Blade Balloon Septostomy to Enlarge a Restrictive Atrial Septal Defect in Infants under 6 Months: Immediate and Medium-Term Outcomes

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SUMMARY

A nonrestrictive atrial septal defect is mandatory in order to maintain adequate arterial oxygen saturation and cardiac output in patients with complex congenital heart defects. We describe six patients under 6 months with severe cyanotic congenital heart defects in whom blade balloon septostomy was performed to enlarge a restrictive atrial septal defect. Immediate and medium-term outcomes are presented. The procedure was successful in all patients, producing a larger and long-lasting atrial septal defect and sustained clinical improvement. The use of intraprocedure echocardiography to guide and evaluate the results is highlighted. We consider that balloon septostomy is a safe and effective option to enlarge a restrictive ASD in carefully selected cases in infants less than 6 months old, with satisfactory outcomes. Echocardiography guidance is very important to warrant success of the procedure.

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Key words > Congenital Heart Defects - Atrial Septal Defects - Heart Septum - Blade Balloon

Abbreviations >

LA	Left atrium	**TEE**	Transesophageal echocardiography
BCB	Balloon catheter with blades	**TTE**	Transthoracic echocardiography
ASD	Atrial septal defect	**IAS**	Interatrial septum
d-TGA	d-Transposition of the great arteries		

BACKGROUND

A nonrestrictive atrial septal (ASD) defect is mandatory in order to maintain an adequate cardiac output, to reduce atrial pressure and to achieve an acceptable blood mixing to preserve adequate oxygen saturation in the systemic circulation in some patients with complex congenital heart defects. Up to the present, percutaneous techniques used to enlarge a restrictive ASD include Rashkind balloon septostomy, blade atrial septostomy with Park blade catheter, static balloon dilatation of the atrial septum and stent placement. (1-4) Balloon septostomy turns out to be difficult after the newborn period as the interatrial septum (IAS) becomes thicker and the procedure is hemodinamically ineffective. We describe our experience with 6 infants under 6 months with complex congenital heart defects associated with restrictive atrial septal defects undergoing a successful septostomy using a balloon catheter with blades (BCB). One of the patients has already been commented as a case report in this Journal (5). The intervention was monitored with transthoracic echocardiography (TTE) or transesophageal echocardiography (TEE), depending on the availability of the center were the procedure was performed. The procedure was successful in all patients, producing a larger and long-lasting atrial septal defect and sustained clinical improvement.

MATERIAL AND METHODS

Cardiac Catheterization and Echocardiography

All procedures were performed under general anesthesia and orotracheal intubation. Short introducers with diameters of 6 or 7 French were placed via one of the femoral veins. Heparin (100 U/ kg) and a cephalosporin (50 mg/kg) were administrated. Two patients required protamine to revert the heparin effect. Routine angiograms were performed according to each specific disease and the intervention in the interatrial septum was monitored with echocardiography in all cases but one. Transesophageal echocardiography was performed to guide the procedure in those centers which had the corresponding probes. Two-dimensional and Doppler images of the IAS were acquired at angles from 0° to 90° until the balloon catheter with blades was adequately visualized

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advancing into the IAS. When TTE was used, images were acquired from the subcostal short-axis and long-axis views which provided the best information (Figures 1 and 2)

Blade Balloon Septostomy

The septostomy was performed using a balloon catheter with blades (Boston Scientific, San Diego, USA) 5 to 7mm in diameter and 10mm in length (the diameters available in our country.) Previously, a 0.018" guide wire had been positioned in the left superior or inferior pulmonary veins or, alternately, adopting the shape of the LA body. Then, short introducers 6 or 7 Fr were advanced over the guide wire. Once the balloon was visualized in the IAS by echocardiography, it was inflated to nominal pressure. Then, the balloon was insufflated several times and it was slightly advanced, withdrawn and rotated clockwise or counterclockwise with each insufflation, making incisions in different parts of the septum. Afterwards, a conventional balloon catheter 12 - 15 mm in diameter by 20 - 30 mm long was advanced over a 0.035" guide wire and was insufflated several times (2 to 4) until the notch disappeared in order to enlarge the IAS.

RESULTS

From July 2006 to April 2009, 6 patients underwent blade balloon septostomy. Median age was 98 days (75 120) and mean weight was 3.6 ± 0.6 kg (3.1-4.2). Four patients were female (66%). The procedure was monitored by TEE in 3 patients and by TTE in 2. The diagnoses were: hypoplastic left heart syndrome after stage I hybrid strategy (n = 1), d-TGA and pulmonic subvalvular and valvular stenosis (n = 1), tricuspid atresia type IB with ventriculoarterial concordance (n = 2), and tricuspid atresia type II C with ventriculoarterial discordance (n = 1). Three patients had a history of previous procedures in the IAS: balloon septostomy in 2 and static balloon dilatation in 1.

The mean size of the ASD measured by Doppler echocardiography in the subcostal view was 2.5 ± 0.6 mm (1.7 -3.7) before the procedure, 7.6 ± 1.1 mm (6 - 9.8) ($p < 0.001$) and 6 ± 1.4 mm (3.5-7.9) during follow-up . The diameter of the balloon catheter with blades varied between 5 and 7 mm, and that of the conventional balloon to end the procedure varied between 12 and 15 mm. The transatrial pressure gradient decreased from 10 ± 3.2 mm Hg (5-17) to 2.8 ± 0.5 mm Hg (0-4) ($p < 0.001$) and arterial oxygen saturation increased from 73% ± 4.2% (69-77) to 84% ± 4.4 % (82-87%) ($p < 0.001$) (Table 1). During a median follow-up of 15 months (3-33), there was no need to perform a reintervention in the IAS in any patient. Five patients underwent palliative/corrective surgery (stage I hybrid Norwood strategy in 2, palliative switch/Glenn anastomosis in 1, Rastelli procedure in 1 and Glenn anastomosis in 1). The remaining patient is waiting for Glenn surgery. During medium-term follow-up, 5 patients achieved a defect size >75% of the diameter measured immediately after the procedure. The remaining patient who had previously undergone failed Rashkind balloon septostomy presented moderate blood flow restriction with a 50% reduction in the size of the ASD 6 months after blade balloon septostomy

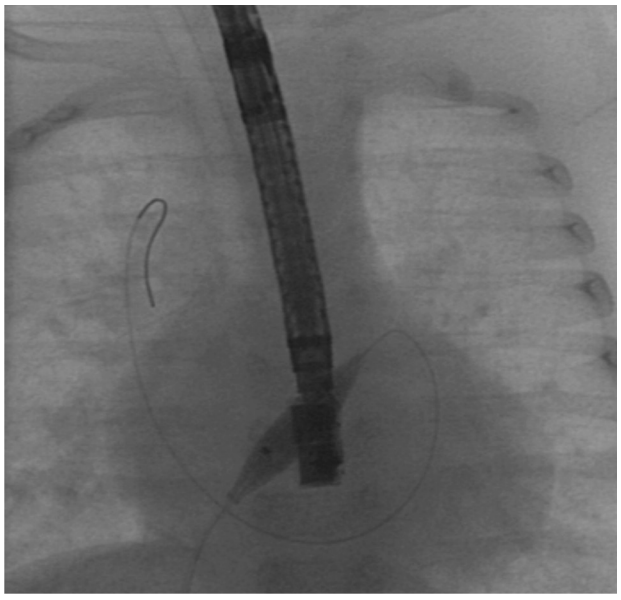

Fig. 1. Fluoroscopic image in the anteroposterior projection (patient N 2) showing the blade balloon catheter insuflatedinsufflated on the interatrial septum. The position of the balloon is simultaneously controlled by transesophageal echocardiography. See the position of the guide wire adopting the shape of the LA and ending in the right superior pulmonary vein.

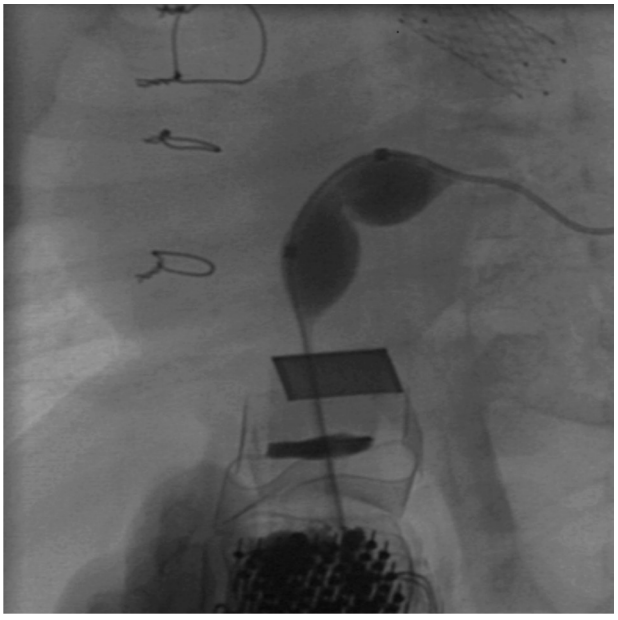

Fig. 1. Fluoroscopic image in the LAO at 60 (patient N 5), showing the I stent positioned in the ductus, the conventional balloon inflated in the interatrial septum (after blade balloon septostomy) and the TTE probe in the subcostal position to guide/monitor the ´procedure.

(Figure 3). The size of the interatrial defect was confirmed during surgery in all patients (except for the one who is one waiting for palliative Glenn surgery).

Table 1. Demographic data, diagnosis and immediate outcomes

Pt	Age (days)	Gender	Weight (kg)	Diagnosis	Echo	ASD sime (mm)		ASD gradient (mm Hg)		Systemic 02 sat t (%)	
						Pre	Pos	Pre	Pos	Pre	Pos
1	105	M	3.6	AT IB	ETE	3.7	9.8	9	0	77	85
2	117	F	3.4	d-TGA. CIV. EP	ETE	1.7	7	N/D	4	73	87
3	90	M	3.7	AT IB	ETT	2.1	7.6	8	3	72	83
4	75	F	3.3	AT IIC	No	2.8	6	17	4	74	82
5	120	F	4.2	SCIH	ETT	3	8.2	5	2	73	86
6	83	F	3,2	SCIH	ETE	1,9	7	11	4	69	83

Pt: Patient. TA: Tricuspid atresia. d-TGA: Transposition of the great arteries. HLHS: Hypoplastc left heart syndrome. Grad: Gradient. Syst 0_2 Sat: Syatemic Oxygen saturation. VSD: Ventricular septal defect. PE: Pulmonic stenosis. N/A: Non available.

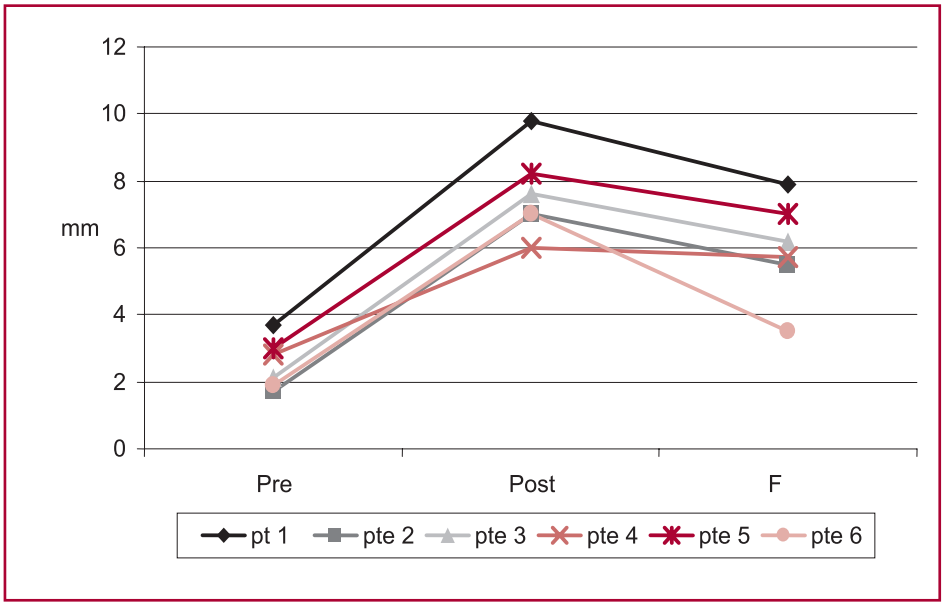

Fig. 3. Diameter of the ASD before (Pre) and after (Post) the intervention, and during the last follow-.up visit (F)

DISCUSSION

Limiting factors for favorable outcomes after Rashkind balloon septostomy are a small left atrium (LA), an elastic aneurysm of the IAS, and a thick IAS. These factors reduce the effectiveness of the procedure and increase the risk of complications such as perforation and/or avulsion of the pulmonary veins and LA. In the same way, a small LA size is a limitation to septostomy with Park blade catheter, so it is not recommended for small infants; the procedure uses long and wide sheaths which may damage the vessels. Static balloon dilatation of the atrial septum is an alternative option in small infants, but the evidence shows that the results do not last long as progressive stenosis develops. (4, 6)

During the last years, stent placement in the IAS has been exceptionally reported to maintain an adequate ASD, particularly in patients with hypoplastic left heart syndrome and restrictive ASD or intact IAS. In this subgroup of patients, conventional septostomy is less effective and its risks are higher due to a thicker IAS, a smaller LA and a posterior ASD. Theoretically, a stent implant might create an ASD with a size adequate enough to produce an effective reduction in LA hypertension, preventing increased pulmonary blood flow through a large ASD. (6, 8, 9)

The use of cutting balloon catheters has been described with diverse outcomes in pediatric patients to enlarge a great number of lesions (using high-pressure balloons at 12- 15 atm), such as resistant peripheral pulmonary artery stenosis, pulmonary vein stenosis, renal artery stenosis, systemic and pulmonary collateral artery stenosis, coarctation of the aorta, and recanalization of the femoral artery and of the right ventricular outflow tract in patients with tetralogy of Fallot. (10-15) Radiofrequency perforation and cutting balloon septoplasty have been performed to create and ASD in patients with hypoplastic left heart syndrome

and transposition of the great arteries with intact IAS. (16, 17)

Although the evidence regarding the use of BCB to enlarge an ASD and the durability of a restrictive ASD is limited, the initial outcomes have been promising. Several authors have suggested that the microblades of the cutting balloon allow a controlled tear of the IAS, which is contrary to the stretching produced by the static balloon dilatation in patients with a thicker IAS. The advance/withdraw movements and clockwise/counterclockwise rotation of the balloon which tend to produce tears in different points of the IAS might improve the outcomes of a subsequent static balloon dilatation, possibly resulting in a long-lasting and larger ASD. (4-7, 16-18)

TTE and TEE play an outstanding role to guide the procedure and monitor its outcomes. Echocardiography is extremely helpful during the placement of the cutting balloon over the IAS (placement guided by angiography is difficult as the blades are10 mm long), provides immediate information of the results of the procedure (diameter of the orifice, degree of restriction) and minimizes its duration, avoiding the manipulation of catheters to estimate pressures and to perform a post-procedure angiography. Echocardiography is also useful to rule out acute complications such as hemopericardium or new valvular regurgitations.

CONCLUSIONS

We consider that blade balloon septostomy is a safe and effective option to enlarge a restrictive ASD in carefully selected cases in infants less than 6 months, with satisfactory short- and medium-term outcomes. Echocardiography guidance is very important to warrant success of the procedure.

RESUMEN

Utilización del "balón con cuchillas" para ampliación de comunicación interauricular restrictiva en lactantes menores de 6 meses: resultados inmediatos y a mediano plazo

Los pacientes con cardiopatías congénitas complejas requieren con cierta frecuencia una comunicación interauricular no restrictiva para mantener una saturación de oxígeno arterial y un gasto cardíaco adecuados. En este trabajo se describen seis pacientes menores de 6 meses con cardiopatías congénitas cianóticas graves, en los cuales se realizó dilatación de una comunicación interauricular restrictiva utilizando un balón con cuchillas. Se presentan los resultados inmediatos y a mediano plazo. En todos los pacientes se logró un incremento importante y duradero del tamaño del defecto interauricular y una mejoría clínica sostenida posprocedimiento. Se resalta la utilización de la ecocardiografía intraprocedimiento para guiar y evaluar los resultados. Consideramos que, utilizada con cautela en casos seleccionados, la ampliación de una CIA restrictiva con balón con cuchillas en lactantes menores de 6 meses es una alternativa segura y eficaz, con resultados satisfactorios. La monitorización ecocardiográfica es muy importante para el éxito del procedimiento.

Palabras clave > Cardiopatías congénitas - Defectos del tabique interauricular - Septum cardíaco - Balón con cuchillas

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