Cardiology in the Young (2015), **25**, 1590–1592
doi:10.1017/S1047951115002486

Original Article

Surveillance of fetal arrhythmias in the outpatient setting: current limitations and call for action

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Abstract Surveillance of fetal arrhythmias in the outpatient setting remains limited by lack of monitoring modalities. Despite technological advances made in the field of obstetrics, existing devices are not currently suitable to monitor fetal arrhythmias. In this report, the author describes the current and developing fetal heart rate monitoring technologies including the recent introduction of hand-held Doppler monitors for outpatient surveillance of fetal arrhythmias.

Keywords: Fetal arrhythmia; outpatient monitoring; cardiotocography; fetal electrocardiogram; hand-held doppler monitors

Received: 10 September 2015; Accepted: 7 October 2015

Fetal arrhythmias occur in 1 to 2% of pregnancies with life-threatening haemodynamic compromise, hydrops fetalis, and fetal demise occurring in 10% of the cases.[1,2] Prompt diagnosis and treatment of fetal arrhythmias is critical. Traditionally, standard surveillance of fetal arrhythmia has been limited to outpatient evaluations at the clinic of the Obstetrician/Perinatology specialist/fetal cardiologist and inpatient monitoring when deemed necessary. Frequent fetal heart rate auscultation several times a week is recommended;[3] however, outpatient surveillance of fetal arrhythmias is limited by lack of monitoring modalities. Cardiotocography and other fetal heart rate monitors used in the field of obstetrics are not currently suitable for use in outpatient monitoring of fetal arrhythmias.

Recently, ambulatory monitoring with hand-held Doppler monitors has been introduced in clinical practice[4] and in clinical research (personal communication). These monitors are used for outpatient monitoring, in the "Heart sounds at home study" for surveillance of SSA-positive pregnancies at risk for heart block, and will be utilised in the "Fast Trial" study for evaluation of randomised medical treatment of fetal arrhythmias. Nevertheless, no literature exists on the reliability of this method for monitoring of fetal arrhythmias.

Fetal arrhythmias require close monitoring, even benign rhythms may have a small risk of complications. The most common abnormal rhythm seen in clinical practice is irregular rhythm, mostly benign; however, 2% of the cases may be associated with long QT syndrome, atrial flutter, and second-degree atrioventricular block.[5] Ectopic rhythm in the form of premature atrial beats has a small risk, 0.5 to 1% of developing into a fetal tachycardia.[6] Intermittent forms of fetal tachycardia (<50% or the ultrasound time) have a small risk of developing into a sustained arrhythmia, thus needing closer surveillance. In addition, pregnant women with lupus or Sjogrens disease and positive autoantibodies have a 2–3% risk of having a fetus with complete heart block. In all the aforementioned situations, standard monitoring practices may not be frequent enough to detect the conversion into a significant arrhythmia, thus engendering a delay in its potential treatment. Traditional monitoring may also be cumbersome and expensive, with maternal compliance limited by distance to the hospital/clinic and lack of transportation.

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Table 1. IRB-approved pilot retrospective study performed at John's Hopkins All Children's Heart Institute: 73 fetuses with tachycardias and 10 with bradycardias between January, 2008 and May, 2013.

	Tachycardia		Bradycardia		PACs	
	n	Mean (SD)	n	Mean (SD)	n	Mean (SD)
Mean time to diagnosis (days)	9	7.9 (5.65)	7	16.96 (14.29)	5	40.6 (11.7)
Mean time to initiation of treatment (days)	14	6.24 (14.37)	1	3.7	0	n/a
Days of conversion from non-sustained to sustained	8	18 (18.65)	0	n/a	0	n/a
Days for conversion to NSR	15	14.47 (27.93)	1	14	0	n/a
Number of days for resolution of hydrops	7	17.29 (18.47)	0	n/a	0	n/a

In the current era, monitoring protocols vary by centre. The evaluation of fetal rhythm and diagnosis are typically performed using Doppler and M-mode echocardiographic techniques,[6] with newer modalities such as the developing fetal ECG and magnetocardiography available only in few centres.[7] Unfortunately, both modalities appear unsuitable for outpatient monitoring of fetal arrhythmia, and neither technology has the ability to record rhythms over long periods of time or to assess trends and changes in fetal heart rate.[8] Magnetocardiography may be able to record for longer periods of time; however, the technology is still cumbersome and available only to specialised referral centres.

In the field of obstetrics, cardiotocography is used in labour management and the assessment of fetal well-being. Cardiotocography records and traces the baseline fetal heart rate and heart rate variability by Doppler and registers uterine contractions using direct electrical signals of the fetal heart captured through a fetal electrode.[9] The use is limited to >30 weeks of gestation, inpatient monitoring, fetal motion, and quality of the data obtained during arrhythmias.[6] The first fetal ECG monitor able to record fetal heart rate and uterine contractions data was the Monica AN24. The fetal ECG utilises signal-averaged electrical data obtained from a non-invasive fetal heart rate monitor to extract ECGs from the fetus.[10,11] The Monica AN24 is currently FDA-approved for use in obstetrics inpatient monitoring during labour and delivery; the device has also been trialed for short outpatient monitoring during labour induction. The recording of fetal heart rate with this device remains technically difficult, limited to specific gestational ages and to recordings no longer than 16 hours. Although helpful for the management of high-risk deliveries and induction, this technology is not yet suited for use in the setting of fetal arrhythmia surveillance. Research and development work towards similar wireless wearable technology suitable for continuous fetal heart rate monitoring is ongoing.[12]

We recently evaluated our outpatient fetal heart rate monitoring protocols and outcomes in an IRB-approved pilot retrospective study performed in 73 fetuses with tachycardias and 10 with bradycardias between January, 2008 and May, 2013 at the John's Hopkins All Children's Heart Institute, St Petersburg, Florida. During the study period, institution-based recommendations for traditional fetal heart rate monitoring were in place, which called for fetal heart rate auscultation at the Obstetrician's/Perinatology specialist's office 2–3 times/week and weekly or biweekly fetal echocardiograms. Subjects diagnosed with sustained arrhythmia and those undergoing transplacental therapy were hospitalised and monitored as inpatients. The findings of this study demonstrated inconsistent/incomplete documentation of fetal heart rate auscultation in the electronic health record and no documentation of compliance. As shown in Table 1, time to diagnosis from a non-sustained to a sustained fetal arrhythmia, initiation of arrhythmia treatment, and successful conversion of arrhythmia to normal sinus rhythm were long. Our clinical impression was that these lag times are unacceptably long and suboptimal for best fetal outcomes. This study prompted the development of an enhanced clinical protocol and electronic medical record-based clinical documentation to facilitate improved adherence to our institutional monitoring recommendations. At this time, we also changed our institutional clinical practice from traditional clinic-based monitoring alone to clinic-based fetal heart rate monitoring plus home-based fetal heart rate monitoring using hand-held Doppler monitors according to a new protocol. In addition, we have launched a mixed retrospective–prospective cohort study designed to assess the reliability of the hand-held Doppler measurements relative to the current gold standard of Doppler ultrasound in clinic, as well as the comparative efficacy and safety of this enhanced fetal heart rate monitoring protocol when compared with the previous protocol in place at our institution.

In summary, at present, there are limited technologies suitable for use in outpatient surveillance of fetal arrhythmias. Effective ambulatory monitoring necessitates the development and

https://doi.org/10.1017/S1047951115002486 Published online by Cambridge University Press

implementation of standardised clinical protocols at the institutional level. Ultimately, with a more robust evidence basis, national/international recommendations can be developed for ambulatory fetal heart rate monitoring. Hand-held Doppler monitors have been recently introduced into clinical practice at some institutions for home-based fetal heart rate monitoring, however, no published data are available on the reliability and acceptability of this method for outpatient surveillance of fetal arrhythmias. Additional and ongoing research is needed to evaluate the clinical outcomes of these enhanced fetal heart rate monitoring regimens. The ultimate goal of this study is the reduction in risk of mortality and morbidity associated with fetal arrhythmias.

Acknowledgements

The author acknowledges Neil Goldbenger, MD, director of research and chief research officer at All Children's Hospital Johns Hopkins Medicine for his mentorship, support, and review and critique of this manuscript.

Financial Support

This research received no specific grant from any funding agency, commercial, or not-for-profit sectors.

Conflicts of Interest

None.

Ethical Standards

The authors assert that all the procedures contributing to this work comply with the ethical standards of the relevant national guidelines on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008.

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