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Leiden

The Netherlands

## Cardiac development : the posterior heart field and atrioventricular reentry tachycardia

Hahurij, N.D.

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Perinatal management and long-term  
cardiac outcome in fetal arrhythmia

## ABSTRACT

### Background

Cardiac arrhythmias are commonly observed in the fetus, however, may have major consequences for fetal development and post natal life.

### Aims

To evaluate the perinatal management and cardiac outcome of fetuses with tachy- or bradyarrhythmia.

### Study design

Perinatal management, outcome and long-term cardiac follow-up were evaluated retrospectively in consecutive fetuses with cardiac arrhythmias.

### Results

Forty-four fetuses were diagnosed: supraventricular tachycardia (SVT, n=28), atrial flutter (AF, n=7) and atrioventricular block (AVB, n=9). The overall incidence of cardiac anomalies was 18% mainly in the AVB group; hydrops was present in 34%. Direct or trans-placental fetal anti-arrhythmic medication was given in 76%. Mortality was 6% in SVT / AF and 78% in the AVB group, respectively. AF resolved in all patients. In the SVT group, Wolff-Parkinson-White (WPW) syndrome was present in 21%, diagnosed at birth or later in life. After the age of one year about 90% of patients in the SVT group remained asymptomatic and free of drugs (median follow-up 76 months).

### Conclusions

Mortality rate is low in patients with fetal SVT and AF but high in patients with AVB. Related morbidity includes WPW syndrome and congenital cardiac anomalies. Electrocardiographic screening is recommended in all fetal SVT cases before adolescence since WPW syndrome may occur later in life.

## INTRODUCTION

Fetal arrhythmias are common in clinical practice with a frequency ranging from 1% to 3% of all pregnancies. Most of these arrhythmias reflect transient, isolated atrial ectopic beats. However, sustained episodes of tachy- or bradyarrhythmia do occur and can lead to congestive heart failure, hydrops, fetal or neonatal demise, or severe neurologic morbidity in survivors.<sup>1-7</sup>

The most common forms of fetal tachycardias are supraventricular tachycardia (SVT) and atrial flutter (AF). The majority of fetal SVTs are atrioventricular reentry tachycardias (AVRT) caused by the presence of an accessory atrioventricular myocardial pathway.<sup>8</sup> If indicated, anti-arrhythmic drugs can be given transplacentally or directly to the fetus. In SVT and AF, various anti-arrhythmic drugs are used, including digoxin, flecainide, sotalol and amiodarone.<sup>9</sup>

More than three quarters of fetal bradycardia cases are caused by complete atrioventricular block (AVB). AVB in the absence of structural heart disease is mostly auto-immune mediated by maternal anti-Ro (SS-A) or anti-La (SS-B) antibodies.<sup>10</sup> In AVB, transplacental steroid treatment may reduce the effects of inflammation and fibrosis of the conduction system caused by maternal antibodies.<sup>11</sup> Complete AVB in the presence of complex congenital heart disease (CHD) has a poor prognosis.<sup>12,13</sup>

Elective delivery by cesarean section can be performed in the third trimester of pregnancy to start direct neonatal therapy (anti-arrhythmic drugs, radiofrequency catheter ablation or pacemaker therapy). The goal of pre- and postnatal treatment of tachycardia is to achieve sinus rhythm or to reduce the fetal heart rate in order to prevent heart failure or death. In most cases of fetal tachycardia, medication can be stopped within the first year after delivery. However, in cases of fetal and neonatal SVT recurrences can be expected in approximately 30% of patients later in life.<sup>14</sup> The aim of this study was to evaluate the perinatal management and long-term cardiologic outcome of fetuses with tachy- or bradyarrhythmia diagnosed at our center.

## MATERIAL AND METHODS

### Patients

We searched both our antenatal and neonatal databases for infants with in-utero cardiac arrhythmia, diagnosed between January 1990 and December 2005 at the Leiden University Medical Center, which is a tertiary fetal referral center. Arrhythmias included both tachy- and bradyarrhythmias. Sinus tachycardias, transient sinus bradycardias, premature atrial or ventricular contractions and ventricular tachycardias were excluded. In this time period the management protocol included complete work up with ultrasound examination and consultation of the pediatric cardiologist. Fetal ultrasound included detailed anatomic imaging of the fetal heart to diagnose or exclude cardiac defects. Routine karyotype was obtained in fetuses with suspected structural heart disease.

### Fetal Diagnosis and Therapy

SVT as a result of AVRT was diagnosed if there was a 1:1 atrioventricular conduction observed at a rate of 200-400 beats / min. AF was diagnosed when the atrial rate was

300-450 beats / min. Ventricular rates in AF depended on the degree of atrioventricular conduction block, usually 200-250 beats / min. The highest (peak) fetal heart rate was noted to give an indication of the severity of the tachycardia. AVB was classified as second degree or complete AVB based on M-mode evaluation and Doppler-flow measurements. Fetal hydrops was defined as a fluid collection visible on ultrasound in two or more cavities of the fetal body.<sup>15</sup> Maternal serum antibody titers (anti-cardiolipin antibodies, anti-Ro (SS-A) and anti-La (SS-B) were obtained in case of a heart block.

Anti-arrhythmic therapy was started when arrhythmias were sustained or associated with hemodynamic compromise prior to 34 weeks' gestation. After 34 weeks' gestation, such cases were delivered. A baseline electrocardiography (ECG) of the mother was obtained before the treatment started and maternal cardiac monitoring was conducted during the loading period to detect early signs of toxicity. During the study period, the following drugs were used: digoxin, sotalol, flecainide, amiodarone and adenosine. Digoxin was administered to the mother in adjusted oral doses to maintain a maternal serum therapeutic level of 1-2 ng/mL (loading dose 2x0.75 mg, maintenance 0.25-0.5 mg, maximum 0.75 mg/daily). Flecainide (oral dose 200-400 mg daily) and sotalol (oral dose 2x80-160 mg daily) were used as secondary agents. Amiodarone was administered by combined direct fetal intravenous and maternal oral and intravenous route. Direct fetal amiodarone therapy consisted of amiodarone on the basis of estimated fetal weight (10 mg/kg). In some cases adenosine was given intravenously (0.1 mg/kg) as direct fetal therapy just before amiodarone therapy. Drugs to treat AVB were given to the mother included ritodrine (intravenously 9 mg / hour), dexamethasone (4 mg daily) and fenoterol (intravenously 150 µgram/hour).

After birth, if tachycardia or AVB was present, ECGs were made to confirm antenatal diagnosis. In all SVT and AF cases, ECGs were made during sinus rhythm to detect ventricular preexcitation (deltawave) caused by anterograde conduction through an accessory pathway (WPW syndrome).

### **Long-term cardiac follow-up**

With approval of the protocol by the institutional review board of the Leiden University Medical Center, family physicians were contacted by letter to explain the aims and nature of the study. After consultation with the family physician, parents were sent an explanatory letter asking their permission to review all medical records and their cooperation for testing the children. All cases were evaluated by a pediatric cardiologist and included medical history, physical examination and ECG. Additional studies, i.e. 24 hour-Holter monitoring, exercise-test and ECG were performed if children were symptomatic. Long-term neurodevelopmental outcome was also assessed and has been reported separately.<sup>16</sup>

## RESULTS

### Study population characteristics

During the 16-year study period, 44 pregnancies were referred to our center because of sustained fetal tachy- or bradyarrhythmia. Figure 1 shows the overall outcome of the 44 fetuses with arrhythmia. Perinatal characteristics of the study population are presented in Table 1.

The mechanism of SVT was AVRT in all cases. One infant in the SVT group with cardiomyopathy and encephalopathy due to hydroxyglutaric aciduria died at the age of 5 months. The AVB cases consisted of complete AVB (n=7) and second degree AVB (n=2). Two of 9 cases had auto-immune associated AVB, 5 had complex congenital heart malformations and 2 had a severe form of long QT syndrome (LQT8 or Timothy syndrome). In the AVB group were 3 fetal deaths and 4 postnatal deaths (Table 2). One case of infant death in the AVB group (LQT8) occurred after follow-up.

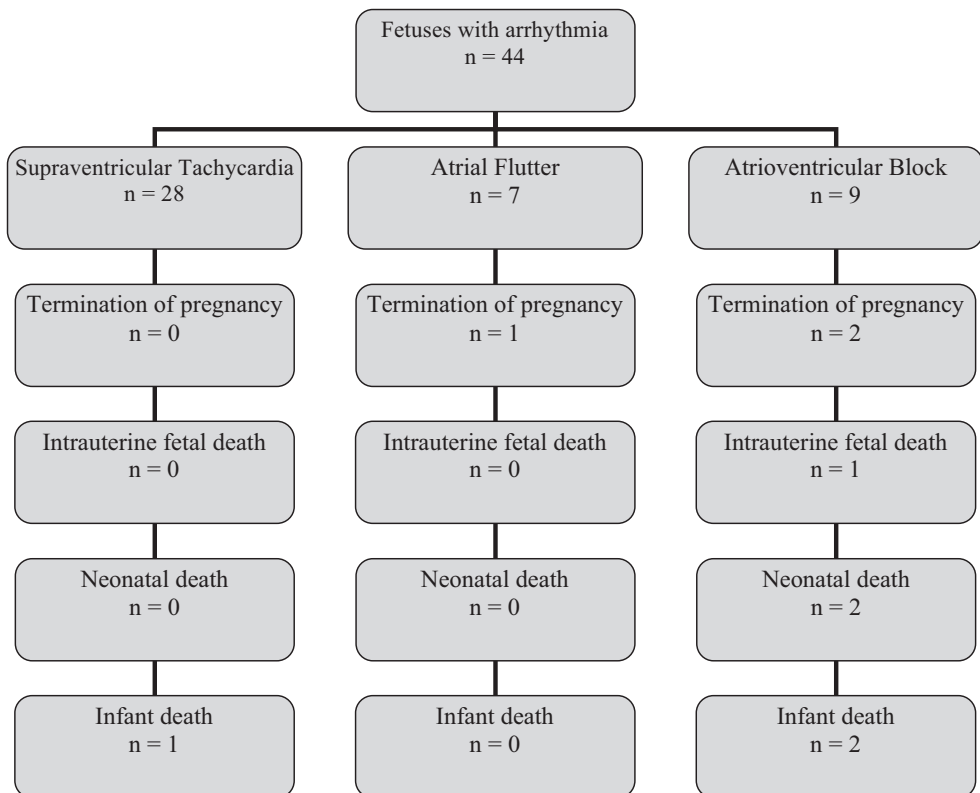


Figure 1. Flowchart showing the outcome of the 44 studied fetuses with tachy- or bradyarrhythmias.

### Prenatal drug therapy

Clinical data and details in all 19 cases of tachyarrhythmia treated prenatally with anti-arrhythmic medication are presented in Table 3. During anti-arrhythmic therapy, sinus rhythm was achieved in 77% (7/9) non-hydropic and in 75% (6/8) hydropic tachycardia fetuses. There was a trend towards multidrug therapy in the more recent years. Clinical data and details in the 3 cases of prenatally treated bradyarrhythmia are presented in Table 4.

### Short-term follow-up

Neonatal management and outcome in live-born infants is presented in Table 5. The overall incidence of cardiac anomalies in the study population was 18% (8/44). In the SVT group 1 infant had a ventricular septal defect and 1 infant had cardiomyopathy, polyvalvular disease and pulmonary stenosis. In the AF group, 1 infant was found to have coarctation of the aorta. In the AVB group, 5 of 9 infants had complex CHD (congenitally corrected transposition of the great arteries (cc-TGA), n=2; left atrial isomerism, n=1; ventricular septal defect, pulmonary stenosis, cardiomyopathy, n=1; endocardial fibroelastosis, n=1). Postnatally, AVB block remained present in all survivors (n=6) and 5 patients received pacemaker therapy immediately after birth.

In 67% of AF-fetuses and 78% of SVT-fetuses episodes of tachycardia or incessant tachycardia remained present after birth. Nineteen of the 28 children in the SVT group were treated with medication after birth. SVT was self-limiting in 74% (14/19), and treatment could be stopped within the first year of life. Five of 28 fetal SVT (AVRT) cases had WPW syndrome, as

**Table 1. Characteristics of the study population by type of arrhythmia.**

| Type of arrhythmia  | Supraventricular Tachycardia (n = 28) | Atrial Flutter (n = 7) | Atrioventricular Block (n = 9) |
|---|---------------------------------------|------------------------|--------------------------------|
| Maternal age – years <sup>a</sup>                               | 28 (20 – 39)                          | 31 (24 – 39)           | 32 (28 – 36)                   |
| Male fetus – % (n)  | 61 (17)                               | 43 (3)                 | 44 (4)                         |
| Gestational age at diagnosis of arrhythmia – weeks <sup>a</sup> | 29 (18 – 40)                          | 30 (24 – 38)           | 23 (12 – 37)                   |
| Peak/slowest fetal heart rate – beats/min <sup>a</sup>          | 247 (200 – 400)                       | 237 (200 – 250)        | 55 (45 – 70)                   |
| Fetal hydrops – % (n)   | 39 (11)                               | -                      | 44 (4)                         |
| Antenatal therapy – % (n)                                       | 57 (16)                               | 43 (3)                 | 33 (3)                         |
| Duration of antenatal therapy – days <sup>a</sup>               | 56 (12 – 95)                          | 49 (43 – 96)           | 33 (12 – 93)                   |
| Gestational age at birth – weeks <sup>a</sup>                   | 38 (30 – 42)                          | 37 (36 – 38)           | 36 (30 – 40)                   |
| Birth weight – grams <sup>a</sup>                               | 2993 (1547 – 3965)                    | 3282 (2530 – 4726)     | 2704 (2300 – 3470)             |

<sup>a</sup>Value given as median (range).

demonstrated by the presence of ventricular preexcitation on the ECG at birth. In 2 cases, radiofrequency catheter ablation of an accessory pathway was performed in the first months of life due to drug-refractory tachycardias. AF was treated with anti-arrhythmic therapy (n=4) or cardioversion (n=2). After initial conversion to sinus rhythm, AF did not recur in all 6 cases. Interestingly, in two AF cases the presence of an accessory pathway was demonstrated. One AF case showed WPW syndrome on ECG after cardioversion, another AF case developed recurrent AVRT requiring anti-arrhythmic therapy.

### Long-term cardiac follow-up

Long-term follow-up was obtained from 28 infants of the 36 survivors. Eight of the 36 surviving infants could not be followed due to declined consent or lack of contact address. At the time of cardiac assessment the median age of the children was 76 months ranging from 6 months to 15 years of age.

Twenty-three children were examined in the SVT-group. No cases still required drug therapy, and no cases were treated with catheter ablation after the first year of life. Twenty-two of 23 patients were still asymptomatic and only one child (six year old) with self-limiting SVTs after birth complained of short episodes of palpitations. Three of 5 cases of postnatal WPW syndrome showed normalization of ECG on follow-up with disappearance of ventricular preexcitation. Interestingly, a new case of asymptomatic WPW syndrome was found in a 9 year old child who had a normal ECG and self-limiting SVTs at birth. In cases of WPW syndrome follow-up ECGs were recommended and instructions were given on how to act when symptoms occur.

**Table 2. Details on cases of tachy- or bradyarrhythmias leading to fetal or infant death.**

| Arrhythmia | Complementary Diagnosis  | Outcome  |
|------------|--|--|
| SVT        | D2 – hydroxyglutaric aciduria induced cardiomyopathy             | Died at age of 5 months  |
| AF         | Trisomy – 21   | Termination of pregnancy   |
| AVB        | -  | Termination of pregnancy   |
| AVB        | Left isomerism   | Termination of pregnancy   |
| AVB        | Corrected transposition of the great arteries, pulmonic stenosis | Intrauterine fetal death   |
| AVB        | Maternal Sjögren syndrome  | Pacemaker, died at age of 20 months  |
| AVB        | Endocardial fibroelastosis                                       | Pacemaker, died at age of 2 days   |
| AVB        | Long QT – syndrome   | Pacemaker, died at age of 29 days  |
| AVB        | Long QT – syndrome   | Pacemaker, implantable cardioverter defibrillator, surgery, died at the age of 2 years |

SVT = Supraventricular Tachycardia; AF = Atrial Flutter; AVB = Atrioventricular Block

Table 3. Clinical data on cases of tachyarrhythmia treated with prenatal maternal and direct fetal medication.

| Year | Type of arrhythmia | Continuous or intermittent | Fetal hydrops | Maternal and direct fetal drug therapy                         | Conversion (after number of days of therapy) |
|------|--------------------|----------------------------|---------------|--|--|
| 1992 | SVT                | continuous                 | yes           | D → F → D → cs   | no   |
| 1994 | SVT                | continuous                 | yes           | D + K  | unknown                                      |
| 1994 | SVT                | intermittent               | no            | D  | yes (66)                                     |
| 1996 | SVT                | intermittent               | yes           | S  | yes (7)                                      |
| 1997 | SVT                | intermittent               | no            | D  | unknown                                      |
| 1997 | AF                 | intermittent               | no            | S  | no   |
| 1997 | SVT                | intermittent               | no            | S  | yes (19)                                     |
| 1998 | AF                 | intermittent               | no            | D → D + S  | yes (14)                                     |
| 1998 | SVT                | continuous                 | yes           | S → S + D → D + F  | yes (5)                                      |
| 1998 | SVT                | continuous                 | yes           | S → D + F → F  | yes (5)                                      |
| 1999 | SVT                | intermittent               | yes           | F → F + D  | yes (5)                                      |
| 2000 | SVT                | intermittent               | no            | D → D + F → F  | yes (4)                                      |
| 2001 | SVT                | continuous                 | no            | D  | yes (4)                                      |
| 2002 | SVT                | intermittent               | no            | D  | yes (16)                                     |
| 2002 | SVT                | continuous                 | yes           | F → F + D → Ad(cc) + Am(cc) + Ad(cc) + Am(iv/o) → Am(iv) D(iv) | yes (19)                                     |
| 2003 | SVT                | intermittent               | yes           | D + F → D + S → Am(cc/iv/o) → Am(cc/iv/o) → cs                 | no   |
| 2004 | SVT                | intermittent               | no            | F  | yes (1)                                      |
| 2004 | AF                 | continuous                 | no            | F → F + D → cs   | no   |
| 2004 | SVT                | intermittent               | yes           | D + F → Ad(cc) + Am(cc/iv/o)                                   | yes (12)                                     |

SVT = Supraventricular Tachycardia; AF = Atrial Flutter; cs = elective preterm delivery by Cesarean Section; iv = intravenous; cc = cordocentesis; o = oral; D = Digoxin; F = Flecainide; K = Kinidine sulphate; S = Sotalol; Ad = Adenosine; Am = Amiodarone.

In the AF group, 5 of 6 cases remained free of arrhythmia symptoms. Four of 6 underwent neurological and cardiac examination. The ECG was normal in 3 of 4. One 2 year old AF case with postnatal WPW syndrome had remained asymptomatic but the ECG still showed ventricular preexcitation. A 9 year old AF case had developed drug refractory AVRT after birth and underwent successful catheter ablation at the age of 4 years. One 4-year old child with AF had coarctation of the aorta and self-limiting AF. The patient underwent coarctectomy and remained asymptomatic after surgery.

Morbidity and mortality rate in the AVB group was extremely high. One infant with cc-TGA received a DDD pacemaker at the age of 6 years and was in good clinical condition at the age of 9 years. Echocardiographic follow-up showed good function of the systemic right ventricle. One autoimmune mediated AVB case developed cardiomyopathy and died unexpectedly during a period with fever and pneumonia at 1.5 years of age. Another AVB case with fetal hydrops received a pacemaker immediately after birth but died on day 2 after birth. Postmortem analysis showed extensive endocardial fibroelastosis. There were two cases of functional 2:1 AV block associated with a severe form of long QT-syndrome, LQTS 8 or Timothy-syndrome. In one case a pacemaker was placed, but the infant died 29 days after birth because of uncontrollable ventricular arrhythmias. The other case also received a pacemaker followed by implantation of an implantable cardioverter defibrillator (ICD) at the age of three months. The ECG showed extreme QT-prolongation and T-wave alternans. He had recurrent ICD shocks for torsade des pointes and died at the age of 2 years of ventricular arrhythmia and cardiomyopathy after stellectomy of the left ganglion stellatum (Table 2).

**Table 4. Clinical data on 3 AVB cases in which drug therapy was applied.**

| Year | Fetal heart rate            | Fetal hydrops | Maternal and direct fetal drug therapy | Outcome   |
|------|-----------------------------|---------------|--|---|
| 1996 | 45 beats/minute (3°- block) | no            | DXM → DXM + R → cs at 37 weeks         | Died at 1.5 years of age                              |
| 2001 | 48 beats/minute (3°- block) | yes           | R → cs at 30 weeks                     | Died 2 days after birth                               |
| 2005 | 45 beats/minute (2°- block) | yes           | F → cs at 34 weeks                     | Cardiomyopathy, pacemaker, severe developmental delay |

DXM = Dexamethason; R = Ritodrine; F = Fenoterol; cs = elective delivery by Cesarean Section.

**Table 5. Management and neonatal outcome in live-born infants (n=40).**

| Management or Outcome                              | Supraventricular<br>Tachycardia<br>(n = 28) | Atrial Flutter<br>(n = 6) | Atrioventricular<br>Block<br>(n = 6) |
|--|---|---------------------------|--------------------------------------|
| Neonatal arrhythmia – % (n)                        | 78 (22)                                     | 67 (4)                    | 100 (6)                              |
| Neonatal ward admission – % (n)                    | 89 (25)                                     | 100 (6)                   | 100 (6)                              |
| Admission duration – days <sup>a</sup>             | 6 (1 – 61)                                  | 6 (4 – 21)                | 22 (2 – 42)                          |
| Mechanical Ventilation at birth – % (n)            | 14 (4)                                      | 33 (2)                    | 83 (5)                               |
| Neonatal anti-arrhythmic therapy – % (n)           | 86 (19)                                     | 67 (4)                    | 100 (6)                              |
| Anti-arrhythmic medication – % (n)                 | 61 (17)                                     | 17 (1)                    | -                                    |
| + electric cardioversion – % (n)                   | -   | 33 (2)                    | -                                    |
| + accessory pathway ablation – % (n)               | 7 (2)                                       | 17 (1)                    | -                                    |
| + pacemaker implantation – % (n)                   | -   | -                         | 83 (5)                               |
| + implantable cardioverter – defibrillator – % (n) | -   | -                         | 17 (1)                               |

<sup>a</sup>Value given as median (range).

## DISCUSSION

We studied perinatal management and long-term cardiac outcome of a consecutive cohort of fetuses with tachy- and bradyarrhythmias.

In the SVT and AF group mortality was remarkably low (6%) and limited to one postnatal death due to severe metabolic disease and one case of termination of pregnancy due to trisomy 21. In contrast to other studies,<sup>2,5</sup> there was no tachycardia-related mortality despite presence of fetal hydrops, young gestational age and the need for maternal or direct fetal drug therapy in a significant number of cases. There is a broad experience in management of fetal SVT and AF, although studies in literature remain limited to retrospective case series.<sup>17,18</sup> In general, maternal drug therapy is opted if tachycardia is intermittent or incessant before 32 to 35 weeks of gestation. Digoxin is often used for SVT and AF in non-hydropic fetuses, although many centers nowadays prefer sotalol or flecainide as drug of choice. Sotalol appears to be more effective than digoxin for treatment of AF.<sup>19,20</sup> In the presence of fetal hydrops, flecainide or amiodarone has become the therapy of choice for SVT.<sup>5</sup>

In 2006, Cuneo *et al.* reviewed literature with regard to the outcome of fetal tachyarrhythmias. They report conversion rates in SVT cases in the range from 23-62% with standard transplacental therapy with relative low mortality in this group. If second-line agents were indicated, mortality rates of 19% with flecainide and 25-30% with sotalol were reported. The combined mortality rate for hydropic and non-hydropic fetuses with AF was 8%.<sup>21</sup> There was no tachycardia-related mortality in the present series, which may be explained by relatively

aggressive treatment strategies with timely switch to alternative transplacental therapies or direct fetal drug therapy after failure of first or second line therapy especially in young and hydropic fetuses.

Thus far, there are very limited data on long-term postnatal outcome of fetal tachycardias.<sup>1</sup> Similar to other studies, AF resolved spontaneously or after cardioversion in all fetal AF cases. Interestingly, we found the presence of an accessory pathway in 2/6 fetal AF cases, which has been reported previously.<sup>22</sup> In the present study the majority of SVT cases remained symptomatic and required drug therapy after birth and two neonates even underwent radiofrequency catheter ablation in the first months of life. Twenty-one percent of SVT cases had WPW syndrome, which corresponds to the incidence of WPW syndrome in neonates with SVTs.<sup>14</sup> In the present series none of the SVT group required medication at median age of 72 months and only one child had mild symptoms. These findings indicate that around 90% of the fetal SVT group, including those with WPW syndrome, becomes asymptomatic without medication after the age of one year. These findings slightly differ with series on AVRT in neonates showing a low recurrence rate in AVRT cases without WPW syndrome but a high recurrence rate in AVRT cases with WPW syndrome.<sup>14</sup>

In this cohort, ventricular preexcitation (WPW syndrome) disappeared in 3 of 5 patients but also newly appeared in one patient on follow-up. There is a risk of sudden cardiac death in approximately 1% of patients with WPW syndrome, caused by atrial fibrillation and a fast ventricular response through the accessory pathway.<sup>23</sup> Therefore, we advocate to perform ECGs at around 8-12 years of life in all children with fetal AVRT to identify possible cases of WPW syndrome. Curative treatment by catheter ablation has become first line therapy in older symptomatic children and adults with WPW syndrome and should be considered in older asymptomatic children after episodes of fetal AVRT.<sup>24</sup>

In the present series the outcome of the group of fetal AVB was disappointing and 7/9 AVB cases died, including one of the two cases with auto-immune mediated AVB due to cardiomyopathy. The poor clinical outcome of this small series can be explained because the majority of AVB cases had either severe CHD (n=5) or LQTS8 (n=2), a severe type of LQTS with poor postnatal prognosis due to lethal ventricular arrhythmias. Previous reports have shown that fetal AVB has relatively poor prognosis and mortality rates are high during the first 12 months of life.<sup>25</sup> Jaeggi *et al.* described clinical outcome in large series of AVB cases. In cases of autoimmune mediated AVB the rates of live birth and 1-year survival were 88% and 75% respectively as compared to rates of only 56% and 19% in cases associated with major structural CHD ( $P<0.0001$ ). They conclude, like in earlier reports, that AVB associated with major structural heart disease other than cc-TGA has an extremely poor outcome.<sup>26</sup> In fetuses with AVB and left atrial isomerism survival rates between 0 and 22% have been reported.<sup>21</sup> The use of dexamethasone as therapy for auto-immune-mediated AVB remains controversial. Several studies have reported improved survival rate after introduction of

dexamethasone treatment for fetal auto-immune AVB.<sup>11</sup> In contrast, a recent study by Lopes *et al.* described the clinical outcome of 116 fetuses with autoimmune-mediated AVB (49%) and CHD related AVB (51%), mainly left atrial isomerism. They showed high survival rate (>90%) in untreated fetuses with autoimmune-mediated AVB, questioning the rationale for steroid therapy in this group. This study further confirmed that poor outcome is highly associated with CHD, fetal hydrops and a slow ventricular rate (<55 bpm).<sup>27</sup>

In conclusion, fetal SVT and AF has low mortality and excellent long-term prognosis, although in some cases aggressive treatment strategies, including direct fetal therapy and radiofrequency catheter ablation in the first year of life, are required. Furthermore, we recommend ECG screening before adolescence to detect WPW syndrome in this patient population. Fetal AVB in the presence of CHD or long QT-syndrome has a dismal prognosis with high pre- and postnatal mortality.

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## REFERENCES

1. Boldt T, Eronen M, Andersson S. Long-term outcome in fetuses with cardiac arrhythmias. *Obstet Gynecol.* 2003;102:1372-1379.
2. Simpson JM, Sharland GK. Fetal tachycardias: management and outcome of 127 consecutive cases. *Heart.* 1998;79:576-581.
3. Eronen M, Heikkilä P, Teramo K. Congenital complete heart block in the fetus: hemodynamic features, antenatal treatment, and outcome in six cases. *Pediatr Cardiol.* 2001;22:385-392.
4. Vlagsma R, Hallensleben E, Meijboom EJ. Supraventricular tachycardia and premature atrial contractions in fetus. *Ned Tijdschr Geneesk.* 2001;145:295-299.
5. van Engelen AD, Weijtens O, Brenner JI, Kleinman CS, Copel JA, Stoutenbeek P, Meijboom EJ. Management outcome and follow-up of fetal tachycardia. *J Am Coll Cardiol.* 1994;24:1371-1375.
6. Schade RP, Stoutenbeek P, de Vries LS, Meijboom EJ. Neurological morbidity after fetal supraventricular tachyarrhythmia. *Ultrasound Obstet Gynecol.* 1999;13:43-47.
7. Sonesson SE, Winberg P, Lidegran M, Westgren M. Foetal supraventricular tachycardia and cerebral complications. *Acta Paediatr.* 1996;85:1249-1252.
8. Kleinman CS, Nehme RA. Cardiac arrhythmias in the human fetus. *Pediatr Cardiol.* 2004;25:234-251.
9. Oudijk MA, Ruskamp JM, Ambachtsheer BE, Ververs TF, Stoutenbeek P, Visser GH, Meijboom EJ. Drug treatment of fetal tachycardias. *Paediatr Drugs.* 2002;4:49-63.
10. Ho SY, Esscher E, Anderson RH, Michaelsson M. Anatomy of congenital complete heart block and relation to maternal anti-Ro antibodies. *Am J Cardiol.* 1986;58:291-294.
11. Jaeggi ET, Friedberg MK. Diagnosis and management of fetal bradyarrhythmias. *Pacing Clin Electrophysiol.* 2008;31 Suppl 1:S50-S53.

12. Baschat AA, Gembruch U, Knopfle G, Hansmann M. First-trimester fetal heart block: a marker for cardiac anomaly. *Ultrasound Obstet Gynecol.* 1999;14:311-314.
13. Jaeggi ET, Hamilton RM, Silverman ED, Zamora SA, Hornberger LK. Outcome of children with fetal, neonatal or childhood diagnosis of isolated congenital atrioventricular block. A single institution's experience of 30 years. *J Am Coll Cardiol.* 2002;39:130-137.
14. Tortoriello TA, Snyder CS, Smith EO, Fenrich AL, Jr., Friedman RA, Kertesz NJ. Frequency of recurrence among infants with supraventricular tachycardia and comparison of recurrence rates among those with and without preexcitation and among those with and without response to digoxin and/or propranolol therapy. *Am J Cardiol.* 2003;92:1045-1049.
15. Phibbs RH. Hydrops fetalis and other causes of neonatal edema and ascitis. In: *Fetal and neonatal physiology.* Philadelphia, PA: Saunders; 1992. p1319-1325
16. Lopriore E, Aziz MI, Nagel HT, Blom NA, Rozendaal L, Kanhai HH, Vandenbussche FP. Long-term neurodevelopmental outcome after fetal arrhythmia. *Am J Obstet Gynecol.* 2009;201:46-51.
17. Frohn-Mulder IM, Stewart PA, Witsenburg M, Den Hollander NS, Wladimiroff JW, Hess J. The efficacy of flecainide versus digoxin in the management of fetal supraventricular tachycardia. *Prenat Diagn.* 1995;15:1297-1302.
18. Krapp M, Baschat AA, Gembruch U, Geipel A, Germer U. Flecainide in the intrauterine treatment of fetal supraventricular tachycardia. *Ultrasound Obstet Gynecol.* 2002;19:158-164.
19. Jaeggi E, Fouron JC, Drblik SP. Fetal atrial flutter: diagnosis, clinical features, treatment, and outcome. *J Pediatr.* 1998;132:335-339.
20. Oudijk MA, Michon MM, Kleinman CS, Kapusta L, Stoutenbeek P, Visser GH, Meijboom EJ. Sotalol in the treatment of fetal dysrhythmias. *Circulation.* 2000;101:2721-2726.
21. Cuneo BF. Outcome of fetal cardiac defects. *Curr Opin Pediatr.* 2006;18:490-496.
22. Lisowski LA, Verheijen PM, Benatar AA, Soyeur DJ, Stoutenbeek P, Brenner JI, Kleinman CS, Meijboom EJ. Atrial flutter in the perinatal age group: diagnosis, management and outcome. *J Am Coll Cardiol.* 2000;35:771-777.
23. Mazur A, Meisel S, Shotan A, Strasberg B. The mechanism of sudden death in the Wolff-Parkinson-White syndrome. *J Cardiovasc Electrophysiol.* 2005;16:1393.
24. Joung B, Lee M, Sung JH, Kim JY, Ahn S, Kim S. Pediatric radiofrequency catheter ablation: sedation methods and success, complication and recurrence rates. *Circ J.* 2006;70:278-284.
25. Eronen M, Siren MK, Ekblad H, Tikanoja T, Julkunen H, Paavilainen T. Short- and long-term outcome of children with congenital complete heart block diagnosed in utero or as a newborn. *Pediatrics.* 2000;106:86-91.
26. Jaeggi ET, Hornberger LK, Smallhorn JF, Fouron JC. Prenatal diagnosis of complete atrioventricular block associated with structural heart disease: combined experience of two tertiary care centers and review of the literature. *Ultrasound Obstet Gynecol.* 2005;26:16-21.
27. Lopes LM, Tavares GM, Damiano AP, Lopes MA, Aiello VD, Schultz R, Zugaib M. Perinatal outcome of fetal atrioventricular block: one-hundred-sixteen cases from a single institution. *Circulation.* 2008;118:1268-1275.

