PERSONAL PRACTICE

Patent arterial duct: when should it be closed?

Ian D Sullivan

Ligation of a patent arterial duct in a 7 year old girl with intractable heart failure in 1938¹ was the first successful “cardiac” operation and may therefore be considered the forerunner of the remarkable developments in surgery for both congenital and acquired heart disease which have occurred since then. It was soon established that ligation of a large arterial duct could not only resolve heart failure by relief of left ventricular volume overload, but also prevent the development of pulmonary vascular obstructive disease and avoid the risk of endarteritis which had been demonstrated in relation to the ductal flow disturbance. Surgical ligation was shown to be both safe and effective. In 936 duct closure operations performed in Great Ormond Street Hospital for Children between 1946 and 1969, only four deaths occurred in patients with no other major congenital abnormality (0.5%), and residual duct patency was found in only four cases (0.4%).² By the early 1980s, about 40% of patients undergoing surgical closure of a patent arterial duct were symptomatic infants—even when infants born prematurely were excluded—and hospital mortality was approaching zero.³

The success of this surgical approach led to the recommendation that the presence alone of a patent arterial duct was sufficient indication for surgical ligation. However, the issue has become more complicated in recent years. The sensitivity of diagnosis has been vastly increased because of the development of colour flow Doppler techniques. Simultaneously, techniques for percutaneous transcatheter duct occlusion have evolved. These developments have been accompanied by changes in the natural history of the condition.

Natural history and risk of endarteritis

The natural history of the patent arterial duct is not well documented. The best data available are those collated by Campbell.⁴ The difficulties in defining the natural history are evident in this detailed review, which was prompted in the late 1960s by the consideration that “physicians who are advising operation for PDA will have no experience of its course without this.” Necropsy series published in 1936 to 1943 in patients in the presurgical and preantibiotic era had indicated high infant mortality, and the average age of death in those surviving infancy was about 30 years. Infective endarteritis was the most common cause of

death, being the attributed cause in 45% of cases. Even so, the likelihood that large ducts in younger patients were over-represented in these series is acknowledged. Campbell also reviewed data published between 1942 and 1957, including his own patients, at a time when the impact of operation and antibiotic treatment for infective endarteritis was already confounding true estimates of natural history. It is reasonable to assume that all patients included in these series had typical physical signs of a haemodynamically important patent arterial duct. Campbell estimated that there was a 30% mortality in infancy, with lower attrition thereafter, so that of those surviving infancy, 34% would be dead by 40 years. In comparison with the previous necropsy series, a lower proportion of deaths—about 30%—was attributed to infective endarteritis owing to the availability of antibiotic treatment. Interestingly, Campbell considered that his most important conclusion was the estimate of spontaneous duct closure, which he suggested occurred in 20% of patients by the age of 40 years. This is almost certainly an overestimate because assessment was based on auscultatory findings, but at the least it suggests that some ducts do become spontaneously smaller. Campbell even proposed that surgery could be deferred in “subjects where the flow is small and the signs suggest that the ductus is already closing.”

It is clear that the risk of infective endarteritis is now much lower than was previously documented. In a study recently reported from Sweden, 270 children and adults with patent arterial duct were followed for an aggregate of 1196 years at risk, with no case of infective endarteritis being documented.⁵ Total deaths in Sweden between 1960 and 1993 were nearly three million, of which only two were attributed to infective arteritis as a complication of patent arterial duct.⁵ One of these was a female aged 33 years at the time of her death in 1971 with Eisenmenger’s syndrome, and she thus almost certainly had a large arterial duct. The other death occurred in 1981, a 42 year old female about whom no further details are available.

A questionnaire of 31 European cardiologists, who it was estimated would have encountered over the past 10 years about 5400 cases of patent arterial duct in children and about 300 cases in adults, disclosed knowledge of only four cases of endarteritis in children, all of whom were older than 10 years, and one in an

Cardiothoracic Unit,
Great Ormond Street
Hospital for Children,
London WC1 3JH

Correspondence to:
Dr Sullivan, e-mail:
cardiacos@compuserve.com

Figure 1 Parasternal short axis echocardiographic view in a 7 year old girl. There are vegetations in the pulmonary trunk attached to the site of entry of a moderately large patent arterial duct (see text). Abbreviations: aoa = ascending aorta; aod = descending aorta; pa = pulmonary artery; pda = persistent arterial duct; rpa = right pulmonary artery; v = vegetations.

adult during that time.⁶ No information is available about the size of the arterial duct in these five affected patients. However, a German study reported that infective endarteritis had been previously diagnosed in six patients among 100 adults referred for consideration of transcatheter ductal closure. The minimum ductal diameter was 4.5 mm or more in all six cases.⁷

In a retrospective review of patient records at Great Ormond Street Hospital for Children for the period 1984 to 1996, only two cases of endarteritis associated with patent arterial duct were found among 17 887 cardiac admissions. Both were in school age children who had haemodynamically important arterial ducts with left ventricular volume overload. One had had dental work without prophylactic antibiotic cover shortly before the development of symptoms (fig 1). During the same period, at Freeman Hospital, Newcastle upon Tyne—which is the regional centre for adult as well as paediatric cardiology—one case of endarteritis was diagnosed in association with a patent arterial duct from a total of 92 093 admissions (C Wren, personal communication). This was a 33 year old woman with Down's syndrome, in whom the patent duct had not previously been recognised. All three patients were successfully treated with antibiotics before surgical duct closure in two, and transcatheter occlusion in the third. This adult patient, and one other case,⁸ can be considered the only cases in which endarteritis in association with a small patent arterial duct has been documented.

The risk of endarteritis following transcatheter duct occlusion is small. One case of infection from 800 patients (0.1%) was reported following duct occlusion using the Rashkind double umbrella device.⁹ Further support for the concept that endarteritis occurs as a complication of a haemodynamically impor-

tant duct is provided by an animal model of patent arterial duct using piglets, in which the risk of inducing infection was related to the size of the duct, whether or not an occlusive device had been deployed.¹⁰

The incidence of a small patent arterial duct will depend on the criteria for diagnosis. The most sensitive diagnostic technique is colour flow Doppler mapping, which has been generally available since the late 1980s—about the same time as transcatheter occlusive techniques began to be widely employed. Diagnosis of a “silent” patent arterial duct with colour flow Doppler was made in 0.5% of children undergoing echocardiography because of the presence of an innocent murmur which was clearly not related to ductal flow, even after retrospective physical examination was performed by two cardiologists with this possibility in mind.¹¹ The incidence of silent patent arterial duct in the normal population is likely to be similar, suggesting that this finding is not a risk factor for endarteritis. Moreover, residual ductal flow was detected by colour flow mapping in as many as 22% of patients who had previously undergone apparently satisfactory surgical duct ligation with no signs otherwise of residual ductal flow.¹² There is no evidence that patients who have undergone clinically satisfactory duct ligation are at risk of endarteritis despite this rather surprising finding.

Occlusion techniques

Transcatheter occlusion techniques were attempted sporadically from the early 1970s until use of the Rashkind double umbrella device was adopted widely in the late 1980s.¹³ Disadvantages of this device include its cost,¹⁴ the availability of only two sizes, rather bulky delivery apparatus making it unsuitable for use in most infants, potential proximal left pulmonary artery narrowing after deployment in small subjects,¹⁵ occasional haemolysis after deployment, and a relatively high incidence of colour Doppler detected residual duct flow of 10–20%.¹⁶ It is reported that blood is given more often than when surgical closure is used at Boston Children's Hospital.³ This device is not currently approved for general use in the USA.

More recently, spring loaded stainless steel coils impregnated with fibres of Dacron, especially those with a mechanism for controlled release from a catheter delivery system, have become the preferred occlusive devices for most patent arterial ducts. Advantages are the relatively low cost and small delivery catheters. Single coils can effect complete occlusion of small ducts in most children.¹⁷ The use of multiple coils has allowed occlusion of larger ducts, up to 5–6 mm diameter.^{18–22} However, there are some concerns associated with their use. Embolisation to the pulmonary circulation occurs in about 10% of patients in most published series. While catheter retrieval using a snare is usually possible, this may add considerably to radiation exposure. Use of multiple coils has been associated with flow acceleration at the origin of the left pulmonary artery, suggesting some compromise of blood

flow to the left lung and the suggestion that these techniques be reserved for patients with body weight of more than 8 kg seems prudent,²⁰ although a number of series describe deployment of multiple coils in smaller patients. Published figures, especially when multiple coils have been deployed, sometimes show alarming quantities of metalwork protruding into the lumen of the proximal left pulmonary artery. As these devices are designed to be thrombogenic, there must also be theoretical concern about this acting as a source of recurrent thromboembolism, although this has not yet been demonstrated. Other complications include late embolisation¹⁹ and late recanalisation of the duct, leading to the recommendation that these patients require follow up for an indefinite period.²⁰

Conclusions

Surgical ligation or transcatheter occlusion of a patent arterial duct in a symptomatic infant or a child who has more than a small left to right shunt is clearly indicated. In practice, the relief of relatively mild left ventricular volume overload in children following duct occlusion often results in symptomatic improvement, even in those who were not thought to be symptomatic before the abolition of duct flow. Surgical ligation is preferred when duct closure is indicated for symptom relief in early infancy. Beyond early infancy, transcatheter coil occlusion using controlled release coils is the preferred technique at present in most cases, almost regardless of the exact morphology of the duct. However, available follow up is short with this technique, and while no major complications are apparent, it may still be premature to describe surgical developments such as thoroscopic clipping of the duct as obsolete.¹⁷ Thoroscopic clipping of the duct in patients of all ages is safe and effective in experienced hands, with mean procedure time as short as 20 minutes and a mean hospital stay of two to three days in the largest series.²³ However, the technique involves three separate short skin incisions and the surgical skills required are not easily obtained. In wider practice, duct ligation through a short transaxillary, muscle sparing incision may be at least as effective and cosmetically acceptable.

The natural history of a small patent arterial duct with a negligible left to right shunt is not known with certainty, but the risk of endarteritis is vanishingly small. The ability to diagnose a small patent duct has been greatly enhanced by the availability of colour flow Doppler imaging. This technique is sensitive to the detection of minor flow disturbance: with careful attention to instrument settings, tricuspid regurgitation and pulmonary regurgitation can be detected in most normal children, and mitral regurgitation in a minority. These

children are not thought to have cardiac pathology. It therefore seems illogical to advise occlusion of a "silent" patent arterial duct detected using the same technique.²⁴ Even when physical signs of a small duct are detected, if echocardiographic measurement of left ventricular dimensions confirms absence of even mild left ventricular volume loading there is no current evidence to support a policy of duct occlusion in order to reduce the risk of endarteritis.

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