Interventional occlusion of congenital vascular malformations

Chun-Hong Xie, Cheng-Sen Xia, Fang-Qi Gong, Yin-Bao Zhou, Wei-Hua Zhu

Hangzhou, China

Background: **New materials and devices have been used in the management of cardiac malformations. In this paper, we present our experience with interventional occlusion of congenital vascular malformations.**

Methods: **Between January 1997 and December 2005, 139 patients with congenital vascular malformations who had undergone interventional occlusion in the Children's Hospital, Zhejiang University School of Medicine were studied. The clinical data of the patients were retrospectively reviewed including pre-operative evaluation, surgical procedures, immediate complete closure rate, short-term complications, and short-term outcome.**

Results: **Of the 139 patients, 126 had patent ductus arteriosus, and successful deployment was achieved in 121 of the 126 patients (96%, 121/126). Six patients had coronary artery fistula and 14 different coils were used for embolization; the immediate complete closure rate was 83.3%, and the complete closure rate after one month was 100%. The abnormal vessels of 3 patients with pulmonary sequestration were completely occluded using four 0.038-inch Gianturco coils. In 3 patients with aortopulmonary collaterals, 14 abnormal vessel branches were occluded with sixteen 0.038-inch Gianturco coils, reaching a closure rate of 100%. One patient with pulmonary arteriovenous fistula was occluded successfully with two 0.038-inch Gianturco coils.**

Conclusions: **Transcatheter closure using coils is a safe and effective alternative to surgical ligation in the management of congenital vascular malformations in children. Selection of appropriate coils is important to achieve a better outcome.**

Author Affiliations: Department of Cardiology, Children's Hospital, Zhejiang University School of Medicine, China (Xie CH, Xia CS, Gong FQ, Zhou YB, Zhu WH)

Corresponding Author: Chun-Hong Xie, Department of Cardiology, Children's Hospital, Zhejiang University School of Medicine, 57 Zhugan Xiang, Hangzhou 310003, China (Tel: 86-571-88380526; Email: xch_hz@hotmail.com)

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Introduction

Interventional management of congenital vascular malformations is one of the fastest growing fields in clinical medicine in the last 20 years. New materials and devices have been used for treatment of different kinds of cardiac malformations.[1-8] An increasing number of interventional techniques are being introduced in children's hospitals in China and more parents prefer interventional management for treatment of their children with vascular malformations.

Interventional closure of pathological vascular communications can be achieved by coil embolization. In this retrospective study, we present our experience in dealing with congenital vascular malformations using coils in children at the Cardiology Department of our hospital in the period of January 1997 to December 2005.

Methods

Patients

Altogether 139 children who had undergone interventional occlusion for the treatment of congenital vascular malformations in the Children's Hospital, Zhejiang University School of Medicine were studied. Clinical records of the patients were retrospectively reviewed for the following items: pre-operative evaluation, surgical procedures, immediate complete closure rate, short-term complications, and short-term outcome. The pre-operative evaluation included the results of electrocardiography, chest X-ray, transthoracic echocardiography, and selective angiography. Data were reviewed by an interventional cardiologist to verify the technical feasibility of intervention therapy as well as by an independent cardiologist. Patients were selected

for device closure if they had the congenital vascular anomaly that was ascertained to result in sufficient hemodynamic derangement to warrant intervention.[9]

Procedures

From January 1997 to December 1998, we used 0.038-inch Gianturco coils in patients; since 1999, we used 0.038-inch detachable coils and 0.052-inch Gianturco coils. The coils were selected according to the appearance of the duct on either echocardiography or angiography. 0.038-inch Gianturco coils were used for ducts with a minimum diameter below 2.5 mm but 0.052-inch Gianturco coils were used for ducts with a diameter greater than 2.5 mm. In patients with other vascular malformations such as pulmonary arteriovenous fistula, coronary artery fistula, pulmonary sequestration, and aortopulmonary collaterals, 0.038-inch detachable and/or Gianturco coils were used.

Percutaneous entry was chosen and a complete right and left heart catheterization was performed to identify hemodynamics, but right heart catheterization was not performed in some patients with isolated patent ductus arteriosus (PDA). Selective ventriculography or angiography was performed to identify pathoanatomical characteristics.

For the PDA using 0.038-inch coils, the coils were deployed retrogradely with a 4-5 Fr multipurpose catheter (Cook, USA) or right Judkins coronary catheter (Cook, USA) for the control of delivery as reported by Rosenthal et al.[10] A 4-5 Fr multipurpose catheter or right Judking coronary catheter was inserted from the right femoral artery. The catheter retrograded to the pulmonary artery from the descending aorta through the ductus arteriosus. A coil was advanced into the catheter until 2/3-1 loop extruding out of the catheter tip. Then the catheter and the wire system were withdrawn until the coil loop reached pulmonary arterial orifice. The delivery guide wire was fixed and the catheter was subsequently withdrawn so that the remaining coil was deployed in the ampulla of the ductus arteriosus. The coil was released at last. Repeated aorta angiography was performed after the coil was released for 10 minutes. If there was a significant residual shunt, second or more coils were deployed using the same method.

For the PDA using 0.052-inch Gianturco coils, the procedure was performed as described previously.[11-13] Briefly, the ball-point end of the coil was grasped by a 4-Fr endomyocardial biotope and the coil was advanced to the descending aorta from the pulmonary artery through the PDA. After 2-3 loops were released, the coil was withdrawn to the ductal ampulla and the remainder of the 2/3 to 1 loop of the coil was implanted into the end of the pulmonary artery retrogradely. Repeated aorta angiography was performed to observe the coil's position. If in the right position, the biotope was opened and the coil was released. If there was a significant shunt, another coil was placed.

In vascular embolization, a coil with a diameter approximately 30% larger than the abnormal blood vessel or orificium fistula was used in closure of coronary artery fistula, pulmonary arteriovenous fistula, pulmonary sequestration, and aortopulmonary collaterals. A multipurpose catheter or a Judkins right coronary catheter was inserted into the abnormal blood vessel and the catheter was pushed toward the distal end of the blood vessel as far as possible. Then a 0.038-inch Gianturco coil was pushed slowly toward the target vessel by the stiff end of a long steel wire. Coronary artery fistula or pulmonary arteriovenous fistula was closed firstly by a detachable coil. The delivery wire was pushed toward the orificium fistula as far as possible. If the position was good, the coil was released. A second 0.038-inch Gianturco coil was implanted if repeated angiography showed a residual shunt.

Results

The patients in this series were aged 0.5 to 16 years (mean, 3.4 years) and weighted 6.0-58 kg (mean, 13.4 kg). These patients were followed up for 7 months on average with a range from 1 to 18 months.

Of the 139 patients, 126 had PDA. Six 0.038-inch Gianturco coils were used in 6 patients, 139 0.038-inch detachable coils were used in 109 patients, eleven 0.052-inch Gianturco coil and 1 detachable coil were used in the remaining 11 patients with medium-sized PDA (2.5-5.0 mm in diameter) (Table 1). Before embolization, 4 patients had residual shunt after PDA surgery, 1 had PDA complicated with ventricular septal defect, 4 complicated with coarctation of aorta, and 5 complicated with pulmonary valve stenosis. Implantation was successful in 121 of the 126 patients, reaching a successful deploy rate of 96% (121/126). The failed deployment in the other 5 patients were due to the migration of the coils into the right pulmonary artery and the patients were subjected to surgery for removal of the coil as well as ligation of PDA. Three of the 5 failed cases occurred in the early period (1997-1998) when the technique was initially introduced into the hospital. Hemolysis as the most common post-operative complication appeared in 4 patients after 4-10 hours of PDA closure using the 0.038-inch detachable coils (Table 2). Postoperative transthoracic echocardiography showed a tiny residual shunt in 16 patients with PDA. The immediate complete closure rate was 87.6% (106/121) and the complete closure rate after one year

Table 1. Distribution of different kinds of diseases using various coil embolization

Diseases	Patient (*n*)	Coils (*n*)
Patent ductus arteriosus	6	0.038 GC (6)
(*n*=126)	109	0.038 DC (139)
	11	0.052 GC (11) + 0.038 DC (1)
Coronary artery fistula	6	0.038 GC (8) + 0.038 DC (6)
Pulmonary sequestration	3	0.038 GC (4)
Aortopulmonary collaterals	3	0.038 GC (16)
Pulmonary arteriovenous fistula	1	0.038 GC (1) + 0.038 DC (1)

GC: Gianturco coil; DC: detachable coil.

Table 2. The outcome of the patent ductus arteriosus patients

n	Coils	Successful deploy	Failed deploy*	Complications
6	0.038 GC	3	3	None
109	0.038 DC	108	1	Hemolysis in 4
11	0.052 GC	10	1	None

*: failed deploy due to removal of the coils into the right pulmonary artery. GC: Gianturco coil; DC: detachable coil.

was 99.2% (120/121). One patient had a tiny residual shunt on follow-up after one year.

For coronary artery fistula, 6 patients were implanted with 14 coils of different size. The ventilator was removed successfully on the second day after embolization in 2 patients who depended on a breathing machine due to pulmonary edema and pneumorrhagia after surgery. The immediate complete closure rate of these patients was 83.3% (5/6), and the complete closure rate after one month was 100%. The abnormal vessels of 3 patients with pulmonary sequestration were completely occluded using four 0.038-inch Gianturco coils. Symptoms such as hemolysis and infections were controlled after the operation. The immediate complete closure rate was 100% at 10 minutes after implantation. In the 3 patients with aortopulmonary collaterals, 14 abnormal vessel branches were occluded by sixteen 0.038-inch Gianturco coils. Pulmonary edema and pneumonorrhagia disappeared after embolization on the 7th day after catheterization. Pulmonary arteriovenous fistula in one patient was occluded using two 0.038-inch Gianturco coils successfully and arterial oxygen saturation increased from 76% to 92% after intervention. All patients showed clinically improvement after closure of the abnormal vessels during the follow-up.

Discussion

Gianturco et al[14] firstly used a steel embolization coil to occlude abnormal vessel structure in 1975. Since its outcome is satisfactory with low complications, this technique has been accepted in the treatment of congenital vascular diseases in the past decades.[12,15-17] In 1992 Cambier et al[18] used coils in transcatheter embolization of PDA. Thereafter coils have been designed to make the occlusion technique simpler so as to decrease the rate of complications.

Transcatheter occlusion using coils has been introduced into our hospital since 1997. In the period of 1997-1998, the complication rate was relatively high because of limited experience. From 1999, we used 0.038-inch detachable coil and 0.052-inch Gianturco coil to occlude PDA. No hemolysis occurred post-intervention in recent years with the accumulation of experience in coil selection.

Coil selection is of utmost importance to achieve a complete occlusion. We commonly used a coil with a diameter 2 times larger than the narrowest portion of PDA in its transcatheter embolization. It is most suitable to use coil embolization if the narrowest diameter of PDA is less than 0.25 cm. If the narrowest diameter is between 0.25-0.40 cm, more than 2 coils or larger diameter coils are needed. In recent years, 0.052-inch Gianturco coils have been used to occlude relatively larger PDA (larger than 0.25 cm). 0.052-inch Gianturco coils have more dacron fibers than other coils and they are easily twisted. Thus this kind of coils can be placed uneventfully without migration and procedural time was shorter than reported.[19] The placement of the 0.052-inch Gianturco coil in the medium-sized PDA will improve the outcome and reduce the cost. For the large-sized PDA (larger than 0.40 cm), we currently use the Amplatzer duct occluder and the outcome is still under evaluation.

Collateral vessels, which originate from the descending aorta to the pulmonary artery, should be occluded after one-stage operation. Otherwise, increased pulmonary volume of circulation can result in pulmonary edema, pneumorrhagia and even death. A coil with a diameter approximately 30% larger than the abnormal blood vessel can be used in closure of coronary artery fistula, pulmonary arteriovenous fistula, pulmonary sequestration, and aortopulmonary collaterals. At this situation, it is the best to use coils to occlude the collateral vessels.

Transcatheter coil embolization of coronary artery fistula, pulmonary sequestration and pulmonary arteriovenous fistula is feasible, and it is the only treatment in some cases. Coronary artery fistulae of 6 patients in this series were occluded using detachable coils and Gianturco coils, saving the time of balloon measurment and reducing the cost. Other patients were clinically improved after closure of their abnormal vessels. Episodes of infection were reduced and oxygen saturation was improved in these patients after catherterization compared to that before catherterization. The immediate complete closure rate in our series was

similar to that of 44 patients with 61 abnormal vascular connections reported by Prieto et al.[20]

In conclusion, selection of appropriate coils is very important to achieve a better outcome. Transcatheter closure using coils is a safe and effective alternative to surgical ligation in the management of congenital vascular malformations especially PDA in children.

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