EDITORIAL

Transcatheter closure of perimembranous ventricular septal defect: is the risk of heart block too high a price?

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The late development of heart block in paediatric patients following device closure of a perimembranous ventricular septal defect may be a cause for concern. *See article on page 355.*

Since the early 1980s, numerous interventional cardiac catheterisation techniques have been developed, which have transformed the management of many congenital and acquired heart malformations. Some, such as balloon pulmonary valvotomy, have been unequivocally successful, and rapidly became the standard of care. For some other procedures, the advantage over the surgical alternative has been less clear.

Innovative techniques are often embraced with enthusiasm, and initial reports emphasise the benefits of the new approach. There may then follow a period when complications or drawbacks of the new procedure become apparent, accompanied by a waning of the initial enthusiasm. Eventually, a dynamic balance is struck between the alternative clinical approaches to the problem in question, being superimposed on simultaneous developments in both knowledge and technology. This process is shown in the evolution of clinical practice with regard to transcatheter closure of perimembranous ventricular septal defect (VSD).

HAEMODYNAMICALLY IMPORTANT VSDs

Congenital defects in the muscular part of the ventricular septum have been successfully closed by interventional catheter techniques over the past two decades in selected patients, using a variety of occlusive devices. This has been especially true of defects near the cardiac apex, which are difficult to access at surgery. However, by far, most of the haemodynamically important VSDs are perimembranous, being located adjacent to the membranous part of the ventricular septum. Part of the margin of the hole is composed of fibrous tissue at the site where the tricuspid and aortic valves are in fibrous continuity, and the penetrating bundle of the normal cardiac conduction axis (bundle of His) courses through the central fibrous body of the heart at the posteroinferior margin of the VSD.[1] The extension of the remaining margin of the hole determines its proximity to the aortic valve, tricuspid valve or mitral valve. Sometimes there may also be distortion of the aortic valve, with a prolapse of part of the valve, usually the right coronary cusp, into the defect, especially if there is an anterior deviation of the outlet septum with respect to the trabecular septum. Aortic valve distortion is also seen in the rare situation when a perimembranous VSD extends so that its superior margin is formed by fibrous continuity between the aortic and pulmonary valves, in which case the hole is not only perimembranous in location but also doubly committed and juxta-arterial.

These morphological features have inhibited attempts at transcatheter closure of perimembranous VSDs. In the 1990s, closure of perimembranous VSDs using the Rashkind double-umbrella device was attempted, but abandoned quite rapidly.[2 3] However, the development of nitinol-based devices has sparked enthusiasm over the past 5 years. Nitinol is an alloy of nickel and titanium, which can be deformed into the lumen of a catheter, but when extruded from the catheter resumes its previous preformed shape. Devices constructed of a lattice of nitinol wires enclosing cloth have been widely used for closure of secundum atrial septal defects and patent arterial ducts since the late 1990s. Similar devices were designed with the intention of closing muscular VSDs. These consist of a central stalk with a retaining flange on either side, a shape rather like a cotton reel. Subsequently, a device specifically designed for perimembranous VSD closure was marketed. This had part of the flange designed to sit on the left ventricular margin of the defect removed, so that the device could be positioned with the left-sided flange snug to the muscular part of the border of the hole, but designed not to abut the adjacent aortic valve or region of fibrous continuity between the aortic and tricuspid valves. Introduction of this device led to a flurry of publications describing transcatheter closure of perimembranous VSDs, which since 2002 have almost exclusively used one or other of these devices.

CLINICAL EXPERIENCE

An early report detailing the experience using the asymmetric device in six patients with median weight 29 (range 15–45) kg and relatively small VSDs concluded that ''transcatheter occlusion of membranous VSDs is safe and effective''.[4] Experience reported elsewhere was also encouraging.[5 6] However, by 2006, a US multicentre report had the more muted conclusion that it ''is

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Abbreviation: VSD, ventricular septal defect

technically feasible and seems safe enough in children over 8 kg to warrant continuation of clinical trials''.[7] This more cautious approach was the result of complications of the technique becoming apparent. Bleeding, incomplete closure, rupture of tricuspid valve chords and haemolysis have been reported, but most concern relates to the induction of heart block.[8–11]

This issue of *Heart* contains a report on closure of perimembranous VSD in 10 patients using the Amplatzer muscular VSD occluder.[12] Patients were selected if there was a rim of ⩾4 mm separating the margin of the hole from the aortic valve. Transient haemolysis occurred in one patient and mild tricuspid regurgitation in three, which of course is common after surgical patch closure of perimembranous VSD because the patch is usually anchored to the base of septal leaflet of the tricuspid valve to avoid suture damage to the conduction tissue. No patient developed heart block. The smallest patient weighed 14 kg and the median weight of patients was 25.5 kg. The use of the muscular device in these patients seems to have been influenced by the authors' experience of five patients with heart block complicating closure of perimembranous VSDs, in whom they had used the asymmetric device. The most concerning aspect of the experience they describe is the late development of heart block, which occurred in the second week after the implantation of the device in two of these patients, both of whom underwent pacemaker implantation. However, the at-risk period for developing heart block seems to be much longer than this, as new heart block occurring up to 1 year after device closure of perimembranous VSD has been reported.[11] This means that resolution of heart block attributed to anti-inflammatory treatment in the days or weeks after device closure[13] is not completely reassuring. Various possible mechanisms for the development of heart block are discussed,[12] the implication being that further modification of device design and careful size selection may reduce the incidence of this complication.

ROLE OF REGISTRIES

Clinical dilemmas often lead to advocacy of a prospective randomised controlled trial. However, this is rarely appropriate in paediatric cardiology. Eligible patients are rare, even for the most common abnormalities such as perimembranous VSD, and relevant end points usually require long-term follow-up, by which time the original clinical question may have been superseded by contemporaneous developments. Consequently, registries have a potentially valuable role. A voluntary European registry (www.vsdeuro.com) receives data regarding transcatheter VSD closure from 23 centres. The registry has restricted access, but reported recently that heart block developed in 13 of 250 (5%) patients undergoing closure of perimembranous VSD. This was described as transient in four, but ''permanent'' in nine, occurring ''late'' after VSD closure in four of these patients. Smaller patients seemed to be more at risk.[14] This is valuable information, but has the disadvantage of selective data input from specified centres, and experience has shown that the absence of data validation means that there will probably be under-reporting, even with the best of intentions of the voluntary participants.

The Central Cardiac Audit Database in the UK has the advantage that every paediatric cardiac centre contributes data on surgical and catheter interventions, and validation of data by site visits aims to minimise under-reporting. In addition, individual unique National Health Service numbers allow actuarial tracking of patient mortality. No Central Cardiac Audit Database data are currently available about late outcome, but this data model should be able to provide information about the need for pacing, or even the dreaded possibility of late sudden death, after transcatheter closure of perimembranous VSD in due course. The data available do illustrate the initial enthusiasm, followed by a more cautious approach, exhibited by UK paediatric cardiologists. There were 5 cases of transcatheter VSD closure reported in 2000–1, 3 in 2001–2, 8 in 2002–3, 45 in 2003–4, 23 in 2004–5 and 4 in 2005–6 (J Gibbs, personal communication, May 2006). It is notable that guidance issued to doctors in the UK gives qualified support for this technique at a time when most of the clinical teams involved believe that a more cautious approach than hitherto is required.[15]

SURGICAL ALTERNATIVES

What about the surgical alternative when closure of a perimembranous VSD is required? The incidence of complete heart block at Great Ormond Street Hospital, London, after surgical closure of a VSD in a heart with normal cardiac connections was reviewed recently.[16] VSD closure was performed in 2079 patients between 1976 and 2001. Permanent complete heart block developed in 7 of 996 (0.7%) patients with an isolated defect, most of which were perimembranous, and in 1 of 847 (0.1%) patients with tetralogy of Fallot, in whom most of the defects would have been perimembranous. Overall hospital surgical mortality after closure of an isolated VSD was 1.5%, and in the era 1997–2001 it was 0.7% (2 of 263). Complete heart block occurred in only four patients with isolated perimembranous VSDs, all of whom were aged ⩽6 months. This low incidence of postoperative complete heart block is consistent with published experience from the past 15 years,[16] suggesting that it is attainable in most major paediatric cardiac surgical centres.

CONCLUSIONS

Induction of heart block after transcatheter occlusion of a perimembranous VSD seems to be more common in smaller patients, but is not confined to this group. The late occurrence of potentially catastrophic heart block long after hospital discharge is especially worrying, although this was not observed in one study of 20 patients with minimum follow-up of 18 months.[17] Complete heart block after surgical closure of perimembranous VSD has been virtually abolished in the best hands, and late onset heart block after surgical closure has not been a concern. Consequently, transcatheter occlusion of perimembranous VSD cannot be recommended at present in infants or toddlers, arguably those weighing about <10 kg, who comprise, by far, most patients requiring closure of a perimembranous VSD. This assumes that a surgical alternative is available. Closure of a perimembranous VSD in larger children is not often required. When it is required, transcatheter device closure should be performed with caution, as part of a prospective trial, or with registry data submission at the very least. Patient selection based on morphology of the perimembranous VSD is important. Potentially favourable morphological features include a fibrous ''aneurysm'' on the right ventricular aspect of the hole in which the device may be anchored remote from the conduction tissue, or an adequate rim of muscle separating the superior margin of the hole from the aortic valve, which can provide support to buttress the left side of the occlusive device. It is inevitable that continued modification of occlusive devices will have an effect on these considerations.

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REFERENCES

1 **Ho SY**, McCarthy KP, Rigby ML. Morphology of perimembranous ventricular septal defects: implications for transcatheter device closure. *J Interv Cardiol* 2004;**17**:99–108.
2 **Rigby ML**, Redington AN. Primary transcatheter umbrella closure of perimembranous ventricular septal defect. *Br Heart J* 1994;**72**:368–71.
3 **Vogel M**, Rigby ML, Shore D. Perforation of the right aortic valve cusp: complication of ventricular septal defect closure with a modified Rashkind umbrella. *Pediatr Cardiol* 1996;**17**:416–18.
4 **Hijazi ZM**, Hakim F, Haweleh AA, *et al*. Catheter closure of perimembranous ventricular septal defects using the new Amplatzer membranous VSD occluder: initial clinical experience. *Catheter Cardiovasc Interv* 2002;**56**:508–15.
5 **Bass JL**, Kalra GS, Arora R, *et al*. Initial human experience with the Amplatzer perimembranous ventricular septal occluder device. *Catheter Cardiovasc Interv* 2003;**58**:238–45.
6 **Thanopoulos BD**, Tsaousis GS, Karanasios E, *et al*. Transcatheter closure of perimembranous ventricular septal defects with the Amplatzer asymmetric ventricular septal defect occluder: preliminary experience in children. *Heart* 2003;**89**:918–22.
7 **Fu Y-C**, Bass J, Amin Z, *et al*. Transcatheter closure of perimembranous ventricular septal defects using the new Amplatzer membranous VSD occluder: results of the U.S. phase I trial. *J Am Coll Cardiol* 2006;**47**:319–25.
8 **Arora R**, Trehan V, Kumar A, *et al*. Transcatheter closure of congenital ventricular septal defects: experience with various devices. *J Interv Cardiol* 2003;**16**:83–91.
9 **Masura J**, Gao W, Gavora P, *et al*. Percutaneous closure of perimembranous ventricular septal defects with the eccentric Amplatzer device: multicenter follow-up study. *Pediatr Cardiol* 2005;**26**:216–19.
10 **Walsh MA**, Bialkowski J, Szkutnik M, *et al*. Atrioventricular block following transcatheter closure of perimembranous ventricular septal defects. *Heart* 2006;**92**:1295–7.
11 **Butera G**, Chessa M, Carminati M. Late complete atriovenous block after percutaneous closure of a perimembranous ventricular septal defect. *Catheter Cardiovasc Interv* 2006;**67**:938–41.
12 **Szkutnik M**, Qureshi SA, Kusa J, *et al*. Use of the Amplatzer muscular ventricular septal defect occluder for closure of perimembranous ventricular septal defects. *Heart* 2007;**93**:355–8.
13 **Yip WCL**, Zimmerman F, Hijazi ZM. Heart block and empirical therapy after transcatheter closure of perimembranous ventricular septal defect. *Catheter Cardiovasc Interv* 2005;**66**:436–41.
14 **Carminati M**, Butera G, Chessa M. Transcatheter closure of congenital and post-infarction ventricular septal defects: results of the European Registry. *Proceedings, Cardiology In The Young*, 19–22 April 2006, Great Ormond Street Hospital for Children and UCL Institute of Child Health.
15 **National Institute for Health and Clinical Excellence**. *Endovascular closure of perimembranous ventricular septal defect. Interventional procedure guidance 172*. London, UK: NICE, 2006.
16 **Andersen HO**, de Leval MR, Tsang VT, *et al*. Is complete heart block after surgical closure of ventricular septum defects still an issue? *Ann Thorac Surg* 2006;**82**:948–56.
17 **Pinto RJ**, Dalvi BV, Sharma S. Transcatheter closure of perimembranous ventricular septal defects using Amplatzer asymmetric ventricular septal defect occluder: preliminary experience with 18 month follow up. *Catheter Cardiovasc Interv* 2006;**68**:145–52.

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