

Percutaneous Treatment of Atrial Septal Defects, Muscular Ventricular Septal Defects and Patent Ductus Arteriosus in Infants Under One Year of Age

Fredy Prada, Carlos Mortera, Joaquim Bartrons, Miguel Rissech, Lorenzo Jiménez, Juan Carretero, Judit Llevadias, and Mireya Araica

Servicio de Cardiología, Hospital Sant Joan de Déu, Esplugues de Llobregat, Barcelona, Spain

Amplatzer devices are used for the percutaneous closure of ostium secundum atrial septal defects, muscular ventricular septal defects, and patent ductus arteriosus. However, very little experience has been gained in using these devices in infants under 1 year of age. Between January 2001 and January 2008, 22 symptomatic infants aged under 1 year underwent percutaneous treatment: three had an ostium secundum atrial septal defect, 15 had patent ductus arteriosus, and 4 had a muscular ventricular septal defect. All the procedures were completed successfully. No immediate or medium-term complications were observed. Closure of these types of defect using an Amplatzer device in infants under 1 year of age, who would otherwise require surgery, is a safe and effective procedure.

Key words: Atrial septal defect. Ventricular septal defect. Ductus arteriosus. Cardiac catheterization.

Tratamiento percutáneo de la comunicación interauricular, la comunicación interventricular muscular y el ductus arterioso permeable en niños menores de un año

Los dispositivos Amplatzer se utilizan en el tratamiento percutáneo de la comunicación interauricular ostium secundum (CIA-OS), el ductus arterioso persistente (PDA) y la comunicación interventricular muscular (CIV-m). Hay muy poca experiencia con estos dispositivos en niños menores de 1 año. Entre enero de 2001 y enero de 2008 se trató a 22 niños menores de 1 año sintomáticos; 3 tenían CIA-OS; 15, PDA, y 4, CIV-m. Todos los procedimientos fueron exitosos. No observamos complicaciones inmediatas o a medio plazo. El cierre percutáneo de estos defectos con dispositivos Amplatzer es una técnica eficaz y segura en niños menores de 1 año sintomáticos que de otro modo requerirían cirugía.

Palabras clave: Comunicación interauricular. Comunicación interventricular. Ductus arterioso. Cateterismo cardiaco.

INTRODUCTION

Amplatzer devices are used in the percutaneous closure of ostium secundum atrial septal defects (OS-ASD),¹ patent ductus arteriosus (PDA),² and muscular ventricular septal defects (m-VSD).³ They are safe and entail little risk and this has led to their widespread use in adult and pediatric patients, but little is known of their use, effectiveness and safety in patients aged <1 year.^{4,5}

Correspondence: Dr. F. Prada.
Servicio de Cardiología. Hospital Sant Joan de Déu.
Pg. Sant Joan de Déu, 2. 08950 Esplugues de Llobregat. Barcelona.
España.
E-mail: fprada@hsjdbcn.org

Received July 26, 2008.
Accepted for publication December 12, 2008.

METHODS

We conducted a retrospective review of children aged <1 year diagnosed with OS-ASD, PDA, or m-VSD, who underwent percutaneous closure procedures in our hospital between January 2001 and January 2008. We did not treat children with perimembranous VSD because these devices entail a risk of complete atrioventricular block, as recently confirmed for $\leq 5\%$ of patients.⁶

For each defect type, we used the techniques described in the literature for older children and adults.^{1-3,7} In all patients, we used general anesthesia; in patients with OS-ASD or m-VSD we also used transesophageal echocardiography.

The Fick method was used to calculate the Qp/Qs. We chose an appropriate device according to the defect diameter; in patients with OS-ASD, a sizing balloon was used to establish the stretched

diameter of the OS-ASD, in ductus arteriosus, we measured at the pulmonary end in lateral aortic angiography; in m-VSD, diameter was estimated using echocardiography and/or the ventriculography in the left oblique projection. We employed nitinol-filament, self-expanding Amplatzer devices (AGA Medical Corporation, Golden Valley, Minnesota, USA) that have thermal memory and can be deployed in a controlled manner.

We recorded demographic, clinical and hemodynamic data, procedure duration recorded as radioscopy time, results, and immediate and late complications. Data are expressed as mean (range).

RESULTS

We treated 22 children aged <1 year with symptoms of OS-ASD, PDA or m-VSD (Table 1). Clinical indications, hemodynamic variables (Qp/Qs and AP/AO systolic pressure ratio), defect diameter and devices employed are in Table 2.

Radioscopy times for OS-ASD, PDA and m-VSD were 23.7 (13-40), 21.5 (6-60), and 44 (34-57) min, respectively.

All procedures were successful. We had no acute or late complications during follow-up of 18.7 (5.5-38.3), 34 (5.7-90.9), and 44.1 (20-65.2) months for OS-ASD, PDA, or m-VSD respectively.

TABLE 1. Demographic Characteristics

Defect	No.	Boys/Girls	Age, Months	Weight, kg
OS-ASD	3	0/3	8 (3.2-11.3)	6.6 (4.9-8.8)
PDA	15	7/8	6.6 (1.9-11.1)	6.7 (3.7-8.9)
m-VSD	4	1/3	6.1 (4.8-8.6)	5.6 (4.4-6.9)

m-VSD indicates muscular ventricular septal defect. Age and weight expressed as mean (range).

We observed no peripheral vascular complications attributable to surgery or administration of heparin and/or thrombolytic agents.

DISCUSSION

Atrial Septal Defects

Most children with OS-ASD have few symptoms and surgery is generally indicated at pre-school age,⁸ although some require earlier treatment. It is reported that OS-ASD tend to grow with time.⁹ The group of children susceptible to early treatment includes those at greatest risk of progressing to irreversible pulmonary hypertension.¹⁰ For example, patient 1, with Down's syndrome, presented severe pulmonary hypertension with AP/AO ratio=1. His pulmonary pressure was normal at 1 year post-procedure. In patient 2, repeated respiratory

TABLE 2. Clinical Indication, Hemodynamic, Defect, and Device Type Variables

Defect Type	Patient	Indication	Age, Months	Weight, kg	AP/AO Ratio	Qp/Qs	Defect/Device Diameter, mm
OS-ASD	1	PHT, FTT	3.2	4.9	1	1.3	8/8 (AS: 24)
	2	RRI, FTT	9.5	6.1	0.33	3.2	12/13 (AS: NA)
	3	PHT, RRI, CAVB	11.3	8.8	0.73	1.5	11/13 (AS: 31)
PDA	4	PHT	1.9	3.7	1.15	NA	1.6/5×4
	5	HF	2.6	5.1	0.67	7.8	2.5/6×4
	6	HF, RRI	2.7	5.4	0.5	2.9	1.9/5×4
	7	RRI	3.5	6	0.73	3	3/6×4
	8	RRI	4	6.2	0.4	10.2	3.2/6×4
	9	RRI	5.6	7.1	0.44	1.6	3.5/8×6
	10	RRI, FTT	6.5	7	0.35	1.5	2.5/5×4
	11	RRI	7.2	7.4	0.38	2.8	4/6×4
	12	RRI	7.6	7.4	0.47	4.1	2.6/5×4
	13	FTT, CAVB	7.6	6.1	0.38	2.5	2.5/5×4
	14	RRI	8.9	8.9	0.69	4	4/8×6
	15	GF	9.6	6.2	0.33	2.7	3/6×4
	16	RRI	9.7	7.8	0.47	1.4	2.5/6×4
	17	RRI, FTT	11	7.6	0.3	3	2/6×4
18	RRI, FTT	11.1	8.4	0.5	1.5	2.3/6×4	
m-VSD	19	HF	4.8	5.1	0.49	3.6	6/8
	20	HF	5.1	4.4	0.8	11.5	8/10
	21	HF	5.9	5.8	0.93	5.6	9/10
	22	*	8.6	6.9	NA	NA	5/6

AP/AO ratio indicates pulmonary artery to aorta systolic pressure ratio; AS: length of interatrial septum; CAVB, congenital complete atrioventricular block; FTT: failure to thrive; HF, heart failure; IAW, interatrial; NA, not available; PHT, pulmonary hypertension; RRI, repeated respiratory infections.

*Girl with truncus arteriosus and additional muscular VSD.

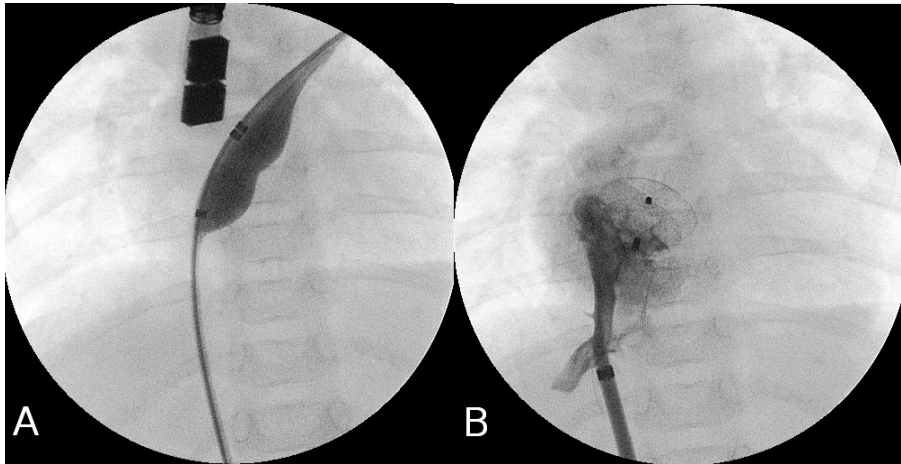


Figure 1. Closure of ostium secundum atrial septal defects (OS-ASD) (patient 3). A: OS-ASD closure with cutting-balloon. B: angiography via previously-deployed 7 Fr sheath, 13 mm device.

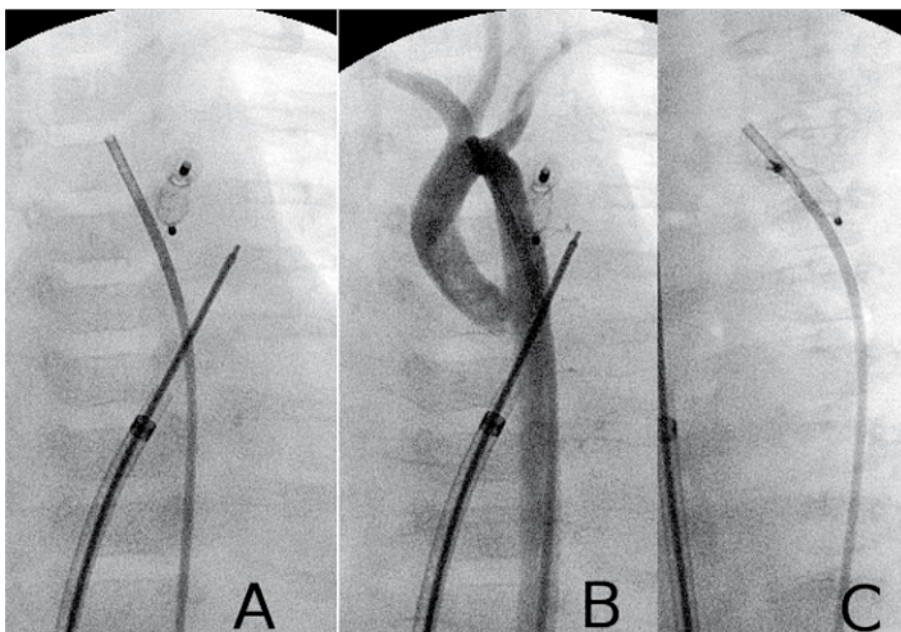


Figure 2. Closure of patent ductus arteriosus (PDA) (patient 4). A and B: device deployed; aortic angiography in posteroanterior projection with and without contrast. C: left oblique projection; note the parallel paths of the occluded ductus and the aorta.

infections, failure to thrive or high Qp/Qs indicated the treatment. Patient 3 (Figure 1), with congenital complete atrioventricular block without indication for pacemaker, had moderate pulmonary hypertension with AP/AO systolic pressure ratio =0.73 during cardiac catheterization. At 6 months, echocardiography showed normal pulmonary pressure. These 3 patients had specific indications for OS-ASD closure and we opted for percutaneous treatment to avoid the inconveniences of surgery. In the only series published in this age-group, OS-ASD required closure with hybrid procedures in 21% of children⁴; although our group is small, we have not needed to employ this technique.

During follow-up (mean, 18.7 months), we found no late atrial wall perforation. A review¹¹ of this rare complication found it occurs ≤ 3 years post-procedure. Patient age or weight were not

risk factors. Both mismatching defect and device diameters and anterosuperior defect location have been suggested as risk factors for late of perforation.¹²

Persistent Ductus Arteriosus

PDA closure was indicated in all four patients because of excessive pulmonary blood flow. In patients 5 and 8, Qp/Qs may have been overestimated due to incorrect blood sampling in the pulmonary artery; however, PDA diameters were 2.5 and 3.2 mm respectively. Patient 4 (Figure 2) was a 40 days old infant girl, with a non-obstructive total abnormal pulmonary veins drainage into coronary sinus and superior vena cava. During cardiac catheterization we found suprasystemic pulmonary hypertension (AP/AO systolic pressure ratio =1.15) and 1.6 mm

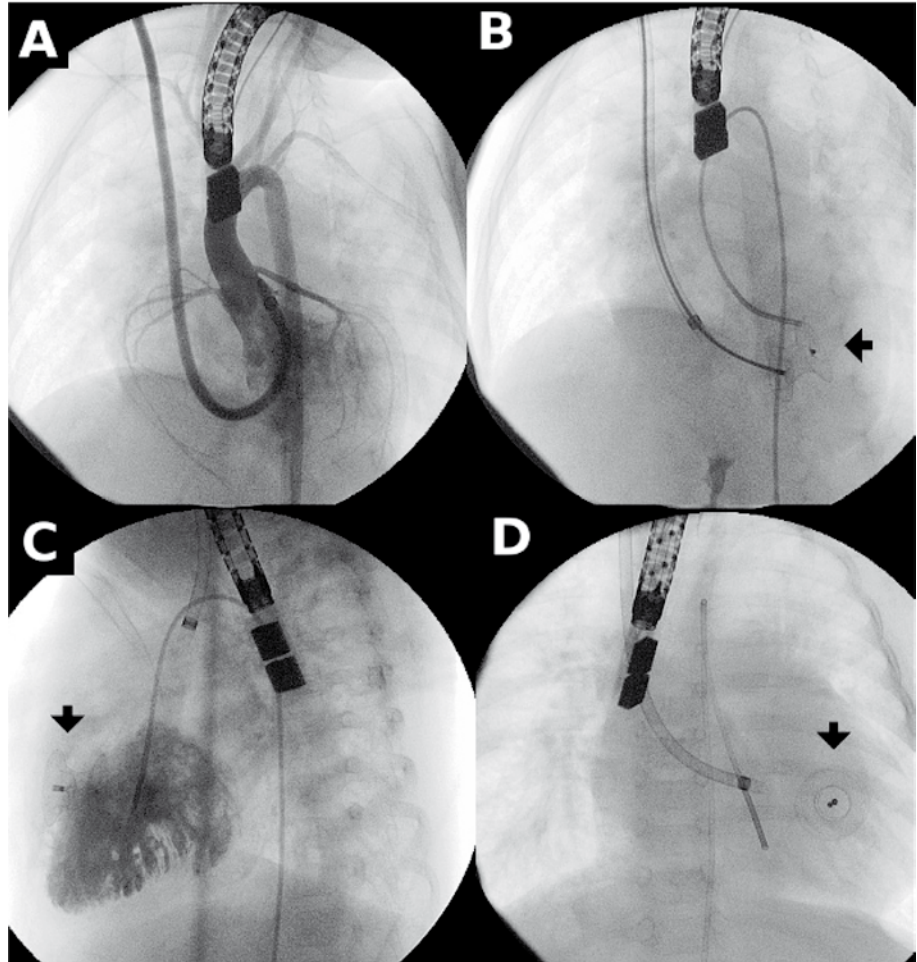


Figure 3. Closure of muscular ventricular septal defect (m-VSD). A: angiography with 6 Fr Mullins sheath, jugular access. A, B, and C: the arrow points to the device before and after deployment.

patent ductus arteriosus; she presented clear clinical improvement following percutaneous duct closure and was operated days later; she evolved well and subsequent examinations showed normalization of pulmonary pressure. In this patient, we decided to use the ductal occluder although the muscular VSD device is considered preferable due to the risk of embolization caused by severe pulmonary hypertension. Despite this, we opted for the ductal occluder because its retention disc is smaller (5 vs 9 mm).

Our results in 15 children aged <1 year are similar to those published by Butera et al¹³ who reported successful closure in 18 children aged <3 years with PDA treated with the same device.

We have found no aortic obstruction similar to that described in a girl of 2 years who required surgery to remove the device.¹⁴ We avoided this complication by using the smallest possible device and also by measuring gradients in the aorta before Amplatzer deployment. During follow-up we found no obstruction in the aortic arch or left pulmonary branch, potential complications given these children were so small. We had no using local vascular complications, despite using sheaths

as large as 7 Fr Mullins sheaths in the femoral vein (patients 9 and 14).

Muscular Ventricular Septal Defects

In a series of 20 children aged <1 year, Diab et al⁵ reported 30% needed a hybrid procedure. In our 4-patient series, none required this. Patient 22, a girl with type I truncus arteriosus, double VSD (one of them muscular apical), had neonatal pulmonary banding. We decided to close the apical m-VSD first because surgical m-VSD closure entails high morbidity and mortality, especially when the location is apical,¹⁵ and the surgical approach may need to be from the left ventricle, with the consequent damage to ventricular function.¹⁶

Risk of Vascular Lesion

Amplatzer deployment sheaths require venous access and are commercialized by internal diameter size. The largest diameter we used was 7 Fr (patients 2, 3, 9, and 14). In patients with m-VSD

(Figure 3), we used 6 Fr sheaths via the internal jugular vein. We believe possible vascular damage caused by such thick sheaths can be minimized by careful handling.

REFERENCES

1. Berger F, Vogel M, Alexi-Meskishvili V, Lange PE. Comparison of results and complications of surgical and Amplatzer device closure of atrial septal defects. *J Thorac Cardiovasc Surg.* 1999;118:674-8.
2. Masura J, Gavora P, Podnar T. Transcatheter occlusion of patent ductus arteriosus using a new angled Amplatzer duct occluder: Initial clinical experience. *Catheter Cardio Vasc Interv.* 2003;58:261-7.
3. Hijazi ZM, Hakim F, al-Fadley F, Abdelhamid J, Cao QL. Transcatheter closure of single muscular ventricular septal defects using the Amplatzer muscular VSD occluder: initial results and technical considerations. *Catheter Cardiovasc Interv.* 2000;49:167-72.
4. Diab KA, Cao QL, Bacha EA, Hijazi ZM. Device closure of atrial septal defects with the Amplatzer septal occluder: safety and outcome in infants. *J Thorac Cardiovasc Surg.* 2007;134:960-6.
5. Diab KA, Cao QL, Mora BN, Hijazi ZM. Device closure of muscular ventricular septal defects in infants less than one year of age using the Amplatzer devices: feasibility and outcome. *Catheter Cardiovasc Interv.* 2007;70:90-7.
6. Carminati M, Butera G, Chessa M, de Giovanni J, Fisher G, Gewillig M, et al. Investigators of the European VSD Registry. Transcatheter closure of congenital ventricular septal defects: results of the European Registry. *Eur Heart J.* 2007;28:2361-8.
7. Herrador JA, Suárez de Lezo J, Pan M, Romero M, Segura J, Mesa D. Cierre percutáneo de comunicación interventricular congénita mediante el dispositivo de Amplatzer. *Rev Esp Cardiol.* 2006;59:510-4.
8. Murphy JG, Gersh BJ, McGoon MD, Mair DD, Porter CJ, Ilstrup DM, et al. Long-term outcome after surgical repair of isolated atrial septal defect. Follow-up at 27 to 32 years. *N Engl J Med.* 1990;323:1645-50.
9. McMahon CJ, Feltes TF, Fraley JK, Bricker JT, Grifka RG, Tortoriello TA, et al. Natural history of growth of secundum atrial septal defects and implications for transcatheter closure. *Heart.* 2002;87:256-9.
10. Cua CL, Blankenship A, North AL, Hayes J, Nelin LD. Increased incidence of idiopathic persistent pulmonary hypertension in Down syndrome neonates. *Pediatr Cardiol.* 2007;28:250-4.
11. Divekar A, Gaamangwe T, Shaikh N, Raabe M, Ducas J. Cardiac perforation after device closure of atrial septal defects with the Amplatzer septal occluder. *J Am Coll Cardiol.* 2005;45:1213-8.
12. Ruiz Lera M, de la Torre-Hernández JM, Zueco J, Francisco Nistal J. Perforación cardíaca tardía tras cierre percutáneo de un defecto septal interauricular con dispositivo Amplatzer. *Rev Esp Cardiol.* 2007;60:451-3.
13. Butera G, de Rosa G, Chessa M, Piazza L, Delogu A, Frigiola A, et al. Transcatheter closure of persistent ductus arteriosus with the Amplatzer duct occluder in very young symptomatic children. *Heart.* 2004;90:1467-70.
14. Duke C, Chan KC. Aortic obstruction caused by device occlusion of patent arterial duct. *Heart.* 1999;82:109-11.
15. Kitagawa T, Durham LA III, Mosca RS, Bove EL. Techniques and results in the management of multiple ventricular septal defects. *J Thorac Cardiovasc Surg.* 1998;115:848-56.
16. Wollenek G, Wyse R, Sullivan I, Elliott M, de Leval M, Stark J. Closure of muscular ventricular septal defects through a left ventriculotomy. *Eur J Cardiothorac Surg.* 1996;10:595-8.