Mechanical Occlusion of the Patent Ductus Arteriosus with Jackson Coils

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Abstract. The effectiveness and safety of a protocol for transcatheter patent ductus arteriosus (PDA) closure was assessed. Our goal is complete mechanical occlusion of the PDA in the catheterization laboratory by adding coils until it is no longer possible to cross the PDA with a guidewire. Detachable coil closure of a PDA with a narrowest diameter of 2.4 ± 0.1 mm was attempted in 83 patients with a median age of 2.8 years (0.7 to 27.8 years) and whose median weight was 14.5 kg (6 to 61.6 kg). Coils were successfully implanted in 82 of 83 patients, and in 1 patient a large Rashkind double umbrella was used instead. Complete closure was obtained in 80 (97.6%) patients, 48 of those (59%) received more than one coil. Reintervention for residual shunting was required in only 1 patient and another patient has a trivial residual shunt. Device embolization occurred in three cases. Despite the use of multiple coils there was no evidence of significant left pulmonary artery stenosis. The fluoroscopy time increased from 14.0 ± 2.0 minutes for a single coil to 25.3 ± 2.9 minutes for multiple coils (p < 0.01). Attempting to obtain complete mechanical occlusion of the PDA during the implant procedure by adding extra coils reduces the need for reintervention for residual or recurrent shunting.

Key words: Patent ductus arteriosus — Transcatheter occlusion — Detachable coils

Coil closure of the persistent ductus arteriosus (PDA) is a cost-effective alternative to other methods of PDA closure [5] and is now a clinically accepted technique [2]. Embolization during the procedure and persistent shunting are the main problems of this technique [3]. Postprocedural shunting can be residual or recurrent [12]. The protocol for coil occlusion may influence the incidence of residual or recurrent shunting. Our protocol for PDA is to achieve mechanical occlusion during the procedure rather than relying on thrombosis to complete the occlusion. We defined mechanical occlusion as the inability to pass a 0.035-inch or 0.025-inch guidewire through the duct combined with the angiographic demonstration of complete occlusion or at most a trivial residual leak. We also aimed to reduce the incidence of coil embolization by using 8-mm-diameter detachable coils, if the narrowest diameter of the PDA was greater than 2.5 mm. To test the clinical usefulness of this protocol we assessed the rates of residual or recurrent shunting and incidence of embolization in all patients undergoing coil occlusion at our hospital.

Materials and Methods

We reviewed the hospital notes and cine angiograms of 86 procedures in 83 patients [median age = 2.8 years (0.7 to 27.8 years) and median weight = 14.5 kg (6 to 61.6 kg)] undergoing detachable coil occlusion of a PDA between September 1994 and December 1997. Patients who had coil occlusion for residual shunts following implantation of a Rashkind device were not included, but 2 patients who had undergone previous surgical ligation were included. Associated significant cardiac and medical conditions were: Down’s syndrome (n = 5), Scimitar syndrome (n = 1), ventricular septal defect (n = 3), bicuspid aortic valve (n = 1), previous Senning operation for simple transposition (n = 1), and developmental delay (n = 3). One patient had device closure of an atrial septal defect at the same procedure.

The lateral angiogram of the aorta was reviewed to measure the narrowest PDA diameter and morphology as described by Krichenko and coworkers [7]. The number of coils used along with their diameter and number of loops and method of delivery were recorded. The fluoroscopy time for each procedure was noted and the times for single and multiple coils were compared.

Protocol

The coil occlusion procedure was performed as described in a previous report [6]. Heparin (50 to 100 U/kg) was given after sheath insertion; this was dependent on operator preference. If the narrowest diameter of the PDA was less than 2.5 mm, a 5-mm-diameter modified Jackson detachable coil (William Cook, United Kingdom) was chosen initially. If the PDA was larger and the ampulla wide, an 8-mm coil was chosen as the first coil. The number of loops of the coil chosen depended on the depth of the ampulla; coils with more loops were used in patients with ducts with longer ampullas. Immediately after release of the first
coil, the duct–coil complex was probed with a guidewire. A further coil was implanted during the initial procedure if a 0.035-inch or 0.025-inch guidewire could be advanced through the duct–coil complex (Fig. 1). If this was not possible, and the postimplantation aortic angiogram showed only trivial residual shunting, then the procedure was terminated. Coils were implanted via the pulmonary artery unless the PDA had been noted to be very small on a preprocedure echocardiogram. In such patients a retrograde arterial technique was used exclusively. Both routes were used sequentially if it did not prove possible to cross a duct–coil complex anterogradely and more than trivial shunting remained.

Residual and Recurrent Shunts and Follow-up

A residual shunt was defined as a persistent shunt on all follow-up examinations, before spontaneous closure or reintervention. A recurrent shunt was defined as a shunt detected on reexamination if complete closure on echocardiography or angiography had been previously documented. Residual shunts were assessed a few minutes following coil implantation in the lateral and usually also the anteroposterior angiograms. A color-flow Doppler echocardiogram was performed the following morning to assess the presence of residual or recurrent shunts and to detect left pulmonary artery stenosis. Repeat color Doppler studies were performed at 1 to 3, 6, and 12 months and then annually. Reintervention was performed when shunting persisted for more than 6 months.

Statistical Methods

The age and weight of patients are reported as median and range. Fluoroscopy times, mean pulmonary artery pressure, pulse pressure, and narrowest PDA diameter are reported as mean value ± standard error. The prevalence of residual shunting and time to permanent complete closure were analyzed by the Kaplan–Meier product limit method. Actuarial estimates were reported with standard errors. Permanent complete closure was considered to have occurred when there was no residual shunting and if there were no further recurrences. Patients who underwent a second procedure were censored at the time of the second procedure. The effects of minimal PDA diameter and morphology, number and size of coils implanted, and administration of i.v. heparin on residual shunts were assessed by the log-rank test. Fluoroscopy times for single and multiple coils were compared by Welch’s t-test because of different variances. We set the threshold for statistical significance at $p < 0.05$.

Results

PDA Diameter and Type

The mean duct diameter was 2.4 ± 0.1 mm (median 2.0; 0.5 to 5 mm). The angiographic classification was as follows: type A in 61 (74%), type B in 5 (6%), type C in 10 (12%), type D in 2 (2%), and type E in 4 (5%).

Route

Forty-four patients had coils implanted through the pulmonary artery approach (53.6%) and 18 patients through the aortic route (21.9%), whereas the rest of the patients (20) had sequential pulmonary followed by aortic route for multiple coils (24.3%).

Fig. 1. Lateral aortogram cine frames in patient No. 33. (A) A conical type A PDA measuring 3 mm at its narrowest end is shown. (B) An 8-mm × three-loop coil was deployed first and an 0.035-inch guidewire could be passed across the duct–coil complex and another 5-mm × three-loop coil was implanted. Complete occlusion was achieved as shown by aortogram.