Transcatheter closure of patent ductus arteriosus with the Rashkind occluder

Acute results and angiographic follow-up in adults


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We performed catheter closure of a patent ductus arteriosus with a Rashkind occluder in 51 adult patients (aged 14 to 76 years). The diameter of the ductus ranged from 2 to 13 mm (mean 4.5 ± 2.0 mm), \( Q_{\text{p}}:Q_{\text{s}} \) from 1.0 to 2.6 (mean 1.6 ± 0.3).

The procedure was successful in 50/51 patients, in one of them at a second attempt. In one patient, the ductus could not be closed even with additional occluders. This patient was sent for surgery. In two patients with a large ductus, two Rashkind umbrellas were implanted simultaneously. Immediately after ductus closure, there was a residual shunt in 40/50 patients decreasing to 26/50 after 20 min. Two of the patients with a residual shunt suffered from haemolysis.

In 15 patients, additional occluders (a second occluder in 12, a third occluder in one, and a fourth and fifth occluder in another) were implanted during the initial procedure or during follow-up. All patients were followed until angiography proved complete closure of the ductus. At the time of the last follow-up angiogram, the ductus was occluded in 49/50 patients; one patient refused a follow-up angiogram.

Ductus occlusion with the Rashkind umbrella can be considered a technique with a high success rate and low rate of complications in adults. However, a residual shunt is not uncommon. Additional occluders have to be implanted in many patients.

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Key Words: PDA, patent ductus arteriosus, Rashkind occluder, duct occlusion, residual shunt, adults.

Introduction

In 1967, Porstmann published a description of the first catheter closure of a persistent ductus arteriosus with a plug made of Ivalon\(^1\). Several other techniques using coils, umbrellas, balloons and other devices have been described. The umbrella device developed by Rashkind\(^2\) has become widely accepted as the method of choice. However, there are some concerns regarding the incidence of residual shunts and experience in adults is limited. This is a report on the acute and long-term results with angiographic follow-up of ductus closure in 51 adults.

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Methods

Between 1990 and 1995, transcatheter closure of a ductus was performed in 51 patients. All patients had given their informed consent. There were 14 male and 37 female patients whose ages ranged from 14 to 76 years. The clinical status was NYHA I in 30, NYHA II in 10, NYHA III in nine and NYHA IV in one patient. Two patients were 14 and one patient 20 years old. Forty-eight patients were older than 20 years, 32 older than 30 years, 30 older than 40 years, 19 older than 50 years, eight older than 60 years and two older than 70 years (Fig. 1).

Surgical closure of the ductus had been performed 24 years earlier in one patient. In 11 patients, the ductus was calcified. The diameter of the ductus ranged from 2 to 13 mm, mean 4.5 ± 2.0 mm (Fig. 2). Left to right shunt (expressed as \( Q_{\text{p}}:Q_{\text{s}} \)) ranged from 1 to 2.6, mean 1.6 ± 0.3. The pulmonary arterial pressure (mean 32 ± 13/15 ± 6) was normal in 31 and elevated (\( PA_{\text{sys}} \geq 30 \text{ mmHg} \)) in 20 patients. It ranged from 20/14
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Figure 1  Age distribution.

to 70/35 mmHg, mean 32 ± 13/15 ± 6 mmHg. One patient had undergone surgical closure of an atrial septal defect one year earlier, the persistent ductus not being diagnosed.

Following local anaesthesia, the right or left femoral vein was punctured and the pulmonary artery entered. Pressures were recorded and a left to right shunt was calculated by oximetry. The ductus was entered with a wire and a standard catheter. The diameter of the ductus was measured with a low pressure balloon catheter[9]. No heparin was given. An 11F-long sheath was advanced through the ductus into the aorta. To facilitate this, the introducer sheath or the introducing wire had to be caught and pulled with a snare wire introduced from the arterial side in some patients. A 17 mm Rashkind occluder (Bard/USCI) was introduced and implanted as described elsewhere[2,4,5]. In two patients with a very large ductus, two occluders were implanted simultaneously during the initial procedure[6]. Two sheaths were introduced via the right and left femoral vein, respectively. The distal umbrellas of both devices were opened in the aorta. Both sheaths were retracted simultaneously until the devices fitted into the ductus. Thereafter, the proximal umbrellas were opened simultaneously. Correct position of the occluder (or the two occluders) was confirmed by X-ray and aortography. In case of a residual shunt, a second aortography was performed 20 min later.

Follow-up catheterization was performed after 3 to 6 months. If a persistent shunt was found, additional control angiograms were performed until complete closure of the ductus was confirmed.

Results

In one patient, a first umbrella could not be implanted correctly and had to be removed. The umbrella was still connected to the delivery catheter. It could be pulled to the femoral vein where it had to be removed by surgery. The ductus was occluded with a second device the following day. In one patient, the ductus could not be closed even with additional occluders. This patient was

Figure 2  Diameter of patent ductus arteriosus.
Immediately after device implantation, 40/50 (80%) patients had a residual shunt. In all patients, a control angiogram was performed 20 min later. The percentage of patients with a residual shunt decreased to 52%. Depending on the size of the residual shunt after implantation of the first occluder, additional occluders were implanted immediately (n=3), within 24 h using the same sheath (haemolysis, n=2) or at the time of angiographic follow-up after 3 months (n=3), 6 months (n=4), 1 year (n=2) or 3 years (n=1).

Consequently, the first procedure (n=51) was successful in 49 patients. Forty-four of these 49 patients received only one occluder, four received two and one five occluders during this initial procedure or within 24 h using the same sheath. In 10 patients, a second procedure was performed. The indication for this second procedure was failure of the first attempt in one patient and a residual shunt at the time of follow-up in nine patients. In all of these nine patients, a second occluder was implanted successfully. In one patient a third procedure (implantation of a third occluder) was performed 3 years after the first procedure because of a residual shunt.

The residual shunt had disappeared spontaneously after 3 months in seven patients, after 6 months in six patients, after 1 year in one patient and after 3 years in one patient. Including those patients who received additional occluders during the initial procedure, 12 patients received a second, one patient a third and one patient a fourth and fifth occluder. In 13 patients, implantation of additional occluders was performed because of a persisting shunt, in two patients because of a persisting shunt and haemolysis. Implantation of additional occluders was possible without complications in all patients. However, in one patient implantation of the second occluder was only possible after dilatation with a 4 mm balloon catheter. In one of the patients with additional occluders, a 12 mm umbrella was used instead of the 17 mm umbrella. Including those patients with additional occluders, the percentage of patients with a residual shunt decreased from 52% at the end of the initial procedure to 30% after 3 months, 10% after 6 months, 8% after 1 year and 2% after 3 years (Fig. 3). Only one out of 50 patients still has a residual shunt. The referring physicians refused implantation of additional devices because the residual shunt was small and not haemodynamically relevant.

Left to right shunt (Qp/Qs) decreased from 1.6 ± 0.3 before ductus closure to 1.01 ± 0.05 at the time of the last follow-up catheterization. Pulmonary artery pressure decreased from 32 ± 13/15 ± 6 to 25 ± 6/11 ± 4 mmHg. No late complications occurred during follow-up over 11 to 71 (mean 52 ± 17) months.

**Discussion**

The rationale for closing a patent ductus arteriosus is in order to prevent left heart failure or pulmonary hypertension. If the ductus is small, there is a risk of infective endocarditis. Surgical closure is a procedure with a very low rate of complication in children. However, shunting occasionally recurs after surgery. In adult patients, surgical closure may be difficult due to calcification of the ductus.
Favourable results have been reported for ductus closure with the Ivalon plug developed by Porstmann. After successful implantation of the plug, a residual shunt is extremely uncommon\cite{1,7-11}. The disadvantage of this technique is that the plug has to be introduced from the arterial side. The diameter of the introducer sheath must be comparable with the diameter of the ductus. This technique therefore cannot be applied if the diameter of the ductus exceeds the diameter of the femoral artery\cite{41}. In many patients, the technique is applicable only after surgical exposure of the femoral artery.

Occlusion of a patent ductus arteriosus can also be accomplished with coils\cite{12,13}. In a multicentre registry, 523 ducts were occluded\cite{12}. However, median ductus diameter was only 2.0 mm. The authors reported embolization of coils to the pulmonary artery in 65 patients and systemic coil embolization in 14 patients. Usually, these coils could be retrieved by catheter techniques. The overall success rate was 95%. However, there was a residual shunt in 20%.

The buttoned device developed by Sideris for atrial septal defect closure has been modified for ductus closure. The results of a multicentre registry have been reported by Lochan et al.\cite{19}. Eighty-one patients have been treated. Their age ranged from 1 to 65 years, median 7 years. The ductus diameter varied from 1 to 15 mm, median 4 mm. The authors reported dislodgement of the device in three patients. These devices could be retrieved by catheter techniques. The procedure failed in one patient. The ductus was completely occluded in 49/81 patients after the initial procedure. There was a residual shunt in 31/81 patients initially. The percentage of patients with a residual shunt decreased over time.

Several other devices such as balloons\cite{15,16,18}, the persistent ductus arteriosus occlusion device (PADOs)\cite{17,18} the Clamshell device\cite{19} the Botallo occluder\cite{20} and the Gianturco-Griñal vascular occlusion device (GGVOD)\cite{21} have been developed or modified for ductus closure. Experience with these devices is still limited.

The Rashkind technique\cite{2,4,5} is widely considered as the first line treatment for patent ductus. The occluder can be introduced from the venous side. Most of the reports in the literature mainly concern children\cite{2,3,22-27}, experience in adults is limited\cite{28-30}. Our results demonstrate that ductus closure in adults is also possible with a very low rate of complications.

There are some concerns regarding residual shunts after ductus closure with this technique. This has been documented in 20% to 40% of patients\cite{5,31}. In rare cases, these shunts cause haemolysis\cite{32}. Usually, these shunts are small and not haemodynamically relevant. More recently, we implanted two occluders simultaneously in a large ductus to avoid a residual shunt\cite{40}. In many patients, it is not the amount of shunting but the risk of endocarditis which is the indication for ductus closure. In these cases, a residual shunt seems inappropriate. In accordance with the results of others\cite{20}, we observed spontaneous closure of residual shunting in many patients. However, spontaneous closure is unlikely in patients with a large residual shunt and in patients with a persistent shunt after several months.

Residual shunts after ductus closure with the Rashkind umbrella may be closed by coil embolization\cite{33}. We preferred to implant a second\cite{5,31} or if necessary even more Rashkind occluders. Our results demonstrate that these residual shunts can be occluded with a very high success rate and low rate of complications using this technique. Nevertheless, the need for additional occluders is a disadvantage of this method. For this reason, we developed a new technique combining the advantages of the Porstmann and Rashkind techniques. A multicentre study with this device has been initiated\cite{34}.

References


