Anterograde transcatheter occlusion of the patent ductus arteriosus with Gianturco coils — a new, effective and inexpensive technique

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Objective. To report the use of Gianturco coils in non-surgical closure of patent ductus arteriosus (PDA).

Design. Retrospective review of patient data.

Setting. Two specialist paediatric cardiology units in Riyadh, Saudi Arabia, and Cape Town, South Africa.

Patients. Thirty children (median age 36 months, weight 12.5 kg) and one adult (24 years old) with PDA underwent attempted transcatheter closure of the duct between August 1994 and February 1995.

Outcome measures. Assessment of duct closure as measured angiographically or with colour flow Doppler techniques after insertion of a Gianturco coil or coils.

Results. Total occlusion was achieved in 90% of patients. In 2 patients, accidental embolisation of the coil occurred during the procedure. The coils were easily retrieved with a snare retrieval device. The median diameter of PDA occluded was 2.5 mm. Between 1 and 6 coils were used to achieve occlusion. The median procedure time was 79 minutes. Seventy-nine per cent of patients in Riyadh were handled as day cases.

Conclusion. Anterograde transcatheter occlusion of a small to moderate PDA with Gianturco coils is safe and effective. The technique is considerably less expensive than the Rashkind double umbrella.


Transcatheter occlusion is an attractive modality for treatment of patent ductus arteriosus (PDA) because it can be performed as a day case procedure, leaves no scar, does not require general endotracheal anaesthesia and generally has less psychological impact on the child than surgery does. Several methods of transcatheter occlusion of PDA have been reported. Although the USCI Rashkind double umbrella device has, until recently, been the most popular method of transcatheter PDA closure the device is very expensive (approximately R8 000 for the equipment alone). Additionally, there are several problems with the umbrella device; these include residual shunting, embolisation and haemolysis and stenosis at the origin of the left pulmonary artery. For these reasons (mainly the expense), most centres in South Africa have continued to rely on surgical ligation of PDA. We report our experience with anterograde transcatheter coil occlusion of PDA with Gianturco coils. This coil procedure is effective, safe, relatively simple and above all, inexpensive.
Patients and methods

Thirty-one patients, diagnosed with a PDA clinically and by means of two-dimensional and Doppler echocardiography (colour at King Faisal Specialist Hospital (KFSH), without colour at Red Cross Hospital (RXH)) underwent cardiac catheterisation for anterograde transcatheter coil occlusion between August 1994 and February 1995. This report does not address those patients with PDA catheterised during this period who may have had a Rashkind umbrella device successfully deployed (at KFSH) or where coils were not deployed because the PDA was deemed too large (2 patients at RXH). Three children at RXH and 27 children and 1 24-year-old adult at KFSH underwent anterograde transcatheter coil occlusion. The median age of the children was 36 months (range 12 - 120 months) and the median weight was 12.5 kg (range 8.2 - 33.5 kg). Only 2 patients had evidence of heart failure, caused by a large left to right shunt. Seven patients had a significant residual shunt as a result of the previous placement of a Rashkind umbrella device and 1 patient had a residual shunt because of a previous PDA ligature. Cardiac catheterisation was done under heavy sedation with intramuscular meperidine 1.5 mg/kg, chlorpromazine 0.5 mg/kg and promethazine 0.5 mg/kg. An anaesthetist was present to give additional intravenous ketamine before deployment of the coils. For the children, a 4Fr sheath was inserted into the femoral artery and either one or two 4Fr sheaths were inserted into the right and/or left femoral vein, depending on the suspected size of the PDA and whether more than one coil would be considered necessary. No patients were given heparin. Antibiotic prophylaxis was given.

The procedure was essentially the same as that described by Hijazi and Geggel. We modified Hijazi's technique slightly to save on costs. The usual haemodynamics and saturations were performed with the 4Fr multipurpose end-hole catheter (Microvena). (Hijazi and Geggel used a 4Fr balloon end-hole catheter for this purpose.) If there was any difficulty in manipulating the catheter across the PDA or down the left pulmonary artery, an 0.035 inch Terumo wire was used. The aortogram was performed with a 4Fr pigtail catheter with the curled end cut off (and the catheter advanced over the Terumo wire) (Fig. 1). This is the most cost-effective catheter for angiography and at RXH this catheter is re-used 4 - 5 times after meticulous sterilisation.

The deployment of the Gianturco coils was exactly as described by Hijazi and Geggel. We used the same criteria for the size and number of coils in relation to PDA size. If the PDA is estimated to be < 2.5 mm at its narrowest diameter, a coil 2.3 - 5 mm in diameter is used. (The coil diameter should be at least twice the size of the PDA.) If the PDA is > 2.5 mm in diameter, two 4Fr Microvena catheters are advanced in an anterograde fashion through the PDA, and multiple coils are deployed sequentially. For a PDA 2.5 - 3 mm in diameter, two 5 mm x 5 cm coils are used and if the PDA is between 3 and 4 mm, one 5 mm x 5 cm and one 8 mm x 5 cm coil are used. A PDA > 4 mm will require at least 3 coils. If the aortogram done 10 minutes after deployment shows a residual shunt, then the 0.032 inch Terumo wire is gently manoeuvred through the duct past the coils. The 4Fr Microvena catheter then slides over the wire and another coil(s) can be deployed.

If the coil accidentally embolises down the pulmonary artery or aorta (as happened in 3 of our cases), it can easily be retrieved through the 4Fr catheter with a 4Fr gooseneck snare (Microvena). When the coil is accidentally pulled through the PDA, before its deployment, the coil can be withdrawn (partially released from the catheter) through the heart, down the inferior vena cava and out through the sheath, because the coil usually remains in the catheter unless physically pushed out by the wire. In 5 cases we were able, in this manner, to remove coils that were already 50% deployed.

Results

Seventy-nine per cent of KFSH patients underwent the procedure as a day case as noted above. Of the 23 remaining patients, 19 (82%) had a type A PDA configuration, 1 (4%) type B, and 1 (4%) type C, and 2 (8%) type E according to the Krichenko classification. The median narrowest diameter of the PDA was 2.5 mm (range 1 - 4.5 mm). The median Qp:Qs ratio was 1.5 (range 1.1 - 3.3) and the median mean pulmonary artery pressure was 18 mmHg (range 7 - 45 mmHg). The procedure and fluoroscopy times ranged from 33 - 165 minutes and 4 - 51 minutes respectively (medians 79 and 13 minutes respectively).

Fifteen patients required a single coil, 6 patients 2 coils, 6 patients 3 coils and 2 patients 4 coils. One patient required 5 coils, and another 6. Sixty-one per cent (19 of 31 patients) demonstrated complete occlusion angiographically 10 minutes after deployment of the final coil (Fig. 2). Nine patients with a tiny residual leak on angiography underwent colour
flow Doppler echocardiography within 6 - 18 hours, and only 3 had a small persistent shunt. Proven complete occlusion before discharge (within 18 hours of the procedure) as demonstrated by angiography or colour Doppler echocardiography was demonstrated in 90% of patients.

The only complications were either pull-through of the coil (through the PDA, when only half the length of the coil is deployed from the catheter) or embolisation of the coil. Pull-through occurred on 5 occasions. Embolisation occurred in 2 cases, once down the left pulmonary artery and once down the aorta. In all situations the coil was successfully retrieved without further complication, and the PDA subsequently occluded. Where embolisation occurred the fluoroscopy time was increased (to 24 minutes and 51 minutes respectively) above the mean fluoroscopy time of 14.2 minutes (SD ± 7.3 minutes for the cases where embolisation did not occur). One patient developed femoral artery occlusion, secondary to the placement of the 4Fr arterial sheath. The pulses and circulation in the leg returned to normal after a streptokinase infusion.

Discussion

The use of the USCI Rashkind umbrella device for transcatheter PDA has become very popular in wealthier countries, as evidenced by a plethora of publications. This device is, however, prohibitively expensive for most centres in developing countries and the method of PDA closure has remained ‘surgical’. Gray et al., at the Mayo Clinic showed that surgical closure of the PDA was more effective and less costly (by almost US $2 500 in 1989) than transcatheter occlusion with the Rashkind device. The published results of surgical closure of the PDA are excellent, although the more recent technology does demonstrate that there is more residual shunting than expected. Because of the cost of the Rashkind umbrella device, most centres in South Africa have continued to rely on surgical ligation of the PDA. Only in Johannesburg was the device routinely used, with an initial occlusion rate of only 52% and an embolisation rate of 3.9% (which required surgical thoracotomy to remove the device). However, transcatheter occlusion of a PDA has major advantages over surgery: (i) shorter hospital stay (even as a day case); (ii) no pain from a surgical thoracotomy; (iii) no surgical scar; (iv) no endotracheal general anaesthesia required; (v) avoidance of the complications of a thoracotomy, wound infection, lobar atelectasis, lung infection, haemothorax, pneumothorax, chylothorax or phrenic nerve palsy, which all increase the cost of the procedure. Overall, the psychological impact on a young child of a transcatheter procedure done as a day case should be much less than that of the thoracotomy and pain of surgical closure.

Anterograde transcatheter coil occlusion is an inexpensive and effective procedure involving only the costs of the catheters, a Terumo wire and the Gianturco coils (approximately R120 each). Because of the shorter hospital stay, coil occlusion should be considerably cheaper than surgery, or indeed other transcatheter procedures. At most public/academic hospitals in South Africa, diagnostic catheters are reused, and there is even a trend in First-World countries to reuse catheters after careful sterilisation. It is uncertain whether it is safe to reuse the catheters for coil occlusion to cut down further on the expense of the procedure. Although the catheter for angiography might be reused, the delivery of ‘hairy’ Gianturco coils through reused catheters is of concern, especially as foreign material is being left behind in the circulation; also because some cases have a residual leak that increases the risk of endarteritis. Until further evidence to the contrary is available, we would advise against the reuse of the end-hole multi-purpose catheters which are used for the delivery of the coils.

Our results show that anterograde transcatheter coil occlusion is a safe procedure for transcatheter closure of a small to moderate-sized PDA, with results which are very favourable compared with those of surgery. Ninety per cent of our patients left hospital with no residual shunt. In those who still had a residual shunt, it will probably have closed by the sixth month post-procedure follow-up date, as the leak in all cases was very small. Where a residual shunt is shown on colour flow Doppler after 6 months, we repeat the attempt at total occlusion. Again the repeat coil occlusion will be relatively inexpensive, compared with the exorbitant cost of delivery of a second Rashkind umbrella device in patients with residual shunt after the first umbrella attempt (approximately R20 000 for delivery of two umbrella devices!). We had particular success with coil occlusion for residual leak on the Rashkind umbrella in 7 patients, 6 of whom required only a single coil. Six of the 7 patients had total occlusion within 24 hours; the seventh had such a tiny residual leak on colour Doppler that it seems unlikely that this will be present in 6 months’ time.

Coil occlusion is also a very attractive method of transcatheter PDA closure because of the small 4Fr catheters used. This compares very favourably with the 8F and 11F sheaths required for the Rashkind device. Although our
patients were relatively large, it is possible with these small catheters to close PDAs in small babies; the smallest patient reported weighed only 2 kg.\(^1\) Additionally, retrieval of embolised coils is far less traumatic than retrieval of an embolised umbrella device. The complications experienced, viz. embolisation and pull-through of the coil, merely resulted in a longer procedure and fluoroscopy time. Embolisation occurred when a fully deployed coil was in an unsatisfactory position and then migrated down the aorta or left pulmonary artery. Coils embolised were retrieved with the Amplatz goose-neck snare (Microvena). Pull-through occurred when a partially extruded coil was pulled through the PDA into the main pulmonary artery. By withdrawing the catheter gently back through the heart, into the inferior vena cava and out through the sheath, the coil remained stuck in the catheter and was thus safely removed from the body. The coil actually needs to be pushed out of the body. The coil actually needs to be pushed out of the body. The coil actually needs to be pushed out of the sheath. The coil actually remained stuck in the catheter and was thus safely removed from the body. The coil actually needs to be pushed out of the body.

The exact choice of the size of the coils may change with further experience. Overall we found the procedure easy to learn. Provided high-quality biplane X-ray equipment suitable for paediatric cardiac catheterisation is available, a qualified paediatric cardiologist doing regular cardiac catheterisations and some basic interventions should be able to perform anterograde transcatheter coil occlusion. Confidence and experience can be built up by starting with the easier cases, viz. those patients who have a residual shunt after a Rashkind umbrella or those with a small type A or E ductus. (where a prominent ampulla is present). Long-term follow-up studies need to be done to assess whether there are late complications from the coil placement, e.g. stenosis at the origin of the left pulmonary artery (which was not demonstrated immediately after coil deployment). From the short-term information available, it appears that anterograde transcatheter coil occlusion is a safe, inexpensive and effective means of PDA occlusion.

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References