

Rhythm abnormalities in the fetus

LK Hornberger, DJ Sahn

Web only references

1. Southall DP, Richards J, Hardwick RA, *et al.* Prospective study of fetal heart rate and rhythm patterns. *Arch Dis Child* 1980;55:506–551.
2. Fouron JC, Proulx F, Miro J, *et al.* Doppler and M-mode ultrasonography to time fetal atrial and ventricular contractions. *Obstet Gynecol* 2000;96:732–736.
3. Andelfinger G, Fouron JC, Sonesson SE, *et al.* Reference values for time intervals between atrial and ventricular contractions of the fetal heart measured by two Doppler techniques. *Am J Cardiol* 2001;88:1433–1436.
4. Kleinman CS. Prenatal diagnosis and management of intrauterine arrhythmias. *Fetal Ther* 1986;1:92–95.
5. Gembruch U, Krapp M, Germer U, *et al.* Venous Doppler in the sonographic surveillance of fetuses with supraventricular tachycardia. *Eur J Obstetr Gynecol Reprod Biol* 1999;84:187–192.
6. Simpson JM, Yates RW, Sharland GK. Irregular heart rate in the fetus – not always benign. *Cardiol Young* 1996;6:28–31.
7. Steward PA, Wladimiroff JW. Fetal atrial arrhythmias associated with redundancy/aneurysm of the foramen ovale. *J Clin Ultrasound* 1988;16:643–650.
8. Rice MJ, McDonald RW, Reller MD. Fetal atrial septal aneurysm: a cause of fetal arrhythmias. *J Am Coll Cardiol* 1988;12:1292–1297.
9. Jaeggi E, Fouron JC, Drblik SP. Fetal atrial flutter: diagnosis, clinical features, treatment, and outcome. *J Pediatr* 1998;132:335–339.
10. Hansmann M, Gembruch U, Bald R, *et al.* Fetal tachyarrhythmias: transplacental and direct treatment of the fetus – a report of sixty cases. *Ultrasound Obstet Gynecol* 1991;1:162–170.
11. Yamada M, Nakazawa M, Momma K. Fetal ventricular tachycardia in long QT syndrome. *Cardiol Young* 1998;8:119–122.
12. Ohkuchi A, Shiraishi H, Minakami H, *et al.* Fetus with long QT syndrome manifested by tachyarrhythmia: a case report. *Prenat Diagn* 1999;19:990–992.
13. Chang IK, Shyu MK, Lee CN, *et al.* Prenatal diagnosis and treatment of fetal long QT syndrome: a case report. *Prenat Diagn* 2002;22:1209–1212.
14. Simpson JJ, Milburn A, Yates RW, *et al.* Outcome of intermittent tachyarrhythmias in the fetus. *Pediatr Cardiol* 1997;18:78–82.
15. Azancot-Benisty A, Jacqz-Aigrain E, Guirguis NM, *et al.* Clinical and pharmacological study of fetal supraventricular tachyarrhythmias. *J Pediatr* 1992;121:608–613.
16. Schmolling J, Renke K, Richter O, *et al.* Digoxin, flecainide and amiodarone transfer across the placenta and the effects of an elevated umbilical venous pressure on transfer rate. *Ther Drug Monit* 2000;22:582–588.
17. Ito S, Magee L, Smallhorn J. Drug therapy for fetal arrhythmias. *Clin Perinatol* 1994;21:543–572.
18. Ito S. Transplacental treatment of fetal tachycardia: implications of drug transporting proteins in placenta. *Semin Perinatol* 2001;25:196–201.

19. Triedman JK, Walsh EP, Saul JP. Response of fetal tachycardia to transplacental procainamide. *Cardiol Young* 1996;6:235–238.
20. Allan LD, Chita SK, Sharland GK, et al. Flecainide in the treatment of fetal tachycardias. *Br Heart J* 1991;65:46–48.
21. Ebenroth ES, Cordes TM, Darragh RK. Second-line treatment of fetal supraventricular tachycardia using flecainide acetate. *Pediatr Cardiol* 2001;22:483–487.
22. Krapp M, Baschat AA, Gembruch U, et al. Flecainide in the intrauterine treatment of fetal supraventricular tachycardia. *Ultrasound Obstet Gynecol* 2002;19:158–164.
23. Sonesson SE, Fouron JC, Wesslen-Eriksson E, et al. Foetal supraventricular tachycardia treated with sotalol. *Acta Paediatr* 1998;87:584–587.
24. Oudijk MA, Michon MM, Kleinman CS, et al. Sotalol in the treatment of fetal dysrhythmias. *Circulation* 2000;101:2721–2726.
25. Oudijk MA, Ruskamp JM, Ververs FFT, et al. Treatment of fetal tachycardia with sotalol: Transplacental pharmacokinetics and Pharmacodynamics. *J Am Coll Cardiol* 2003;42:765–770.
26. Strasburger JF, Cuneo BF, Michon MM, et al. Amiodarone therapy for drug-refractory fetal tachycardia. *Circulation* 2004;109:375–379.
27. Jouannic JM, Delahaye S, Fermont L, et al. Fetal supraventricular tachycardia: a role for amiodarone as second-line therapy? *Prenat Diagn* 2003;23:152–156.
28. Kohl T, Tercanli S, Kececioglu D, et al. Direct fetal administration of adenosine for the termination of incessant supraventricular tachycardia. *Obstet Gynecol* 1995;85:873–874.
29. Gest AL, Blair DK, Vander Straten MC. Thoracic duct lymph flow in fetal sheep with increased venous pressure from electrically induced tachycardia. *Biol Neonate* 1993;64:325–330.
30. Gest AL, Martin CG, Moise AA, et al. Reversal of venous blood flow with atrial tachycardia and hydrops in fetal sheep. *Pediatr Res* 1990;28:223–226.
31. Petrivisky B, Schneider G, Ovadia M. natural history of hydrops resolution in fetuses with tachyarrhythmias diagnosed and treated in utero. *Fetal Diagn Therap* 1996;11:292–295.
32. Hallak M, Neerhof MG, Perry R, et al. Fetal supraventricular tachycardia and hydrops fetalis: combined intensive, direct and transplacental therapy. *Obstetr Gynecol* 1991;78:523–525.
33. Flack NJ, Zosmer N, Bennett PR, et al. Amiodarone given by three routes to terminate fetal atrial flutter associated with severe hydrops. *Obstet Gynecol* 1993;82:483–486.
34. Schmidt MR, Smerup M, Kristiansen SB, et al. Maternal hyperglycemia improves fetal cardiac function during tachycardia-induced heart failure in pigs. *Circulation* 2004;110:2627–2630.
35. Moak JP, Barron KS, Hougen TJ, et al. Congenital heart block: development of late-onset cardiomyopathy, a previously underappreciated sequela. *J Am Coll Cardiol* 2001;37:238–242.
36. Buyon JP, Hiebert R, Copel J, et al. Autoimmune-associated congenital heart block: demographics, mortality, morbidity and recurrence rates obtained from the national neonatal lupus registry. *J Am Coll Cardiol* 1998;31:1658–1666.

37. Gladman G, Silverman ED, Yuk L, *et al*. Fetal echocardiographic screening of pregnancies of mothers with anti-Ro and/or anti-La antibodies. *Am J Perinatol* 2002;19:73–80.
38. Brucato A, Frassi M, Franceschini F, *et al*. Risk of congenital complete heart block in newborns of mothers with anti-Ro/SSA antibodies detected by counterimmuno-electrophoresis: a prospective study of 100 women. *Arthritis Rheum* 2001;44:1832–1835.
39. Groves AMM, Allan LD, Rosenthal E. Outcome of isolated congenital complete heart block diagnosed in utero. *Heart* 1996;75:190–194.
40. Saleeb S, Copel J, Friedman D, *et al*. Comparison of treatment with fluorinated glucocorticoids to the natural history of autoantibody associated congenital heart block. *Arthritis Rheum* 1999;42:2335–2345.
41. Bierman FZ, Baxi L, Jaffe E, *et al*. Fetal hydrops and congenital complete heart block: response to maternal steroid therapy. *J Pediatr* 1988;112:646–648.
42. Kaaja R, Julkunen H, Ammala P, *et al*. Congenital heart block: Successful prophylactic treatment with intravenous gamma globulin and corticosteroid therapy. *Am J Obstet Gynecol* 1991;165:1333–1334.
43. Groves AMM, Allan LD, Rosenthal E. Therapeutic trial of sympathomimetics in three cases of complete heart block in the fetus. *Circulation* 1995;92:3394–3396.
44. Räsänen J. The effects of ritodrine infusion on fetal myocardial function and fetal hemodynamics. *Acta Obstet Gynecol Scand* 1990;69:487–492.
45. Liddicoat JR, Klein JR, Reddy M, *et al*. Hemodynamic effects of chronic prenatal ventricular pacing for the treatment of complete atrioventricular block. *Circulation* 1997;96:1025–1030.
46. Buyon JP, Heibert R, Copel J, *et al*. Autoimmune-associated congenital heart block: demographics, mortality, morbidity and recurrence rates obtained from a national neonatal lupus registry. *J Am Coll Cardiol* 1998;31:1658–66.
47. Li Z, Strasburger JF, Cuneo BF, *et al*. Giant fetal magnetocardiogram P waves in congenital atrioventricular block: A marker of cardiovascular compensation? *Circulation* 2004;110:2097–2101.

Additional key references

1. Pennisi DJ, Rentschler S, Gourdie RG, *et al*. Induction and patterning of the cardiac conduction system. *Int J Dev Biol* 46:765–75. **Review of the current understanding of the development of the conduction system.**
2. Leiva MC, Tolosa JE, Binotto CN, *et al*. Fetal cardiac development and hemodynamics in the first trimester. *Ultrasound Obstetr Gynecol* 1999;14:169–74. **The first study to evaluate ventricular inflow and outflow Doppler patterns in the first trimester beginning as early as 5–6 weeks of gestation**
3. Kleinman CS, Nehgme RA. Cardiac arrhythmias in the fetus. *Pediatr Cardiol* 2004;25:234–251. **A recent review of the diagnosis and treatment of fetal arrhythmias.**
4. Boldt T, Eronen M, Andersson S. Long-term outcomes in fetuses with arrhythmias. *Obstetr Gynecol* 2003;102:1372–9.
5. Oudijk MA, Gooskens RH, Stoutenbeek P, *et al*. Neurological outcome of children who were treated for fetal tachycardia complicated by hydrops. *Ultrasound Obstet Gynecol* 2004;24:154–8.

6. Krapp M, Kohl T, Simpson JM, *et al*. Review of diagnosis, treatment and outcome of atrial flutter compared with supraventricular tachycardia. *Heart* 2003;89:913–7.
7. Jaeggi E, Fouron JC, Fournier A, *et al*. Ventriculo-atrial time interval measured on M-mode echocardiography: a determining element in the diagnosis, treatment and prognosis of fetal supraventricular tachycardia. *Heart* 1998;79:582–7.
8. Wakai RT, Strasburger JF, Li Z, *et al*. Magnetocardiographic rhythm patterns at initiation and termination of fetal supraventricular tachycardia. *Circulation* 2003;107:307–12.
9. Clancy RM, Buyon JP. Autoimmune-associated congenital heart block: dissecting the cascade from immunologic insult to relentless fibrosis. *Anat Rec* 2004;280A:1027–35.
10. Nield LE, Silverman ED, Taylor GP, *et al*. Maternal anti-Ro and anti-La antibody associated endocardial fibroelastosis. *Circulation* 2002;105:843–8.