

Residual shunting after treatment of a persistent arterial duct

Maarten Witsenburg^{1*}, MD, PhD; Ad J.J.C. Bogers², MD, PhD

1. Department of Cardiology and Paediatric Cardiology, Erasmus MC, Rotterdam, The Netherlands; 2. Department of Cardiothoracic surgery, Erasmus MC, Rotterdam, The Netherlands

In this edition of the journal, Kusa et al report on their experience with catheter closure of residual shunting after surgical treatment of a patent arterial duct¹. They collected their patients over a 15 year period, illustrating that this is a rather uncommon problem. Especially with present day surgery, it should be rare in experienced hands. The question can be raised why a residual duct needs closure anyway, especially when its haemodynamic significance frequently will be small.

In foetal life the arterial duct is an important vessel. It connects the main pulmonary artery to the descending aorta and has a diameter comparable with that of the descending aorta. Due to the high resistance in the foetal pulmonary vascular bed, the right ventricular output mainly contributes to the systemic circulation via a “right-to-left” shunt through the duct. At birth, major changes occur. The acute decrease in the pulmonary vascular resistance and increase in systemic resistance result in a temporary “left-to-right shunt”. Constriction of the duct after birth is induced by the rapidly increased oxygen tension and decrease in circulating prostaglandin and prostacyclin. Normally this results in functional ductal closure within 48 hours².

In prematurely born infants, ductal constriction is frequently delayed. It may further compromise the ventilation of the premature lungs in such tiny newborns, especially in those born before 30 weeks of gestation. Prostaglandin antagonists like indomethacin and ibuprofen are used to facilitate ductal constriction. If this is not successful, surgical closure via a small left lateral thoracotomy is the ultimate solution. Catheter intervention in these babies weighing much less than 1,000 grams is not an option.

Delayed ductal closure in term born infants is not uncommon. From clinical experience it has become clear that when an arterial duct is

still open at three months after term birth, spontaneous closure will not occur any more. The haemodynamic consequences of an isolated persistent duct are a continuous left-to-right shunt from the aorta to the pulmonary artery, resulting in a volume load of the left heart. The shunt size will depend on flow restriction from the duct (diameter and length) as well as the systemic and pulmonary vascular resistance. A moderate or large duct may result in cardiac failure due to the large volume load. Clinically, this becomes clear three to six weeks after birth when the pulmonary vascular resistance has reached its lowest value. A large non-restrictive duct may ultimately lead to pulmonary vascular changes that increase the pulmonary vascular resistance again and an Eisenmenger reaction may occur after years.

A small duct will clinically be well tolerated during life, due to absence of a significant volume overload. An arterial duct is called “silent” when clinical signs like the typical continuous murmur are absent and when it is found coincidentally during routine echocardiography.

Except for the “silent” ductus however, its common practice to close all persistent arterial ducts, independent of shunt size because of the significant risk of bacterial endarteritis. Historically the incidence of endarteritis of the duct has been reported to be 1% per year, and continuous to be a risk especially in less developed countries³. It is likely that nowadays, the incidence of endarteritis is much lower, with the present routine of surgical or catheter closure, the use of antibiotics and a higher duct detection rate due to high quality echo-Doppler equipment. The availability of safe and effective catheter techniques has led to a practice of routine closure of any persistent duct. Whether this should be advocated in a coincidentally found silent duct without a high velocity jet remains

* Corresponding author: Dept of Cardiology, Thoraxcenter, Erasmus MC, PO box 2040, 3000 CA Rotterdam, The Netherlands

E-mail: m.witsenburg@erasmusmc.nl

unclear⁴. In incomplete ductal closure, either after surgery or catheter intervention, the endarteritis risk remains and forms the major argument to try to close even a haemodynamically non-significant residual shunt.

Surgical closure of a persistent duct was first reported by Ross and Hubbard in 1939⁵. It is still used frequently in premature infants and in young infants below the weight of four kilograms, who can not be properly managed medically and in whom catheter intervention is not yet feasible. Surgery is a quick and reliable procedure where the arterial duct is clipped or doubly ligated and divided. In infants over four kilograms, children and adults most ducts can be closed with a catheter intervention.

The study of Kusa et al nicely illustrates the device development for catheter closure of the ductus over the last two decades. Although the first use of a transcatheter technique to close the duct with an Ivalon plug was reported in 1967, the breakthrough came with the report by Rashkind of the use of a "double umbrella" device in 1979^{6,7}. With this device, catheter closure became widely available. However, for these devices, large introducer sheaths were needed, which still prevented the use of this technique in young children and infants. Residual shunting shortly after implantation was frequently observed, but used to disappear in many patients within months. In the 1990's, the use of coils became popular for closure of small to moderate ducts, also in smaller infants⁸. At first Gianturco and other free release coils were used, but many physicians nowadays will prefer coils with a controlled release mechanism, like the Flipper (William Cook Europe ApS, Bjaeverskov, Denmark) and the NitOcclud (PFM Medical, Cologne, Germany). A more recent breakthrough is the development of a specially designed Amplatzer duct occluder (AGA Medical Corporation, Plymouth, MN, USA) which is now widely used for ducts with a minimal diameter over 2-3 mm⁹⁻¹⁰. Full closure is almost always obtained instantly.

Ductal morphology may vary from conical to tubular, so there is no ideal device for every case. In addition to that, the use of large devices in small babies may result in device protrusion in the aorta with possible aortic obstruction. In those cases surgery is a well established alternative, until improved catheter devices become available.

The question whether all ducts need closure will continue to be based on expert opinion, rather than on evidence. However, both the surgeon and the cardiologist should aim for full closure, which for the cardiologist means no residual shunt on the final aortogram before the patient leaves the cardiac catheterisation laboratory. Whenever a residual shunt remains, the indication for closure, and the type of treatment have to be carefully discussed between the cardiologist and the cardiac surgeon.

References

1. Kusa J, Szkutnik M, Czerpak B, Bialkowski J. Percutaneous closure of previously surgical treated arterial duct. *Eurointervention* 2008;3:584-587.
2. Schneider DJ, Moore JW. Patent ductus arteriosus. *Circulation*. 2006;114:1873-1882.
3. Campbell M. Natural history of patent ductus arteriosus. *Br Heart J* 1986;30:4-13.
4. Thilen U, Astrom-Olsson K. Does the risk of infective endocarditis justify routine patent ductus arteriosus closure? *Eur Heart J* 1997;18:503-506.
5. Gross RE, Hubbard JP. Surgical ligation of a patent ductus arteriosus: a report of first successful case. *JAMA*. 1939;112:729-731.
6. Porstmann W, Wierny L, Warnke H. The closure of the patent ductus arteriosus without thoracotomy (preliminary report). *Thoraxchir Vask Chir*. 1967;15:199-203.
7. Rashkind WJ, Cuaso CC. Transcatheter closure of patent ductus arteriosus. Transcatheter closure of a patent ductus arteriosus: successful use in a 3.5 kilogram infant. *Pediatric Cardiol* 1979;1:3-7.
8. Cambier PA, Kirby WC, Wortham DC, Moore JW. Percutaneous closure of the small (less than 2.5 mm) patent ductus arteriosus using coil embolization. *Am J Cardiol*. 1992;69:815-1816.
9. Masura J, Walsh KP, Thanapoulos B, Chan C, Bass J, Goussos Y, Gavora P. Catheter closure of moderate- to large-sized patent ductus arteriosus using the new Amplatzer duct occluder: immediate and short-term results. *J Am Coll Cardiol*. 1998;31:878-882.
10. Wang JK, Hwang JJ, Chiang FT, Wu MH, Lin MT, Lee WL, Lue HC. A strategic approach to transcatheter closure of patent ductus: Gianturco coils for small-to-moderate ductus and Amplatzer duct occluder for large ductus. *Int J Cardiol* 2006;106:10-15.