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Flipper coil closure of patent ductus arteriosus

V Grech¹ and JV DeGiovanni²

¹Paediatric Department, St. Luke's Hospital, Guardamangia, Malta

²Cardiology Department, Birmingham Children's Hospital, UK

Contact information: Dr. Victor Grech, Editor-in-Chief, Images Paediatr Cardiol ;
Email: victor.e.grech@gov.mt

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Abstract

Transcatheter closure of patent ductus arteriosus is now a well established therapeutic option. In this paper, we illustrate step by step the technique of Flipper coil closure of small (<3mm) ducts.

MeSH: Heart Defects, Congenital, Ductus Arteriosus, Patent, Heart Catheterization/Instrumentation, Embolization, Therapeutic, Radiography, Instrumentation, Interventional

Introduction

Patent ductus arteriosus (PDA) is a persistent normal fetal structure that connects the left pulmonary artery and the descending aorta. The ductus closes spontaneously within hours or days of birth and persistence of this structure beyond 10 days of life is considered abnormal. This lesion comprises 5-10% of all congenital heart defects (excluding PDA associated with prematurity). The available retrospective data on the natural history of untreated PDA are poor but morbidity and mortality rates are directly related to the flow volume through the PDA. Small ducts are usually asymptomatic as they cause a very minor degree of left to right shunting with minimal ventricular volume overload. Spontaneous closure after three months of age is rare and bacterial endocarditis is a potential risk. For these reasons, small ducts that are still present by two years of age or are diagnosed – often incidentally – after two years of age are closed electively.

This article will detail how a small duct (up to 3mm diameter) can be occluded with a Flipper (Cook) detachable coil.¹ Larger ducts should be occluded with an Amplatzer PDA plug.

Coils

The coil occlusion technique has been used for embolisation purposes in various sites of the body since 1972. Coil closure of PDA was first achieved in 1992 using Gianturco coils (see below).² The embolisation principle is simple in that the loops of the coil chosen for any particular PDA are larger than the diameter of the PDA. When

the coil is deployed, loops placed on each side of the PDA (in the pulmonary and the aortic end) hold the coil in position through the coil's inherent spring effect and in a short while, the coil fibres promote clot formation which eliminates flow through the PDA. The coil and clot are then endothelialised.

Flipper coils are stainless steel spring wires coated with tetrafluoroethylene and lined with synthetic Dacron fibres over their entire length. They are first deployed and then detached (unscrewed) off the delivery wire. This permits retrieval of the coil if the delivery position is unsatisfactory. This is in contrast to the classical Gianturco coils which are pushed out of a delivery catheter by a coil pusher wire and once deployed, cannot be retrieved except by a snare and are therefore nondetachable.

Coils come in several sizes and the useful sizes include 3 by 3, 3 by 4, 3 by 5, 5 by 3, 5 by 4, 5 by 5, 6.5 by 3, 6.5 by 4, 6.5 by 5 where the first figure is the coil loop diameter in mm and the second figure is the number of loops that comprise the coil. Larger sizes are available (8 by 3, 8 by 4, 8 by 5) but are not widely used. The coil diameter chosen should be twice that of the PDA diameter at its narrowest point. The number of loops chosen depends on the size of the ductal ampulla at the aortic end – the deeper the ampulla, the larger the number of coils that can be packed into it.

Method

The femoral artery is entered with a 4F sheath and antibiotics and heparin (100u/kg bolus) are given. A 4F pigtail is passed up the aorta next to the PDA. The tube orientation is turned to 90 degrees and conventionally, this is the LAO position with the ascending aorta anteriorly. A descending aortogram is obtained (1ml/kg over 1 second up to a volume of 40ml) and a suitable image showing the duct is frozen on a slave monitor and the narrowest diameter of the duct is measured. It is useful to remember the position of the duct relative to the trachea for orientation purposes.

A coil is now chosen for deployment that is twice the size of the duct at its narrowest point, with the number of loops depending on the width and depth of the ampulla. The straight end of a double-ended exchanged wire is passed through the pigtail to straighten it in the ascending aorta. The wire is left protruding for a few centimetres out of the pigtail. The degree of angulation of the pigtail can be controlled, to some extent, by the amount of wire left protruding out of the catheter – the more wire protruding out of the catheter, the less acute will be the angle of the pigtail.

The catheter is then pulled back into the descending aorta until the wire flicks into the duct. If this technique fails because the exact entry angle into the duct cannot be obtained, attempts to cross the duct can be made with a Judkins right coronary catheter or an internal mammary catheter which are exchanged over the wire.

Once the duct is crossed, the wire is pushed into the main pulmonary artery (PA). Ectopics imply that the wire has entered the right ventricle and the wire should be withdrawn to the pulmonary artery so as to avoid damaging the pulmonary valve. The catheter is removed leaving only the wire in the pulmonary artery.

The 4F sheath is then replaced by an appropriately sized sheath. The Flipper coil consists of an 0.038" wire but passes through an 0.041" lumen due to its bristles. The smallest catheter that it passes through is the Cook PDA catheter and the Microvena 4F snare catheter. These have a large lumen at the expense of stiff but thin walls that kink easily. A conventional catheter alternative is a 6F JR 4 guiding catheter. However, this will cause substantial bleeding around the delivery system unless used with a haemostatic valve, such as a Tuohy-Borst adapter (Cook) which is specifically designed to prevent the backflow of fluid around an instrument inserted through the adaptor's working channel.

The coil delivery catheter is pushed over the exchange wire into the pulmonary artery and the exchange wire is then pulled out.

Figure 1 Lateral aortogram showing PDA with filling of the pulmonary arteries

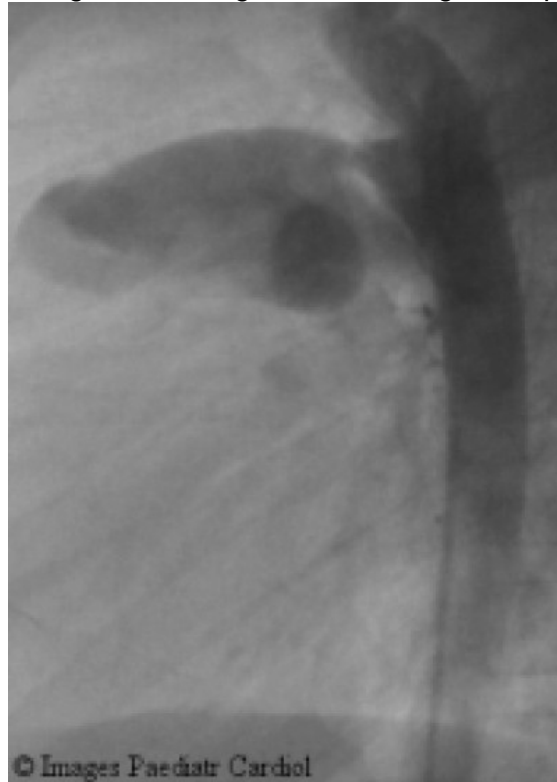


Figure 2 Exchange wire straightening pigtail catheter

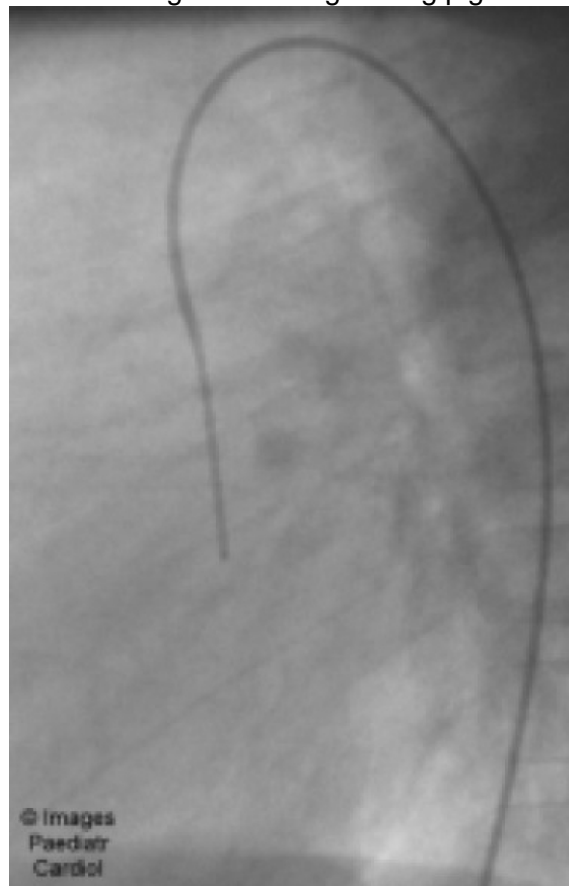


Figure 3 Wire initially in aorta, and later flicks into the pulmonary artery

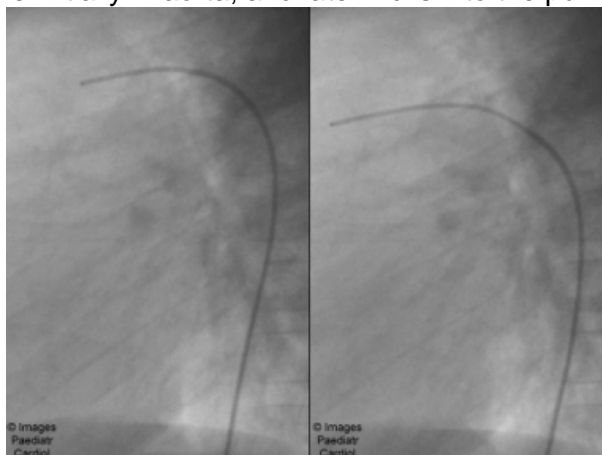
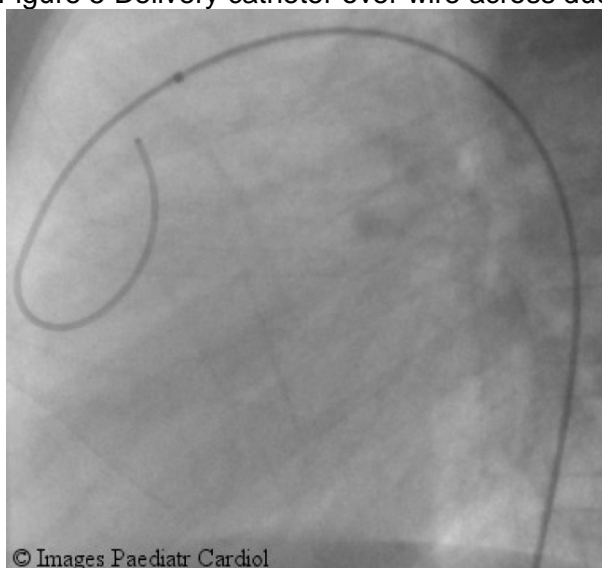


Figure 4 Tuohy-Borst adapter



Figure 5 Delivery catheter over wire across duct



The coil and delivery system are now prepared for deployment. The delivery wire universally fits all sizes of Flipper coils and has a distal end that screws on to the coil, and a proximal end with a torquer (green arrow) for eventual coil detachment (figure 6). The delivery wire is hollow in section and contains a stiff steel mandrel (green arrows) that protrudes from both ends of the wire (panel A). The distal end is extruded as required to straighten the coil prior to insertion into the delivery catheter

(B). Straightening is achieved by pushing on the proximal end of the mandrel (red arrow bottom of panel C) and this will extrude the mandrel from the distal end (red arrow top of panel C). Conversely, pulling on the proximal end of the mandrel will pull in the distal end (blue arrows panel C). Extrusion of the distal end allows the mandrel to enter the hollow section of the coil (orange arrow panel D - see below). The movement of the mandrel can be seen in this animation (figure 7).

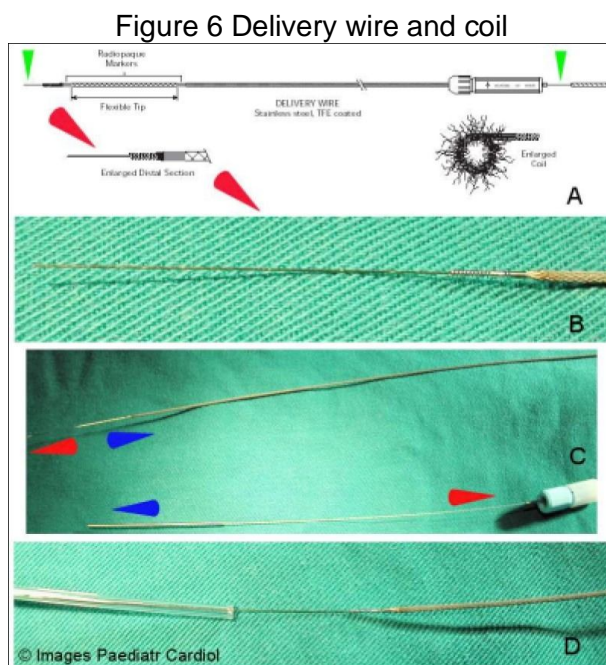
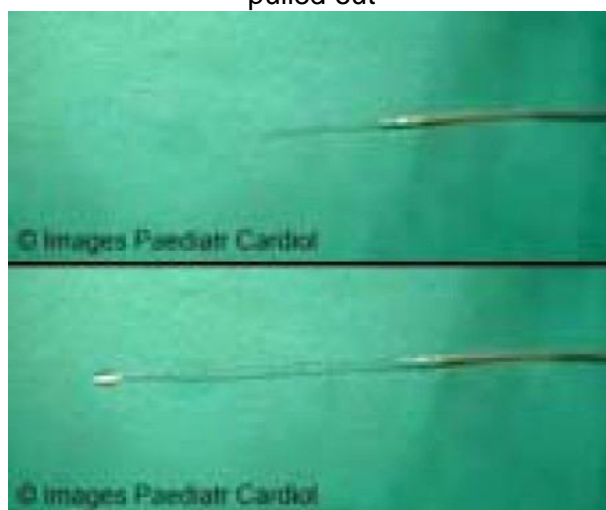


Figure 7 Distal end of the delivery wire showing mandrel being pushed into and pulled out

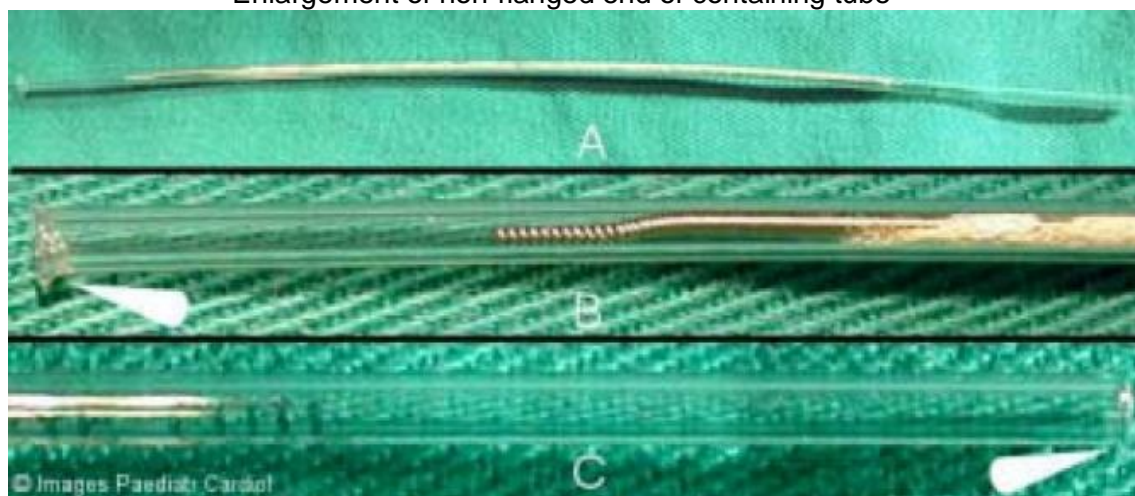


On removal from the sterile packaging, the coil can be seen to be held straightened out in a transparent plastic tube (figure 8). Only one end of this containing tube is flanged and this indicates the end of the coil that is to be screwed on to the delivery wire.

The coil which is still in its transparent plastic introducer is screwed on to the delivery wire through the flanged end of the introducer (figure 8 panel B). The coil is then loaded into the delivery catheter and pushed out through its end until a centimetre or so can be seen to protrude out of the catheter into the pulmonary artery. The stiff

central wire is then pulled back allowing one loop of coil to form in the pulmonary artery.

Figure 8 A. Flipper coil. B. Enlargement of flanged end of containing tube. C. Enlargement of non-flanged end of containing tube



The entire system is then pulled back against the pulmonary artery end of the duct and once the coil impinges against the wall of the artery, the aspect of the coil will change.

The catheter is now sleeved back over the delivery wire, i.e. through the duct and into the descending aorta. The coil is allowed to coil up in the ampulla by releasing the tension on the delivery wire. If there is a large aortic ampulla, one should attempt to pack the coil into the ampulla horizontally rather than vertically so as to increase the chances of complete occlusion.

Figure 9 One loop out of delivery catheter in the pulmonary artery. Arrow denotes the proximal end of the coil where it is attached to the delivery wire

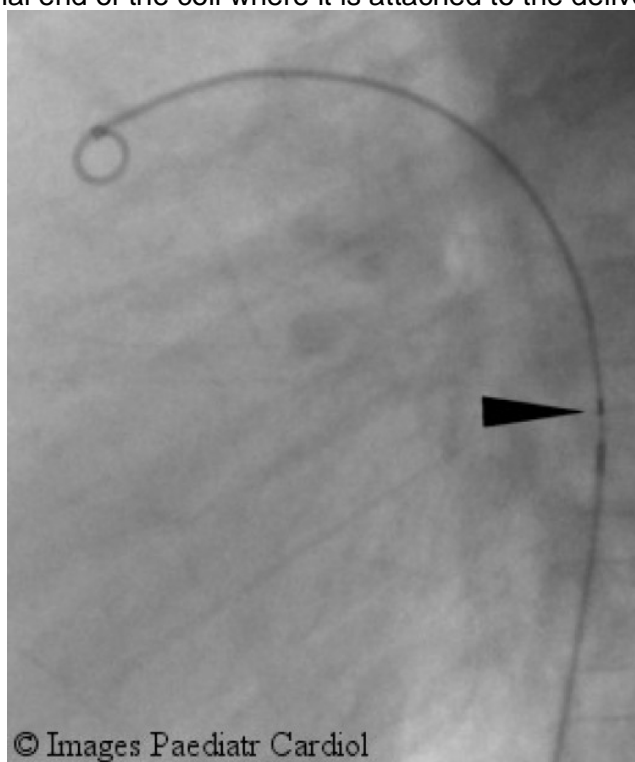
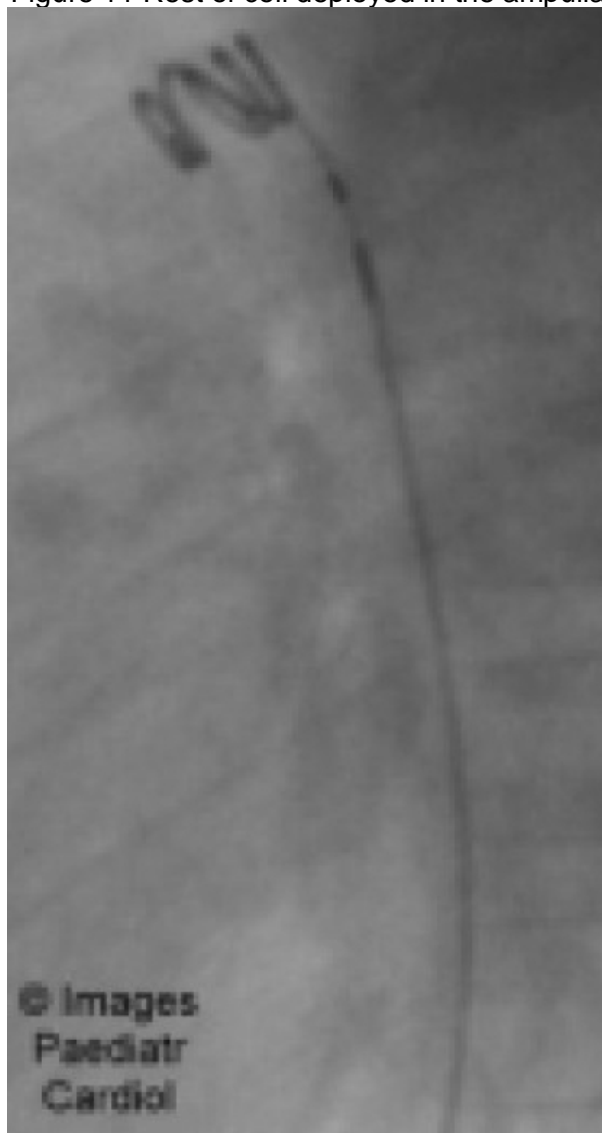


Figure 10 Loop pulled back against pulmonary artery end of the coil



Figure 11 Rest of coil deployed in the ampulla



The effect of pulling back on the mandrel on the coil is shown in figure 12.

Figure 12 Pulling back on the mandrel allows the coil to revert to its natural coiled shape.



Figure 13 Coil released



Figure 14 Repeat aortogram showing little residual flow across the PDA

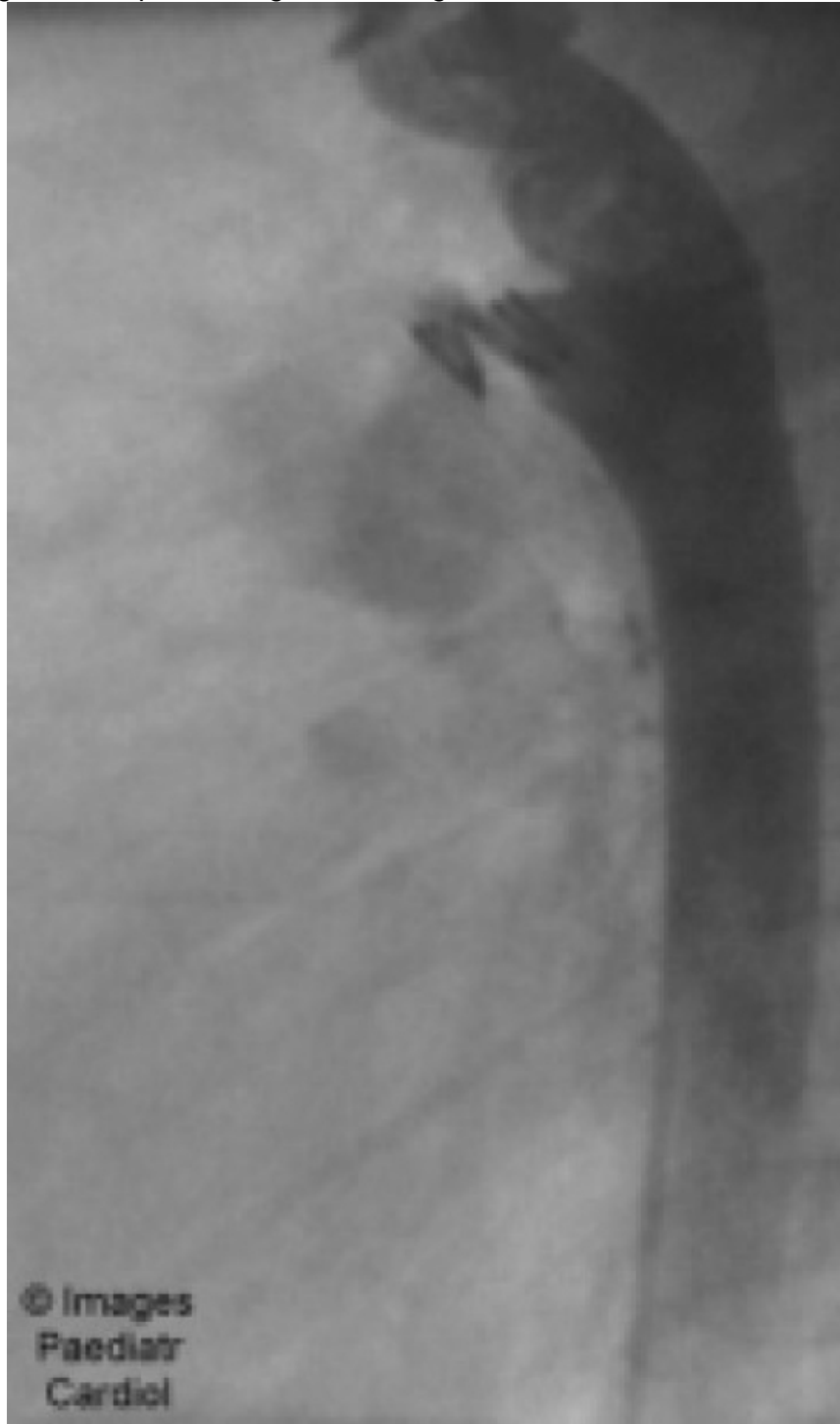


Figure 15 Pigtail straightened so as to avoid catching the catheter on the coil



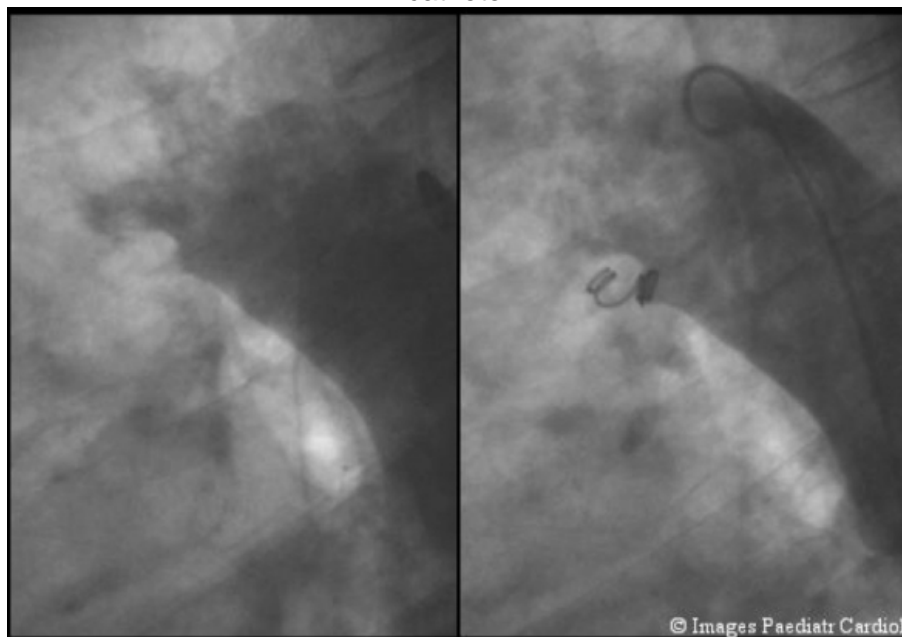
When the coil is in a satisfactory position, the delivery wire is slowly unscrewed from the torquer to release the coil. If, while unscrewing, the aspect of the coil begins to change, one should pause to let the delivery cable catch up in the unscrewing with the coil.

When the coil is released, delivery wire should be pulled back into the catheter so as to avoid tears or perforations of the aorta. Once released, the coil may need further packing into the ampulla with the help of the delivery catheter. The aortogram is repeated using the pigtail.

Care should be taken not to catch the pigtail on the coil while retrieving the pigtail - the pigtail should be straightened out with the exchange wire.

Small ducts in adult patients may be difficult to cross because of lack of catheter support due to the large aorta (figure 16).

Figure 16 Small PDA in a large adult patient. This was crossed with an innominate catheter



Similarly, very small PDAs – and these are usually silent ducts – may prove virtually impossible to cross, even with a wire. The case shown in figure 17 was one of these. Larger ducts cannot be closed with coils. The duct in figure 18 was initially thought to be small enough for coil closure. The pigtail entered the pulmonary artery with no effort whatsoever.

Figure 17 A tiny PDA that proved impossible to cross with a wire (arrows)

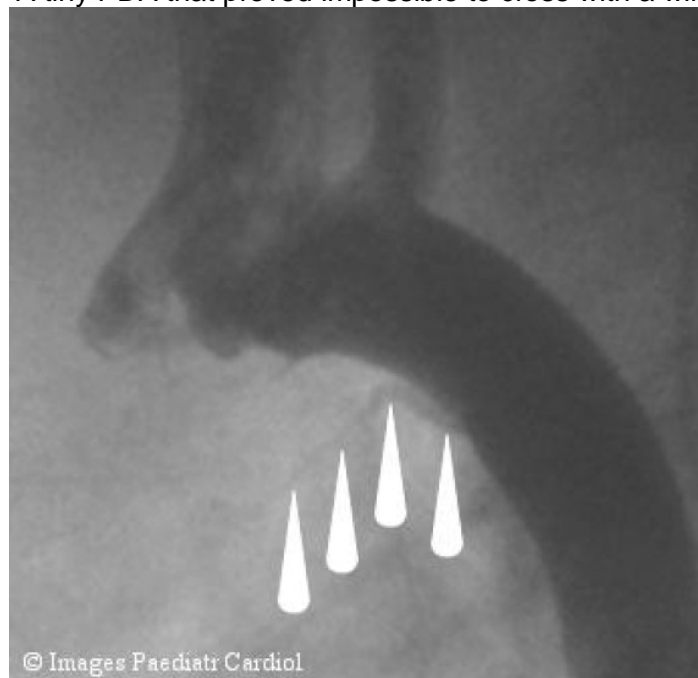


Figure 18 Pigtail across duct into pulmonary artery showing main pulmonary artery and branches (left: lateral view and right: AP view)



Repositioning so as to obtain an aortogram showed the duct clearly. Attempted coil deployment simply allowed the coil to slip entirely into the PA. The coil was therefore retrieved and duct was closed with an Amplatzer PDA plug.

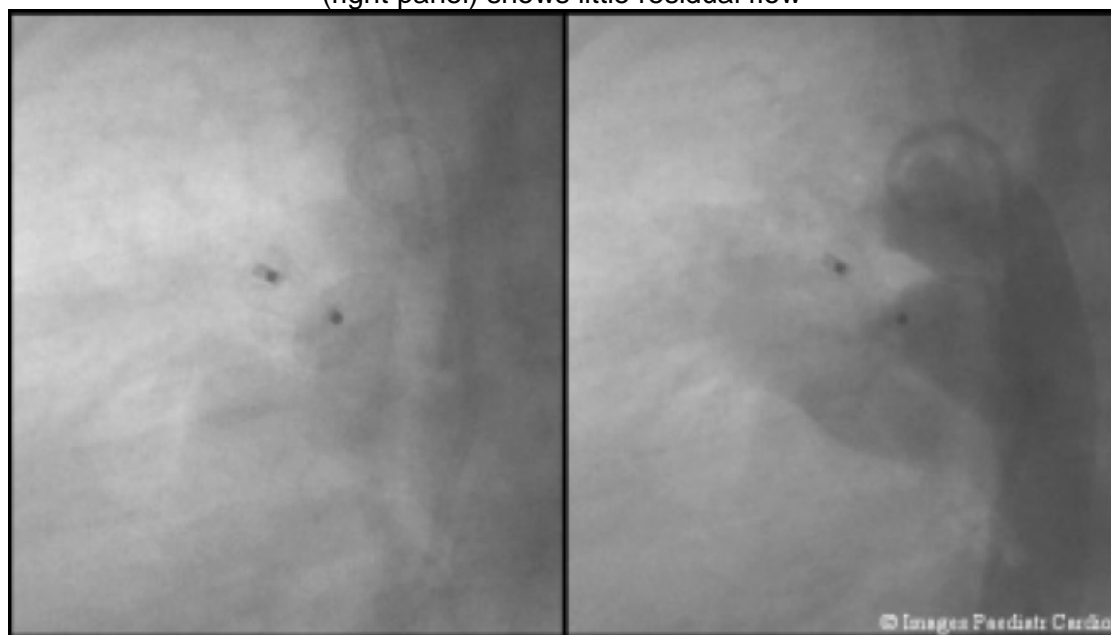
Figure 19 Lateral aortogram showing PDA (arrow)



Figure 20 Coil deployment – coil persistently slides into the pulmonary artery



Figure 21 Same duct as in figures 18-20 closed with an Amplatzer plug. Aortogram (right panel) shows little residual flow



The coil closure technique has an approximately 3% chance of leaving a residual duct which will need redo coiling. Figures 22 and 23 show a case of mild coarctation in association with a small duct that was coiled leaving a persistent leak around the coil. This was redone after 2 years so as to allow the duct sufficient time to close with the first coil.

If the patient needs a magnetic resonance scan (for whatever reason), it is better to delay for six weeks so as to allow the coil to become completely embedded. At the time of writing, coil closure is the interventional method of choice in small PDAs. This animation summarises the procedure (figure 24).

Figure 22 Coil closure of a PDA in a patient with mild coarctation



Figure 23 Same patient as in figure 22. The deployment of a second coil completely eliminated the residual PDA

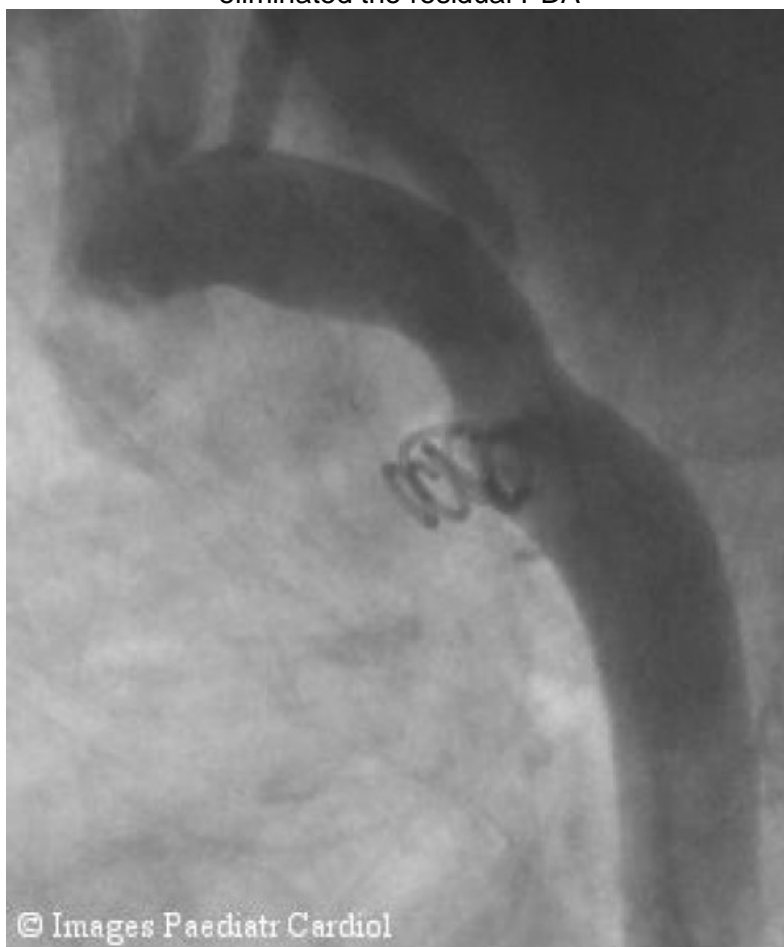
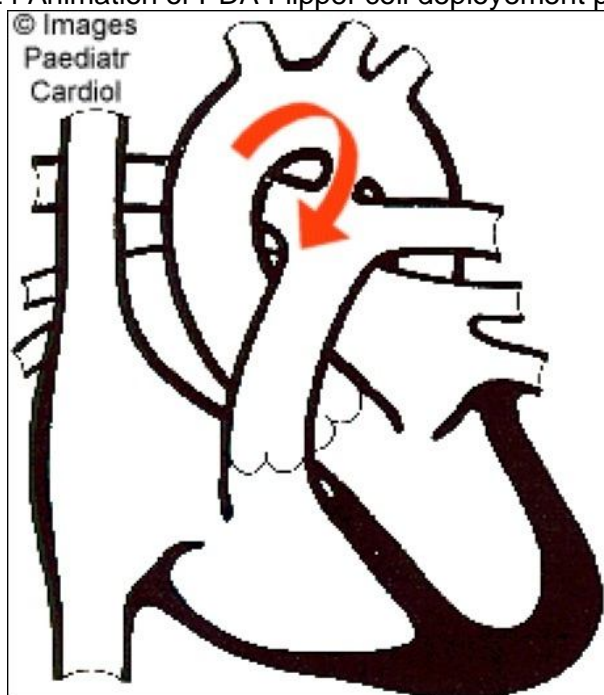


Figure 24 Animation of PDA Flipper coil deployment procedure



V Grech and JV DeGiovanni. Flipper coil closure of patent ductus arteriosus. *Images Paediatr Cardiol.* 2007 Apr-Jun; 9(2): 1–15.

Related link

<http://www.cookincorporated.com/products/embol/FMWCE.html>

References

1. Galal MO. Advantages and disadvantages of coils for transcatheter closure of patent ductus arteriosus. *J Interv Cardiol.* 2003;16:157–163.[PubMed: 12768920]
2. Cambier PA, Kirby WC, Wortham DC, Moore JW. Percutaneous closure of small (<2.5 mm) patent ductus arteriosus using coil embolization. *Am J Cardiol.* 1992;69:815–816.[PubMed: 1546662]

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