

FETAL ARRHYTHMIAS

Andrej Robida, MD, FACC*

ABSTRACT

As many as 20% of referrals for fetal echocardiography is due to fetal arrhythmias. They may occur in 2% of pregnancies. Indication for echocardiographic evaluation of heart rhythm are sustained fetal heart rate below 100 beats per minute, sustained heart rates above 180 beats per minute, unexplained hydrops fetalis, and frequent and repetitive irregular heart beats. Fetuses with either sustained bradycardia or tachycardia deserve expeditious evaluation. The most important fetal bradycardia is a complete atrioventricular block, which can be associated with a structural heart disease or occur as a consequence of maternal collagen vascular disease and/ or lupus associated antibodies. Fetal therapy is difficult and often unsuccessful. The most common serious fetal tachycardia is orthodromic reciprocating atrioventricular tachycardia followed by atrial flutter. These tachycardias can be treated in utero and proposed protocols for drug management are described. A close fetal and maternal monitoring during treatment and a team approach is advised. (**Heart Views. 2000;1(9) 358-364**)

© 2000 Hamad Medical Corporation.

Introduction

Fetal echocardiography has developed over the past several years into an important modality of hemodynamic and structural examination of a fetal heart. It differs substantially from postnatal echocardiogram and obtaining good images depends on gestational age of the fetus, position of the fetus in the uterus, and obesity of a pregnant woman. The best time for evaluation of the fetal heart is between 16 and 32 weeks of gestation. A complete initial examination of the fetal heart takes around 45 to 60 minutes. Determination of fetal heart rate with relation of atrial to ventricular contractions has been included in standard protocol of fetal heart examination (1).

Fetal arrhythmias accounts for up to 20% referrals for fetal echocardiography and may occur in as many as 2% of pregnancies (2). Indications for echocardiographic evaluation of heart rhythm are:

- ? Sustained fetal heart rate below 100 beats per minute
- ? Sustained heart rates above 180 beats per minute
- ? Unexplained nonimmune hydrops fetalis

? Frequent and repetitive irregular heart beats
Fetuses with either sustained bradycardia or tachycardia deserve expeditious evaluation whereas in fetuses with an irregular heart rates the assessment is less urgent.

Technique of echocardiographic examination

For diagnosis of an arrhythmia a combination of two-dimensional, M-mode, and Doppler techniques can be used to accurately describe rhythm abnormalities. Echocardiographic examination for detection of fetal rhythm disturbances begins with a two-dimensional imaging. With this modality it can be appreciated if the heart beats are regular or irregular, too fast or too slow, and whether hydrops fetalis is present or absent. A search for a structural abnormality is also carried out, as certain rhythm disturbances are associated with congenital heart anomalies.

For an accurate diagnosis M-mode and Doppler techniques are used. With the M-mode technique, the cursor line is positioned over the atrial free walls, atrial septum, atrioventricular valves, ventricular free walls and semilunar valves. It is necessary to simultaneously interrogate at least one structure representing atrial activity and at least one structure showing ventricular activity. These images are not always easy to obtain.

*Consultant Pediatric Cardiologist, Pediatric Cardiology Section, Department of Cardiology and Cardiovascular Surgery, Hamad Medical Corporation, Doha, Qatar.
Correspondence to: Dr. Andrej Robida, Hamad Medical Corporation, P. O. Box 3050, Doha, Qatar. E-mail: androb50@qatar.net.qa

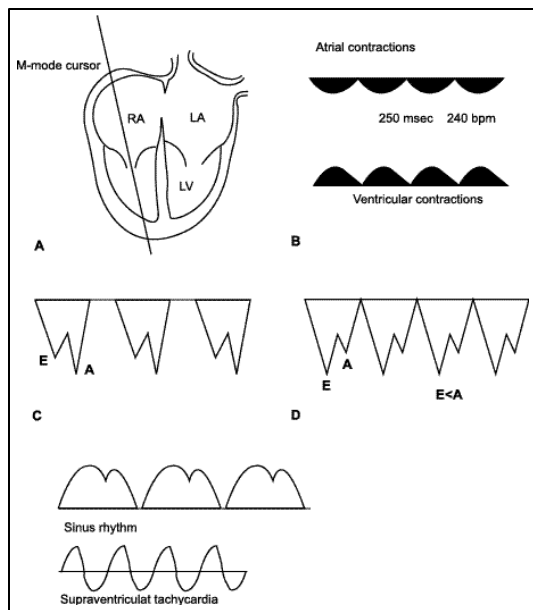


Fig. 1. Scheme of fetal supraventricular tachycardia. A, M-mode cursor crossing atrial and ventricular wall. B, Rapid 1:1 atrioventricular conduction with atrial and ventricular rates of 240 beats per minute. C, Doppler flow across atrioventricular valve during sinus rhythm. D, Doppler flow across atrioventricular valve during sinus tachycardia. Note reversal of E and A wave ratio. E, Normal Doppler flow in inferior vena cava during sinus rhythm and retrograde flow during supraventricular tachycardia.

Motion of these structures along the time line allows for accurate timing and correlation of the motion events in relation to each other (fig. 1a,b). Simultaneous Doppler interrogation of the left ventricular inflow and outflow can also allow timing and relation of atrial and ventricular activities. M-mode color Doppler can also help in timing the relationship of atrial and ventricular events (3).

Bradyarrhythmias

Complete atrioventricular block

In a complete atrioventricular block the atrial rate is faster than the ventricular rate and there is atrioventricular dissociation. The usual atrial rate in a fetus is between 110 to 160 beats per minute and the idioventricular rate varies between 40 to 80 beats per minute. Comparison of atrial and ventricular contractions patterns will reveal faster atrial than ventricular rate and dissociation between the two (Fig 2). The M-mode tracing of an atrioventricular valve shows the presence of frequent regular atrial waves when a leaflet is open during a prolonged ventricular diastole. The

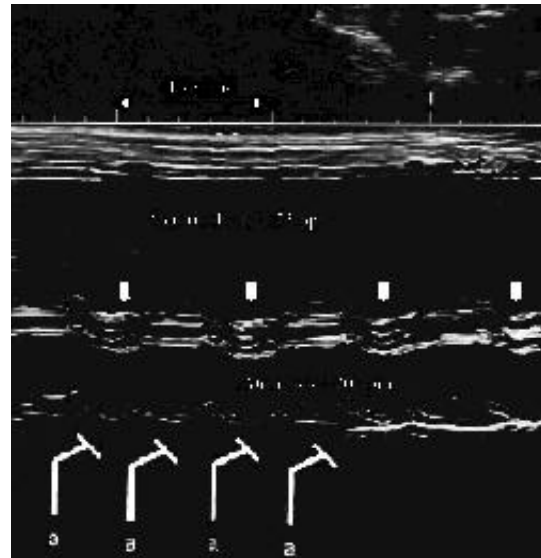


Fig. 2. A complete atrioventricular block in a 31-week-old fetus whose mother had positive Ro-SS-A antibodies. Atrial rate was 120 and ventricular rate was 75 beats per minute. Note atrioventricular dissociation. This fetus was followed with frequent echocardiographic examination for a development of heart failure and hydrops until delivery at 39 weeks of gestation. Permanent pacemaker was inserted in the first week of life. A, atrial contractions, arrows ventricular contractions.

semilunar valves open regularly but slowly and unrelated to atrial activity. A complete atrioventricular block has to be distinguished from other forms of bradycardia such as sinus bradycardia due to fetal distress, blocked premature atrial contractions with atrial bigeminy, and atrial flutter with high degree atrioventricular block.

About half of fetuses with a complete atrioventricular block have structural heart disease and their prognosis is poor with only 14% surviving the neonatal period. Fetal and neonatal death correlated with hydrops fetalis, atrial rate less than 120, and ventricular rate less than 55 beats per minute (4). Postnatal surgery and insertion of a pacemaker is the only viable treatment. Prenatal insertion of a pacemaker (5) or drug treatment with sympathomimetic medication has been largely disappointing.

In fetuses with congenital heart block without structural cardiac anomaly, maternal collagen vascular disease and/or lupus-associated antibodies are often present. These antibodies, anti-Ro and anti-La, also known as SS-A and SS-B, cross the placenta and damage the His-Purkinje fibers (6). Complete heart block usually occurs between 18 to 20 weeks of gestation. Prognosis

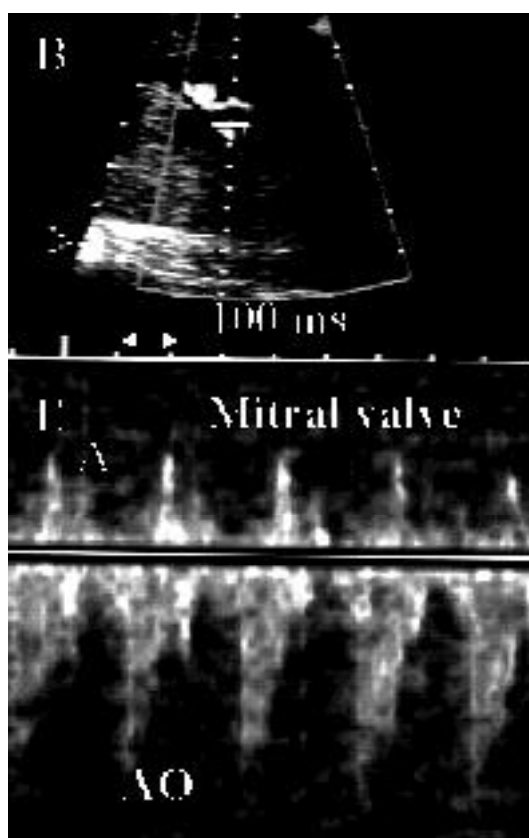
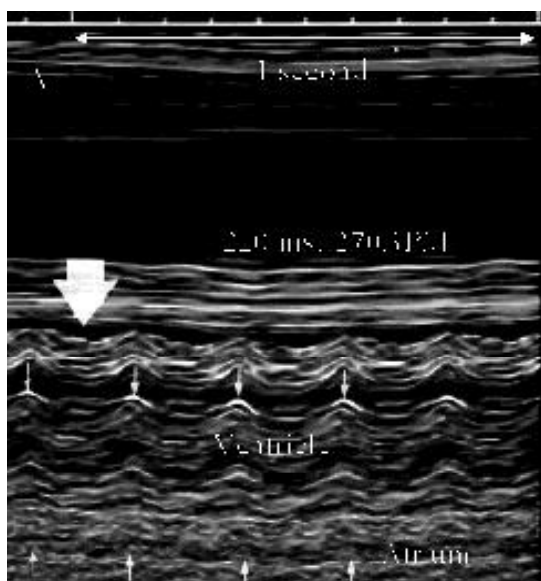
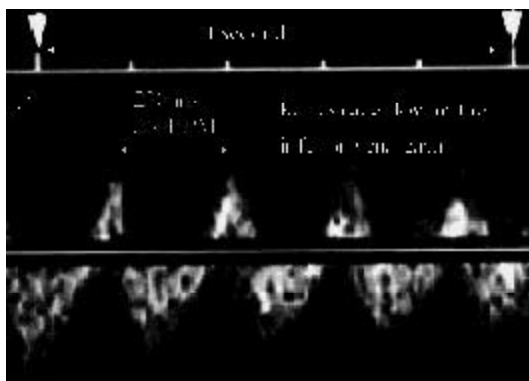


Fig. 3. Supraventricular tachycardia with 1:1 atrioventricular conduction with the rate of 270 beats per minute (bpm) in a mildly hydropic fetus at 32 weeks of gestation. A, M-mode echocardiogram with simultaneous recording of atrial and ventricular contractions (small arrows). A small pericardial effusion is seen (large arrow). B, simultaneous Doppler interrogation of the left ventricular inflow and outflow tract showed synchronous atrial and ventricular activity. On the mitral valve tracing E wave is larger than the A wave; AO, aortic flow. C, Doppler probe in the inferior vena cava. A retrograde flow was observed. Transplacental treatment with digoxin was unsuccessful. Flecainide was added and partial control of arrhythmia was achieved with persistence of hydrops. A combination of digoxin and amiodarone converted the abnormal rhythm to sinus rhythm. Hydrops has disappeared but atrioventricular reentry tachycardia returned few hours after birth and was controlled with propranolol.



for this group is better and 85% are alive after the neonatal period. However, if hydrops develops and the heart rate is less than 50 beats per minute, the prognosis for fetal or neonatal survival is poor (7, 8). Drug therapy is difficult and rarely successful. Plasmapheresis, steroids and sympathicomimetic drugs have been used with various success (9,10).

Medical treatment is particularly difficult if there is hydrops fetalis in a small fetus. In such a case, a staged approach is recommended. Therapy consists of a short course of maternal corticosteroids and thyroid releasing hormone therapy for enhancement of fetal lung maturation, caesarean section, and continuous intravenous postnatal sympathicomimetic drug infusion. Management of hydrops with drainage of all effusions, temporary external pacing, pacing with placement of epicardial wires, and finally

implantation of a permanent pacemaker when pacing threshold exceeds 20 mA or when the infant's weight approach 1500 grams, have been proposed (11).

Tachyarrhythmias

The mechanism of fetal arrhythmia is mainly inferred from studies in neonates (12). It is also possible to measure ventriculoatrial time using the M-mode fetal echocardiogram. Short

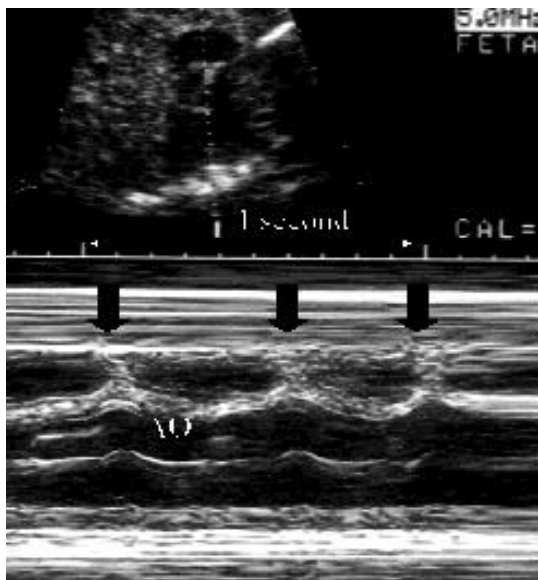


Fig. 4. A conducted premature atrial contraction. Note contractions of atrial wall (black arrows) followed by opening of the aortic valve. The third contraction is premature.

ventriculoatrial and long ventriculoatrial tachycardias can be distinguished, thus, facilitating therapeutic decision-making (13).

Orthodromic Reciprocating Atrioventricular Tachycardia

The most common fetal tachycardia is orthodromic reciprocating atrioventricular tachycardia. The reentry circuit in this type of supraventricular tachycardia conducts antegradely through atrioventricular node and retrogradely through an accessory pathway. The rate of this tachycardia is usually 220 to 240 beats per minute with little beat-to-beat variability (figures 1,3). There is 1:1 atrioventricular conduction. It is often triggered by an atrial extrasystolic beat. It can run for a few beats or may last for hours. Sustained tachycardia lasting more than 12 hours can cause hydrops fetalis (12).

Fetal tachyarrhythmia may cause congestive heart failure, fetal hydrops, and eventually fetal death if not treated. Several factors, like gestational age, sustained or intermittent tachycardia, presence or absence of hydrops fetalis are taken into account before deciding to start therapy.

There are several routes available for administration of drugs to a fetus. The most frequently used is transplacental maternal therapy. Direct drug delivery to a fetus can be accomplished

intramuscularly or intravenously into the umbilical vein. However, these procedures are not always safe (14,15). Therapy should be initiated in a hospital because most antiarrhythmic drugs are potentially proarrhythmic and can cause maternal complications.

If tachycardia is intermittent (tachycardia with periods of normal sinus rhythm during fetal scan), no hydrops is found, and a fetus is near term (gestational age more than 36 weeks), it is advisable to deliver the fetus because evaluation and treatment is easier postnatally. If a nonhydropic fetus is very premature and tachycardia is intermittent, systolic biventricular function is normal, and there is no structural heart defect, then only close observation might be all that is required since spontaneous resolution of isolated fetal supraventricular tachycardia maybe a common occurrence (16). Others do not share this view and recommend treatment for intermittent tachycardia because it can have a deleterious effect on the fetus with significant risk of neurological damage and death (17,18). Monitoring the heart rate in these subset for several hours can determine the duration of tachycardia. Some investigators recommend initiation of therapy with a fetal heart rate above 230 beats per minute because they have found a correlation between high fetal heart rate and development of hydrops fetalis (19). Another study however, has shown that only sustained tachycardia and lower gestational age correlated with hydrops fetalis (12).

Hydrops fetalis is a life-threatening condition. If hydrops fetalis is present, rapid conversion to sinus rhythm is mandatory since prognosis for survival is poor. Resolution of hydrops fetalis after conversion to sinus rhythm is expected to occur in 4 to 6 weeks with the following sequence: diminution of ascites, pleural and pericardial effusions, and disappearance of skin and scalp edema (20). Drug therapy of a hydropic fetus decreases the neonatal risks associated with delivery of a hemodynamically compromised hydropic newborn. In the near-term period, antiarrhythmic drugs should be initiated as soon as the diagnosis of hydrops fetalis is made. One should not wait to deliver the fetus first before instituting therapy.

Antiarrhythmic drugs in supraventricular tachycardia

Many drugs have been used to treat fetal

supraventricular tachycardia such as digoxin, adenosine, quinidine, procainamide, propranolol, verapamil, flecainide, propafenone, sotalol, and amiodarone (21).

Digoxin, especially in nonhydrotic fetus is the drug used almost universally as a first line of treatment. The mother is hospitalised and medical history and cardiac status are evaluated. A 12 lead electrocardiogram is recorded, serum electrolytes are taken and continuous electrocardiographic monitoring of the mother is initiated. Intravenous loading dose of digoxin is started (1 to 2 mg divided into 3 doses). Fetal heart rate is continuously monitored electronically and periodically with fetal ultrasound. After intravenous loading of digoxin, oral therapy is started (0.5 to 0.75 mg divided into 2 or 3 doses). Maternal symptoms of digoxin toxicity, maternal electrocardiogram, and serum digoxin levels are regularly followed. The maternal serum digoxin levels should be at the upper limit of normal (2.56 nmol/L) and to achieve this level, digoxin up to 1 mg per day is often required. About 60% of supraventricular tachycardias without hydrops can be controlled with digoxin alone. If conversion to sinus rhythm does not occur in the presence of adequate digoxin levels, flecainide is usually added (22). When the addition of flecainide fails other drugs should be tried (20,23).

Digoxin is a poor choice as a monotherapy for a hydrotic fetus with supraventricular tachycardia mainly because of poor transplacental transfer (15,24). However, a combination of transplacental and fetal intramuscular therapy with digoxin has decreased the conversion time to sinus rhythm (25). Flecainide crosses the placenta effectively and resolves tachycardia more rapidly than the combination of digoxin and verapamil (15 24). Because of its proarrhythmic effect, the mother should be admitted to the hospital and monitored with electrocardiogram and flecainide serum levels. If this combination is ineffective, antiarrhythmic class III drugs can be tried and/or more aggressive direct fetal therapy applied (14,23).

Atrial flutter

In atrial flutter, the atrial rate is much higher than in reentrant atrioventricular tachycardia. The atrial rate is usually 300 to 500 beats per minute and there is variable atrioventricular conduction. Therefore, ventricular rate is typically lower than the atrial rate. It is a serious arrhythmia and can frequently cause hydrops fetalis. Fetal death and

neurological damage may occur. Neurological damage is likely due to inadequate cerebral perfusion. Intrauterine treatment is needed to control ventricular rate or convert the atrial flutter to sinus rhythm. Digoxin rarely converts atrial flutter to sinus rhythm but can slow ventricular rate and thus improve cardiac output. Sotalol (80 to 160 mg orally twice a day, maximum 160 mg three times a day) given to the mother has been more successful and is currently used as a first line therapy. Digoxin can be added if control of atrial flutter is not achieved (26). Maternal QT interval has to be measured because of proarrhythmic effect of sotalol. If fetal proarrhythmia occurs, the drug has to be stopped. Amiodarone is also useful but has many side effects and crosses the placenta less readily than sotalol (27).

Atrial fibrillation

Atrial fibrillation is rare. Ventricular rate in this arrhythmia is irregular and fine and chaotic motions of the atrial wall are present.

Ventricular tachycardia

Ventricular tachycardia is uncommon. The ventricular rate is often 180 to 200 beats per minute and may conduct retrogradely resulting in atrial contractions. It is sometimes difficult to determine if atrial contractions precedes or follow the ventricular beat. The diagnosis of atrioventricular dissociation with atrial rate lower than the ventricular rate is easier to make. Ventricular tachycardia is quite well tolerated because of its relatively low rate (2)

Premature atrial contractions

The most common fetal arrhythmia is premature atrial contractions (fig.4). More than 50 % of premature atrial contractions resolve before or shortly after birth. They may or may not conduct to the ventricles. If blocked atrial bigeminy occurs each sinus beat is followed by non-conducted premature atrial contraction. This pattern cause ventricular rates to fall to the range of 60 to 70 beats per minute and has to be differentiated from a complete heart block and fetal distress. Around 1% of fetuses with frequent premature atrial contractions may develop supraventricular tachycardia, therefore, follow-up auscultation of the fetal heart rate is recommended. Routine sonographic follow-up is not needed.

Premature ventricular contractions

Premature ventricular contractions are less common and can also resolve before birth. They can be distinguished from premature atrial but not from premature junctional contractions. They may be a precursor of ventricular tachycardia. 🧑🏻‍⚕️

CONCLUSION

The vast majority of fetal arrhythmias are benign. However, fetal heart block, especially if associated with structural heart disease has extremely poor prognosis. For supraventricular tachycardias, prognosis is better and treatment is available. Good outcome can be expected with early therapy. A hydropic fetus due to arrhythmia is much more difficult to treat and mortality could be high. Fetal and maternal monitoring and team work with a perineonatologist, a pediatric cardiologist and sometimes an adult cardiologist, are of utmost importance to coordinate the various steps necessary in decision-making for the well-being of the mother and her fetus.

References

- Satomi G, Yasukochi S, Iwasaki Y, Kumita Y, Harada Y, Takeuchi T, Morishima K, Ohta K. Standardization and advantages of fetal echocardiography: a proposal. *Proceedings of the second world congress of pediatric cardiology and cardiac surgery*. Futura Publishing Company, 1998, pp 618-619.
- Crosson JE, Scheel JN. Fetal arrhythmias: diagnosis and current recommendations for therapy. *Prog Pediatr Cardiol* 1996; 5: 142 – 147.
- Fyfe DA, Meyer KB, Case CL. Sonographic assessment of fetal cardiac arrhythmias. *Sem Ultrasound, CT, MRI* 1993; 14:286-297.
- Schmidt KG, Ulmer HE, Silverman NH, Kleinman CS, Copel JA. Perinatal outcome of fetal complete atrioventricular block: a multicenter experience. *J Am Coll Cardiol* 1991; 17:360-1366.
- Carpenter RJ, Strasbourger JF, Garson A, Smith RT, Deter RL, Engelhardt HT. Fetal ventricular pacing for hydrops secondary to complete atrioventricular block. *J Am Coll Cardiol* 1986; 8:1434-1436.
- Taylor PV, Scott JS, Gerlis LM, Esscher E, Scott O. Maternal antibodies against fetal cardiac antigens in congenital complete heart block. *N Engl J Med* 1986; 315, 667.
- Chan AY, Silverman RK, Smith FC, Geifman-Holtzman O. In utero treatment of fetal complete heart block with terbutaline. A case report. *J Reprod Med* 1999; 44:385-387.
- Vignati G, Brucato A, Pisoni MP, Pome G, La Placa S, Mauri L, Lunati M. Evoluzione pre e postnatale del blocco atrioventricolare congenito isolato diagnosticato in utero. *G Ital Cardiol* 1999; 29:1478-1481.
- Rosenthal D, Druzin M, Chin C, Dubin A. A new therapeutic approach to the fetus with congenital complete heart block: preemptive, targeted therapy with dexamethasone. *Obstet Gynecol* 1998; 92:689-691.
- Yamada H, Kato EH, Ebina Y, Moriwaki M, Yamamoto R, Furuta I, Fujimoto S. Fetal treatment of congenital heart block ascribed to anti-SSA antibody: case reports with observation of cardiohemodynamics and review of the literature. *Am J Reprod Immunol* 1999; 42:226-232.
- Deloof E, Devlieger H, Van Hoestenbergh R, Van den Berghe K, Daenen W, Gewillig M. Management with a staged approach of the premature hydropic fetus due to complete congenital heart block. *Eur J Pediatr* 1997; 156:521-523.
- Naheed ZJ, Strasburger JF, Deal BJ, Benson DW Jr, Gidding SS. Fetal tachycardia: mechanisms and predictors of hydrops fetalis. *J Am Coll Cardiol* 1996; 27:1736-1740.
- Jaeggi E, Fouron JC, Fournier A, van Doesburg N, Drblik SP, Proulx F. Ventriculo-atrial interval measured on M mode echocardiography: a determining element in diagnosis, treatment, and prognosis of fetal supraventricular tachycardia. *Heart* 1998; 9:582-587.
- Hansmann M, Gembruch U, Bald R, Manz M, Redel DA. Fetal tachyarrhythmias : transplacental and direct treatment of the fetus – a report of 60 cases. *Ultrasound Obstet Gynecol* 1991; 1:162-170.
- Simpson JM, Sharland GK. Fetal tachycardias: management and outcome of 127 consecutive cases. *Heart* 1998; 79:576-581.
- Simpson LL, Marx GR, D'Alton ME. Supraventricular tachycardia in the fetus: conservative management in the absence of hemodynamic compromise. *J Ultrasound Med* 1997; 16:459-464.
- Schade RP, Stoutenbeek P, de Vries LS, Meijboom EJ. Neurological morbidity after fetal supraventricular tachyarrhythmia. *Ultrasound Obstet Gynecol* 1999; 13:43-47.
- Simpson JM, Milburn A, Yates RW, Maxwell DJ, Sharland GK. Outcome of intermittent tachyarrhythmias in the fetus. *Pediatr Cardiol* 1997; 18:78-82.
- Guntheroth WG, Cyr DR, Shields LE, Nghiem HV. Rate-based management of fetal supraventricular tachycardia. *J Ultrasound Med* 1996; 15:453-458.
- Petrikovsky B, Schneider E, Ovadia M. Natural history of hydrops resolution in fetuses with tachyarrhythmias diagnosed and treated in utero. *Fetal Diagn Ther* 1996; 11:292-295.
- Ito S, Magee L, Smallhorn J. Drug therapy for fetal arrhythmias. *Clin Perinatol* 1994; 21:543-71.
- Allan LD, Chita SK, Sharland GK, Maxwell D, Priestley K. Flecainide in the treatment of fetal tachycardias. *Br Heart J* 1991; 65:46-48.
- Sonesson SE, Fouron JC, Wesslen-Eriksson E, Jaeggi E, Winberg P. Fetal supraventricular tachycardia treated with sotalol. *Acta Paediatr* 1998; 87:584-587.
- 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.
- Parilla BV, Strasburger JF, Socol ML. Fetal supraventricular tachycardia complicated by hydrops fetalis: a role for direct fetal intramuscular therapy. *Am J Perinatol* 1996; 13:483-486.

Fetal Arrhythmias

26. Oudijk MA, Michon MM, Kleinman CS, Kapusta L, Stoutenbeek P, Visser GHA, Meijboom EJ. Sotalol in treatment of fetal dysrhythmias. *Circulation* 2000; 101:2721-2726.
27. 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.

