

Balloon atrial septostomy using echocardiographic monitoring

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Two dimensional (2-D) echocardiography was used to guide balloon atrial septostomy (BAS) in twelve infants with cyanotic congenital heart disease during the period 1992 to 1995. Eleven infants had dextro-transposition of the great arteries (d-TGA) and one had tricuspid atresia (TA). Balloon atrial septostomy was success fully performed in 9 of the 12 infants. Atrial septal defect (ASD) size and systemic arterial oxygen saturation (SAT) were measured before and after the procedure. In d-TGA there was a statistically significant increase in SAT ($P<0.01$). This study showed that BAS under the 2-D echocardiographic method was a safe and effective palliative therapeutic procedure in some life threatening types of congenital heart disease.

Key words: *Balloon atrial septostomy, Echocardiographic monitoring.*

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การศึกษา Balloon Atrial septostomy (BAS) โดยอาศัย Echocardiography ในผู้ป่วยทารกซึ่งเป็นโรคหัวใจแต่กำเนิดชนิดเขียว 12 ราย 11 รายเป็น Dextro-transposition of the great arteries (d-TGA) 1 รายเป็น tricuspid atresia (TA) จาก 12 ราย 9 ราย สามารถทำ BAS และทำให้เกิด atrial septal defect(ASD)ได้ จากการวัดขนาด ASD และค่า systemic arterial oxygen saturation (SAT) ทั้งก่อนและหลังทำ BAS พบว่าค่า SAT ในผู้ป่วย d-TGA หลังทำ BAS เพิ่มขึ้นอย่างมีนัยสำคัญทางสถิติ ($P<0.01$) การศึกษานี้แสดงว่าการทำ BAS โดยอาศัย echocardiography เป็นวิธีหนึ่งที่ได้ผลและมีประสิทธิภาพในการรักษาแบบประคับประคองในผู้ป่วยโรคหัวใจแต่กำเนิดบางชนิด ก่อนจะรักษาด้วยวิธีผ่าตัดในภายหลัง

Balloon atrial septostomy (BAS), introduced by Rashkind and Miller in 1966, was the first intracardiac therapeutic procedure using catheter under cardiac catheterization. Originally this procedure was designed for patients with dextro-transposition of the great arteries (d-TGA),⁽¹⁻³⁾ but it also had been used in tricuspid atresia,⁽⁴⁾ pulmonary atresia with intact ventricular septum, and total anomalous pulmonary venous return.⁽⁵⁾ In 1982 Perry LW, et al. used echocardiographically assisted balloon atrial septostomy in a pediatric intensive care unit.⁽⁶⁾ The outcome was good and many physicians have done BAS under two-dimensional (2-D) echocardiographic control.⁽⁷⁻⁹⁾

BAS is effective in infants less than one week old or as early after diagnosis as possible because septal thickness will increase with age. This procedure has been indicated for palliation in congenital heart lesions in which all systemic, pulmonary, or mixed venous blood must traverse a restrictive interatrial communication in order to return to systemic circulation. BAS, however is not without risk. Complications include arrhythmia, inferior vena cava laceration and/or thrombosis, pulmonary vein tear, atrioventricular valve avulsion and atrial perforation.⁽¹⁰⁻²²⁾ In order to achieve a low complication rate, it must be established that the balloon is within the body of the left atrium prior to withdrawal under echocardiographic guidance⁽²³⁻²⁴⁾

Materials and Methods

1. The patients

Twelve infants with cyanotic congenital heart disease were studied by two dimensional

echocardiography using an Aloka, SSD-118 echocardiographic machine with a 5 MHz transducer. The diagnosis was confirmed by echocardiography in each case. Eleven infants had d-TGA, with or without ventricular septal defect (VSD), or patent ductus arteriosus (PDA). One infant had tricuspid atresia (TA), pulmonary artery stenosis (PS) and PDA. The study period was from May 1992 to August 1995. There were 9 males (75%) and 3 females (25%). The age ranged from 1 day to 48 days (mean=10.8 days). The patient weight was from 1850 gm. to 3980 gm. (mean=2813 gm.).

2. Technique

The balloon septostomy catheter used was either a single lumen Edwards Laboratories balloon septostomy catheter or single or double lumen USCI balloon septostomy catheter. Cutdown was performed at the groin area and the balloon catheter was introduced either directly into the femoral vein or indirectly through the long saphenous-femoral vein junction. The umbilical vein was an alternative approach. The echocardiographic transducer was positioned subcostally so that the right atrium (RA) - inferior vena cava (IVC) junction was visualized. The catheter was then advanced until the tip could be identified in the RA. The foramen ovale could be detected echocardiographically (Figure 1.). Further advancement would bring the tip of the catheter into the left atrium (LA) via the foramen ovale (Figure 2.). The balloon was then filled with either saline or diluted contrast medium before it was pulled rapidly, or better stated, "jerked" across the atrial septum into the RA (Figure 3.) using as forceful and as rapid but, at

the same time, as short and controlled a pull as possible. The entire procedure was repeated many times until no resistance to withdrawal of the fully inflated balloon was encountered and an ASD was successfully created (Figure 4). SAT were measured by pulse oximetry both

before and after BAS while the ASD size was measured echocardiographically. The procedures were performed in the intensive care unit. Video cassette tape was used for recording and stop frame imaging permitted still photographs to be taken with a camera.

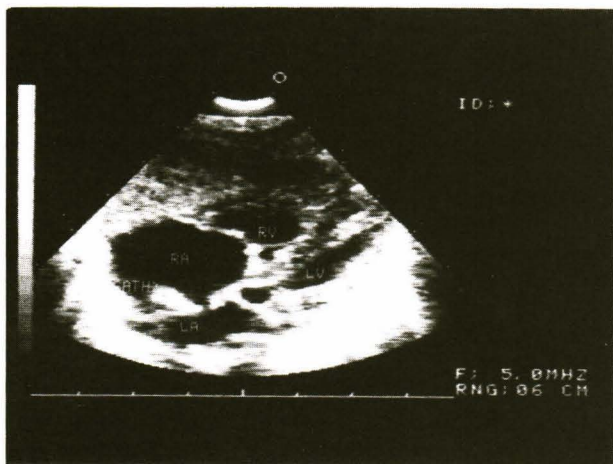


Figure 1. The subxiphoid four-chamber section of the heart is visualised on the echocardiogram demonstrating the deflated balloon catheter (CATH) in the right atrium (RA) before BAS. LA, left atrium; LV, left ventricle; RV, right ventricle.

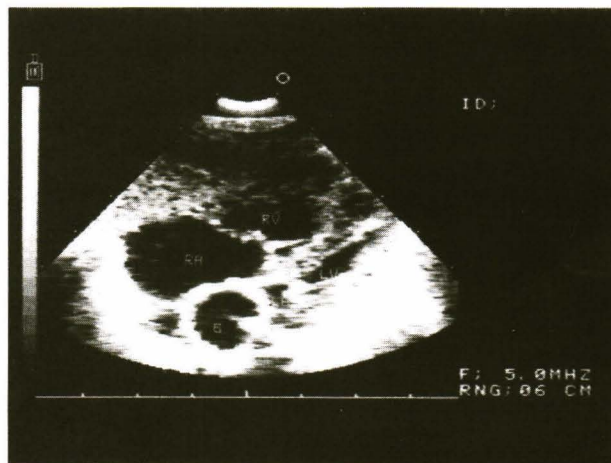


Figure 2. The subxiphoid four-chamber view of a patient demonstrating the inflated balloon catheter (B) seen within the left atrium (LA) before septostomy, and it clearly is separated from the mitral valve apparatus.

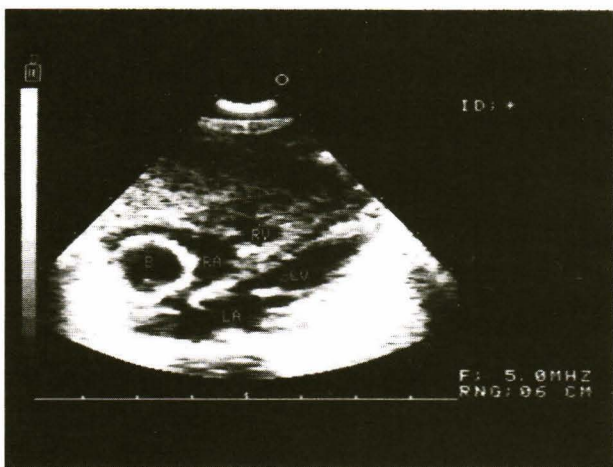


Figure 3. The subxiphoid four-chamber view of a patient demonstrating the inflated balloon catheter (B) seen within the right atrium (RA) after septostomy by withdrawal traversing atrial septum from LA into RA.

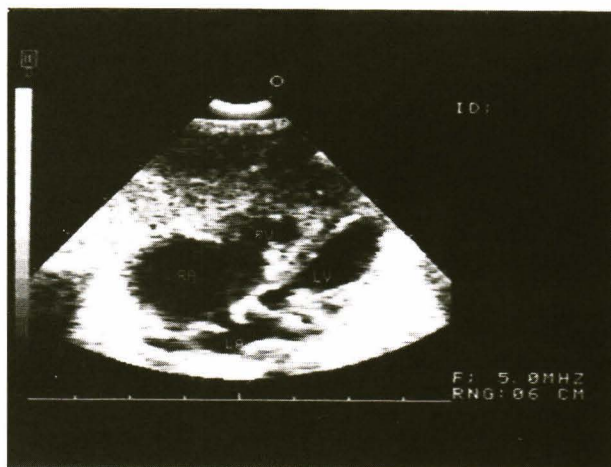


Figure 4. The subxiphoid four-chamber view of a patient demonstrating the created atrial septal defect after septostomy. The approximate size of the defect can be measured.

3. Statistical analysis

Pre-and postseptostomy SAT were compared using the student t-test for paired observations.

Results

Twelve infants received echocardiographically assisted BAS (Table 1) using the technique described above. The sex, age, weight, diagnosis, ASD size, SAT before and after BAS, and surgery for each patient were determined. The initial and subsequent placements and withdrawals of the balloon catheters were performed entirely by echocardiographic guidance. In nine infants, septostomies could create ASD measuring 2 mm. to 10 mm. in diameter. The success of the procedures in eight infants who had d-TGA was indicated by the rise in SAT after BAS compared to the SAT before the procedures. Using the student t-test for paired observations, there was a statistically significant rise in the mean SAT after BAS \pm SD (87.5 \pm 6.7%) compared to those before BAS \pm SD (67.9 \pm 17.7%) (Figure 5).

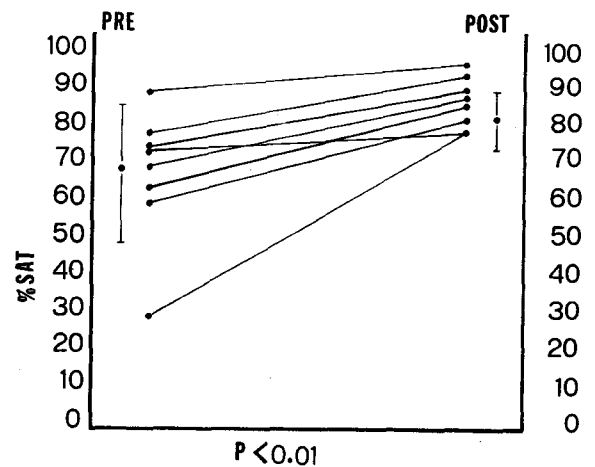


Figure 5. Systemic arterial blood oxygen saturation (% SAT) before and after BAS in 8 patients with D-TGA.
mean SAT before BAS \pm SD = 67.9 \pm 17.7%
mean SAT after BAS \pm SD = 87.5 \pm 6.7%
PRE = before septostomy
POST = after septostomy

Table 1. Data on twelve infants receiving echocardiographically assisted BAS.

case	sex	age (day)	wt. (gm.)	diagnosis	ASD size (mm)	SAT (%)		surgery	result
						pre	post		
1	M	13	3200	d-TGA,VSD,PDA	10	65	87	PA-banding,ligation PDA	good
2	F	1	3980	d-TGA,IVS,PDA	10	60	82	arterial switch operation	dead
3	M	48	2650	d-TGA,VSD,PDA	5	76	90	PA-banding,ligation PDA	dead
4	F	5	2100	TA,PS,PDA	2	86	92	none	good
5	M	7	3330	d-TGA,IVS,PDA	5	70	88	Blalock-Hanlon operation	good
6	M	14	2480	d-TGA,IVS,PDA	8	90	98	PA banding--> arterial switch operation	good
7	M	1	2800	d-TGA,IVS,PDA	7	77	95	none	good
8	M	1	1850	d-TGA,IVS,PDA	7	75	80	arterial switch operation	good
9	M	1	2180	d-TGA,VSD,PDA	7	30	80	Mustard operation	dead
10	M	22	2420	d-TGA,VSD,PDA	-	-	-	Blalock-Hanlon, PA-banding	good
11	M	1	3930	d-TGA,VSD,PDA	-	-	-	arterial switch operation	dead
12	F	15	2840	d-TGA,VSD,PDA	-	-	-	Blalock-Hanlon operation	good

M = male, F = female,
VSD = ventricular septal defect,
PDA = patent ductus arteriosus,
PA-banding = pulmonary artery banding,
post = after BAS, wt. = weight.

d-TGA = dextro-transposition of the great arteries
IVS = intact ventricular septum
TA = tricuspid atresia, PS = pulmonary artery stenosis
Pre = before BAS

BAS was not successful in 3 infants because in 2 of them the veins were torn and a balloon catheter could not be passed into the vein. In the third infant the balloon catheter could not be passed from the right atrium into the left atrium. All 3 of these patients eventually underwent either Blalock Hanlon or arterial switch operations.

Complications during and after balloon atrial septostomy included bleeding and anemia in 2 infants, a arrhythmia in 2 infants, a burst balloon in 3 infants, an infected wound at the cutdown site in 1 infant and thrombosis in the inferior vena cava in 1 infant. Ten infants underwent surgery and 4 died (40%). Six infants had palliative surgery and one later died from pneumonia and acute renal failure. Corrective surgery was performed in 5 infants; 4

underwent arterial switch operation and 2 died (50%). One infant had an atrial switch operation (Mustard operation) and died after the procedure.

Discussion

Before the introduction of surgical techniques to increase atrial mixing, the mortality rate of patients with d-TGA was very high; 95% of cases died by the end of the second year of life and approximately 40% in the first month.⁽²⁵⁾ Surgical septostomy still had a very high mortality rate in the first three months of life. This led to the introduction of balloon septostomy.⁽¹⁾ This palliative procedure allows the patient to survive until the appropriate time for corrective surgery.

In cases of d-TGA, adequate atrial septostomy with increased use of 2-D echocardiogram and intensive care facilities had led to increased survival after balloon septostomy. BAS using echocardiographic monitoring without delay would minimize the risk of the procedure.

The echocardiographic estimation of the ASD size predicts the adequacy to atrial septostomy. Other's experiences showed that at least 5 mm. in superior-inferior dimension to the ASD measured by 2-D echocardiogram was adequate. In all, this had been associated with increased motion of the inferior portion of the atrial septum. ASD size generally was underestimated by 1 to 2.5 mm. due to resolution errors inherent in the technique.⁽²⁶⁾ Hence, measuring a 5 mm. ASD by 2-D echocardiogram might not provide a true indication of ASD size due to resolution errors and/or because the tear might extend into a plane not measured by that technique. In our studies, statistically significant increases of the SAT ($P < 0.01$) after BAS was obtained in addition to clinical improvement.

The most common complication in this study was a burst balloon. This occurred in 3 cases (25%). The reason for this complication was reusing balloon catheters. For treatment of an ASD, the balloon catheter was pulled back from the left atrium to the right atrium 5-16 times in each patient. Effective ASD treatment occurred in each patient except for one case which had tricuspid atresia. Balloon atrial septostomy was tried for a total of 14 times before the balloon ruptured. Although the ASD size was only 2 mm. in diameter the patient showed some improvement both by SAT and by

echocardiographic examination which revealed less bowing of the atrial septum to the left, indirectly indicating decreased pressure in the right atrium.

Other complications such as bleeding and anemia were found in 2 cases and corrected by blood transfusion. Arrhythmias in two cases disappeared after completing the procedure. An infected wound was successfully treated with intravenous antibiotics.

After BAS, 10 infants who had d-TGA underwent palliative surgery (Blalock-Hanlon operation with or without pulmonary artery banding) or corrective surgery (Mustard or arterial switch operation) (Table 1.).

The number of patients in this study was too small to evaluate the mortality rate. A study of larger numbers of patients is needed.

BAS can be done with the assistance of 2-D echocardiogram or fluoroscopy, but 2-D echocardiogram is superior in defining the relations between the septostomy catheter and the atrial septum, and the pulmonary veins and the atrioventricular valves. It can also decrease the risk of exposure to ionizing radiation, both to the patient and to the physician.⁽²⁷⁾ We believe that 2-D echocardiographic monitoring should replace standard cardiac catheterization for BAS in selected cases of patients.

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