedures.

**Alex:** We don't receive reimbursement for fetal CMR; we conduct it primarily for research purposes. Sometimes, we're asked to include cases for research studies which have potential to impact care; we have IRB approval to investigate the potential diagnostic potential of this technology, thus we include these cases for research and are approved to share our imaging findings with the care team.

In terms of potential reimbursement, we believe our current approach indirectly benefits us during the research translation process. Doctors may choose to refer a pregnant mother for an MRI primarily to gather brain or lung-related information. But the potential for an added fetal CMR may play a role in some of the referral decisions where insurance will reimburse a non-cardiac MRI. This may contribute to MRI referral volumes, but also allows us to incorporate research into the care of these patients in the form of IRB-approved add-on exams.

### **What do you believe will be the future application of fetal CMR?**

**Malenka:** Fetal CMR becomes particularly valuable in the later stages of gestation, especially in complex cases where 3D reconstruction is beneficial. It proves especially useful in cases where hemodynamic measurements are of use, such as coarctation and TGA, or severe AV valve regurgitation. Additionally, it offers insights into lung volumes and lung pathologies, evaluating the lung-cardiac interface.

**David:** Big question! In the short term, we still lack a clear consensus on how fetal CMR will be deployed clinically, as existing methods mature and more people globally gain access to it. We have scanned over 700 patients in our service, and so are confident that fetal CMR

can be effective, add to clinician confidence and improve patient care – but it is critical that this can also be demonstrated more widely. I think it's crucial to observe what other centers are doing and collaborate with each other to understand how fetal CMR functions in different settings. Building a consensus on its usage, identifying scenarios where it can be beneficial, and understanding its potential impact across different fetal medicine and cardiology centres should be the next steps.

In the longer term, I see huge potential for fetal CMR in reshaping our understanding of the maternal-fetal-placental circulation. There is still so much we don't understand about the development of CHD – particularly difficult lesions such as coarctation of the aorta - and how CHD interacts with other organ systems such as the placenta and the developing fetal brain. I think fetal CMR could also have applications in other settings, such as placental insufficiency, twin pregnancies – the list is endless. It's a really exciting field to be involved in!

**Alex:** We're actively working on improving 4D flow CMR techniques, although we currently face limitations related to spatial-temporal resolution. Collaborating with Drs. Pim van Ooij, PhD and Eric Schrauben, PhD in Amsterdam, we're exploring motion-corrected strategies to enhance the quantitative hemodynamic information we can obtain.

While we've made significant progress in obtaining high-quality structural images, we recognize the immense value of functional information, especially given MRI's ability to provide multiple contrast mechanisms. If we can overcome motion-related challenges and speed up our imaging processes, we anticipate exciting possibilities in functional assessments, including areas like oxygenation and 2D/4D flow analysis. Additionally, I am excited to apply these advancements to our complex pediatric cases where gating has been challenging in the past.

**Eleanor:** It is my hope that fetal CMR will become a robust tool to help resolve uncertainty in individual cases, for both the expectant family and for medical providers who care for some of the most critically ill infants. I believe the modality could be useful beyond structural CHD – to study hydrops, fetal growth restriction, TTTS, CDH, and more.

## **What has changed when using smart-sync in comparison to use metric optimized gating (MOG)?**

**David:** *smart-sync* has proven to be a really valuable tool acquiring gated sequences, such as phase-contrast flows. The fact that we can have a real-time gating signal at the time of the scan allows us much more flexibility to use “off-the-shelf” sequences, and removes the need for extensive post-processing associated with retrospective gating methods. Having gated sequences al-



**Alexander Barker, PhD,**  
Associate Professor Radiology  
at University of Colorado

Alex started using the *smart-sync* prototype as early as 2018. Today he and his team perform about 1-2 scans/week.

lows us to make a better assessment of image quality “on-scanner”, as we no longer have gating artefacts which could be interpreted as fetal motion. We are also exploring the option combining the *smart-sync* with motion correction to generate time-resolved 3D sequences, which is another direction we are really excited about. ●

*“Our collaboration started rather fortuitously in 2018 at the ISMRM in Paris when Fabian mentioned he is commercializing the device and “[We] should use the device”. I happened to have some surplus funding to support the effort and that is how the journey has started. Back in the hospital everybody was asking why? “Echo is good enough”, It was really considered some off the wall stuff until Dr. Browne started showing the maternal fetal medicine team our results.”*