# Fetal arrhythmias associated with cardiac rhabdomyomas

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**BACKGROUND** Primary heart tumors in fetuses are rare and mainly represent rhabdomyomas. The tumors have a variable expression and can be associated with arrhythmias, including both wide and narrow QRS tachycardia. Although multiple Doppler techniques exist to assess fetal heart rhythm, it can be difficult to record precise electrophysiological abnormalities in fetal life.

**OBJECTIVE** Investigations defining precise electrophysiological diagnosis were performed by using fetal magnetocardiography (fMCG).

**METHODS** In addition to routine fetal echocardiography, fMCG was used to investigate electrophysiological rhythm patterns in a series of 10 fetuses with cardiac rhabdomyomas.

**RESULTS** The mean gestational age of the fetuses was 28.6 ± 4.7 weeks. The multiple rhabdomyomas were mainly located in the right and left ventricles as well as around the atrioventricular groove. Arrhythmias or conduction abnormalities were diagnosed in all 10 patients, although only 6 of them were referred due to that indication. Remarkably, 80% (8 of 10) had associated Wolff-Parkinson-White pre-excitation. In addition, we found prominent P waves in 4 fetuses.

**CONCLUSION** In fetuses with rhabdomyomas, a disease where rhythm pathology is common, precise electrophysiological diagnosis can now be made by fMCG. fMCG is complimentary to echocardiography for rhythm assessment and can detect conduction abnormalities that are not possible to diagnose prenatally with M-mode or pulsed Doppler ultrasound. Risk factor assessment using fMCG can support pregnancy management and postnatal treatment and follow-up.

**KEYWORDS** Rhabdomyomas; Fetus; Infants; Arrhythmia; WPW pre-excitation

**ABBREVIATIONS AV** = atrioventricular; **ECG** = electrocardiogram; **fMCG** = fetal magnetocardiography; **SQUID** = superconducting quantum interference device; **SVT** = supraventricular tachycardia; **WPW** = Wolff-Parkinson-White

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## Introduction

Primary heart tumors in children are rare. The incidence has been reported to range between 0.08% and 0.2%[1,2]; however, the true incidence of cardiac tumors in prenatal life is difficult to estimate as these tumors often regress over time. In addition, atrial tumors can be small and may be difficult to recognize and not all pregnancies are screened with ultrasound. The majority of the cardiac tumors in fetal life are rhabdomyomas. These cardiac tumors are highly associated with tuberous sclerosis complex, which has a prevalence of about 1:8000 in newborns.[3]

DeVore et al[4], using echocardiography, were the first to report on rhabdomyomas in utero. Most rhabdomyomas are located in the fetal ventricular septum,[5] but they have been present in all cardiac chambers. Cardiac findings associated with rhabdomyomas are related to the size and position of the tumor and vary widely. The tumors can be clinically silent or cause hemodynamically significant obstructions, heart failure, cerebral embolization, arrhythmias, and sudden cardiac death. Symptoms can be due to a variety of anatomical prerequisites, including displacement, mobility, space occupation, coronary infiltration, and flow obstruction.

Postnatal electrocardiograms can show a variety of conduction defects, including tachycardia (ventricular, atrial ectopic, and supraventricular) and bradycardia, prolonged PR interval, nonspecific ST changes, Wolff-Parkinson-White (WPW) pre-excitation, and aberrant atrial and intraventricular conduction.[6–10] Surgical resection of cardiac tumors is necessary primarily if they induce severe hemodynamically relevant obstructions. Ablation can be necessary in case of life-threatening rhythm disorders.[11]

Prenatally, cardiac tumors are associated with several arrhythmias.[12,13] As it has not been possible to measure

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precise electrophysiological pathologies using direct methods in fetal life, the mechanisms of the arrhythmias are often inferred on the basis of mechanical echo/Doppler measurements. However, severe arrhythmias can induce fetal hydrops[14,15] and can cause fetal or neonatal death[16] and interruption of the pregnancy.[17]

This retrospective case series presents data from fetal magnetocardiography (fMCG). fMCG is the magnetic analog of fetal electrocardiography but provides improved signal quality owing to its favorable signal transmission properties through tissue. Thus, this is the first report to describe the precise electrophysiology of these patients. We also summarize the known literature.

## Methods

### Patients

The fMCG records of pregnant women referred to the Biomagnetism Laboratories at the Department of Medical Physics, University of Wisconsin-Madison, from 2002 to 2013 were retrieved from our database.

Informed consent was obtained from each participant, and the University of Wisconsin Institutional Review Board reviewed and approved the fMCG protocol.

The study included 10 patients diagnosed with fetal cardiac rhabdomyomas. The patients were referred from several Midwest fetal programs owing to the underlying cardiac diagnosis, with or without associated clinical arrhythmias. The mean gestational age at the time of the first measurement was 28.6 ± 4.7 weeks. The fMCG data (n = 12 studies) were evaluated. One fetus was measured on 3 separate occasions.

### Methods

#### *Review of the literature*

A PubMed search was done including keywords "rhabdomyoma" and "fetal arrhythmia." All articles in English language were included in the literature analysis.

#### *Measurements*

A 37-channel monoaxial (Magnes, 4D Neuroimaging, Inc, San Diego, CA) or a 21-channel (Tristan Technologies, San Diego, CA) vector superconducting quantum interference device (SQUID) was used to record the fMCG tracings. Recordings of about 10 minutes in duration were obtained in a magnetically shielded room. The SQUID was placed directly above and in direct contact with the mother's abdomen. A SonoSite M-Turbo (Bothwell, WA) portable ultrasound scanner equipped with a 60-mm broadband (2–5 MHz) curved array transducer was first used to locate the position of the fetal heart before positioning the SQUID. Spatial filtering was used to remove maternal interference.[18] All fMCG recordings were reviewed by at least 2 pediatric cardiologists.

## Results

### Review of the literature

The PubMed search identified 30 articles in English language. Twenty-four were available as original articles and 6 as abstracts. Nine studies reported ≥10 rhabdomyoma cases, 3 studies included less than 10 patients, and a total of 18 were single-case reports.

A total of 213 fetuses with fetal rhabdomyomas were reported in the literature. The locations of tumors are summarized in Table 1. In 78 (37%) fetuses, arrhythmias presented prenatally but were often not classified.

### Fetal measurements

Ten fetuses were included in our study with a mean gestational age of 28.6 ± 4.7 weeks. All fetuses had multiple cardiac rhabdomyomas. These tumors were mainly located in the right and left ventricles (Table 2). In some cases, atrial extension was found and the atrioventricular (AV) groove was affected. No patients were treated with antiarrhythmic agents at the time of their procedure.

Arrhythmias or conduction abnormalities were diagnosed in all 10 patients, although only 6 of them were referred for that indication. Referral diagnosis and fMCG diagnosis for fetal study patients are summarized in Table 2. The referral diagnosis was supraventricular tachycardia (SVT) in 3 fetuses. All 3 had fetal WPW pre-excitation. It is remarkable that in our patient series of rhabdomyomas, 80% (8 of 10) of the fetuses had associated WPW pre-excitation. Fifty percent (4 of 8) of these had intermittent WPW pre-excitation on fMCG. The mean PR interval was shorter in fetuses with WPW pre-excitation (52 ± 23 ms) than that in fetuses without WPW pre-excitation (88 ± 6 ms). In fetuses with WPW pattern, the QRS durations were generally in the high normal range, which is narrower than is seen with postnatal WPW pattern. Indeed, the duration from the beginning of the P wave to the end of QRS complex was 121 ms or less in 3 fetuses. This result suggests that the insertion of the accessory connection is more proximal to the normal conduction pathways than is typically seen in WPW pre-excitation.

In addition, we found higher P-wave amplitude and duration in 4 fetuses as compared to gestation-match normative data.[44]

Postnatal ECGs were available in 8 neonates. Six of them had fetal WPW pre-excitation, and 3 of those 6 were intermittent. In 50% (3 of 6) of the neonates, fetal WPW pre-excitation was confirmed in postnatal life.

In addition to these electrophysiological findings, the evolution of conduction abnormalities can be demonstrated in patient 8 (Figure 1). This fetus was measured at 3 separate times during pregnancy: 24, 33, and 36 weeks' gestation. Initially, only prominent P waves were seen, but over time this fetus developed premature atrial contractions and WPW pre-excitation. The conduction abnormalities can also be confirmed by using postnatal ECG (Figure 1).