CASE REPORT

Transumbilical Balloon Atrial Septostomy with Echocardiographic Monitoring

by

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Abstract

Balloon atrial septostomy is usually necessary for survival beyond infancy in patients with transposition of the great arteries and insufficient intravardiac mixing. Since the umbilical vein and ductus venosus are often patent in the newborn infants, this route can be considered as an alternative to a femoral venous route in a critically ill infant.

A 7 day-old newborn with D-transposition with intact ventricular septum and small patent foramen ovale was successfully managed by creating atrial septal defect through transumbilical balloon arterial septostomy. The procedure was carried out in the neonatal intensive care unit, guided by 2D-echocardiography. The arterial oxygen saturation increased dramatically upon the completion of the procedure, and a large atrial septal defect could be demonstrated echocardiographically. Unfortunately the infant died before further definitive surgery was performed.

Introduction

In complete transposition of the great arteries (TGA), the systemic and pulmonary circuits are in parallel instead of series relation in normal condition. The exchange of blood between the 2 circuits (intercirculatory mixing) is mandatory to sustain life. Intercirculatory mixing may take place within the heart (through a ventricular septal defect, atrial septal defect or persistent foramen ovale), or outside the heart (through a patent ductus arteriosus). The position, size and number of the communications determine the degree of mixing achieved, besides the rate of blood flow through the respective circuits. Many studies have indicated that best mixing could be expected when the communication located at the artrial level through large atrial septal defect. Mixing will be better if a large atrial communication is accompanied by additional communication (ventricular septal defect, patent ductus arteriosus, or both) (Tynan, 1972; Mair and Ritter, 1972).

Before 1964, nearly 90% of patients with transposition died in the first year of life (Liebman et al., 1969; Mitchell et al., 1971; Gutgesell et al., 1979). The introduction of balloon atrial septostomy (BAS) by Rashkind and Miller (1966) has reduced the neonatal and infant mortality of patients with TGA. BAS has become the standard palliative procedure of every patient with TGA in most pediatric cardiac centers.

The original description of BAS required catheter insertion through the femoral vein, and it was done in the catheterization laboratory. Newfeld et al. (1974) described BAS performed via the umbilical vein in 16 infants with complete transposition, all under 4 days of age. Since the wide use of 2 dimensional echocardiography, several authors have reported the advantage of using 2D-echocardiography for monitoring BAS procedure instead of using the more usual fluoroscopy in catheterization procedure (Sastroasmoro and Goh, 1987).

We report our experience in performing transumbilical BAS in a 7 day old baby with transposition using 2-D echocardiography as a monitor.

Report of the Case

A 6 day-old baby boy was referred from a private maternity hospital because of persistent cyanosis. He was born spontaneously at term with the body weight of 3700 g and body length of 49 cm, without evidence of birth asphyxia. On day 2, when he was having breast feeding, the mother noted that the baby looked dusky. On the subsequent days he became more and more blue, and then was consulted to a pediatric cardiologist (BM) who referred the baby to our unit.

Physical examination on admission disclosed an alert but deeply cyanotic baby, with mild tachypnea and retractions. The heart rate was 136/minute, the respiratory rate was 44/minute; blood pressure was 70/40 mmHg. The chest was normal. On auscultation the first heart sound was normal, and the second sound single. There was a grade 2/6 systolic murmur at the 2nd left sternal border. The lungs were normal. The abdomen was soft, the liver and the spleen were not palpable.

Electrocardiographic tracing showed usual rightward axis deviation with right forces preponderance. Chest X-ray showed mildly enlarged heart (cardiothoracic ratio

0.63) with normal pulmonary vasculature.

Two-dimensional echocardiography was performed immediately, disclosing D-transposition of the great arteries with intact ventricular septum and restricted interatrial communication via a small patent foramen ovale. There was no left or right outflow tract obstruction. No extracardiac communication between aorta and pulmonary artery was detected, nor there was a coarctation of the aorta.

Blood gas analysis showed mild acidemia with profound hypoxemia (pH 7.30; pCO_2 43.9 mmHg; pO_2 25 mmHg; HCO3 22 mEq/L; TCO_2 23 mmHg; BE -3.8 mEq/L; O_2 sat 39.5%; Hb 14.4 g/dl). Sodium concentration was 130 mEq/L and potassium 5.0 mEq/L; urea and creatinine were within normal limits.

The infant was then put on intravenous fluid drip, and was transferred to the Pediatric Intensive Care Unit for monitoring and preparation of balloon atrial septostomy. Broad spectrum antibiotics were administered. The septostomy was performed on the next day, using a 5F Fogarty Dilatation Catheter. First attempt to access the femoral vein had failed, so then we changed to use umbilical vein to insert the catheter. Surprisingly, the 7 day-old infant still had patent umbilical vein and ductus venosus. The catheter was introduced quite easily without sheath. With echocardiographic monitoring, the catheter with deflated balloon was advanced very carefully via umbilical vein, ductus venosus and inferior vena cava and then up to the right atrium, with continuous ultrasound guidance. At this point, a subxiphoid 4-chamber view was used to monitor continuously further steps of the procedure. The catheter was manipulated so that its end with the balloon entered the left atrium via the small foramen ovale. The balloon was then inflated with 0.5 ml of normal saline (diameter approximating 10 mm) (fig.1) and then with jerky movement the catheter was withdrawn so that the balloon tore the atrial septum (fig.2). The balloon was then deflated rapidly to prevent occlusion of the caval vein – right atrium junction. The procedure was repeated several times with increasing inflation up to maximum capacity (1.8 ml or 15 mm in diameter), to ensure adequate inter-atrial communication. After the completion of maximum balloon capacity without resistance, a large created atrial septal defect could be demonstrated by echocardiography.

Continuous transcutaneous arterial oxygen saturation monitor showed low O_2 saturation (24-32%) shortly before the procedure, but during the attempt of creating atrial septal defect the saturation increased dramatically. Immediately after the completion of septostomy, the arterial O_2 saturation rose significantly up till 63%. This was not stable, however, and several minutes thereafter the saturation went down to approximately 35-40%. Continuous monitoring of O_2 saturation and frequent blood gas analysis disclosed a wide fluctuation of O_2 saturation between 30 to 65%.

Despite demontrated widely open atrial septal defect and significant rise in saturation and pO_2, there was no clinical improvement. The baby was still looked dusky, with increasing rapid respiration. On day 3 after the procedure he developed jaundice and occasional apnea. The bilirubin content rose rapidly on the following day, and the apneic attacks became more frequent. The infant expired on day 5 after septostomy despite maximal supportive measures. No autopsy was done.

Discussion

Transposition of the great arteries (TGA) is the most frequently found cardiac malformation presenting with cyanosis in the first few days of life. In this malformation, the aorta rises from the right ventricle and the pulmonary artery rises from the left ventricle. Since there is normal (concordant) atrio-ventricular connection, the systemic and pulmonary circuits are in parallel, and the mixing of blood between the two circuits is a *sine qua non* if life is to be sustained. Patients with transposition who present symptoms in the first days of life must have inadequate mixing between the pulmonary and systemic circuits. These babies are prone to develop severe cyanosis which is usually followed by ongoing acidosis that frequently results in death if attempt to modify the intercirculatory mixing is not done. Indeed, the first month is the most vulnerable time for babies with TGA (Gutgesell et al., 1979). With the development of balloon septostomy that enable the physician to create a large interatrial communication without surgery (Rashkind and Miller, 1966), many babies with this problem could be salvaged beyond the neonatal period, while awaiting for further surgery (physiologic or anatomic correction). Rashkind procedure was originally performed in the catheterization laboratory, and has become the standard procedure during cardiac catherization of babies with d-transposition (Mullins et al., 1972). Cardiac catheterization was inevitable for the diagnosis of TGA, because although clinical, electrocardiographic and roentgenographic findings may highly suspect transposition, definitive diagnosis could only be established by catheterization and angiography. On the other hand, cardiac catheterization and angiography, especially when followed by atrial septostomy will carry significant risk to the severely hypoxic and acidotic baby. With the wide use of 2-dimensional echocardiography, it is now possible to establish definitive diagnosis of any congenital heart disease, including transposition, without cardiac catheterization and angiography. Further more, it will be possible to perform BAS with echocardiographic monitoring. The main advantage of this technique is the reduction of risk to the severely ill baby.

The standard techique in performing BAS has been femoral vein cut down (Rashkind and Miller, 1966; Mullins et al., 1972). Sunderland et al. (1976) reported their experience in performing BAS using percutaneous technique, which was considered to be easier and faster than using femoral venous cut down. To enable inserting the relatively large balloon catheter, they dilated the femoral vein puncture with increasingly large dilator. Newfeld et al. (1974) reported their success in using umbilical vein to insert the balloon catheter, which was usually easy to do in infants less than 72 hours of age.

We have used transumbilical approach after had failed to insert the balloon catheter via femoral vein cut down. Surprisingly, although the baby was 7 days old, the catheter could pass easily the umbilical vein and ductus venosus to enter the right atrium, and subsequently, the left atrium via the foramen ovale.

We could directly see the entrance of catheter with deflated balloon coming up from the inferior vena cava into the right atrium with sagital subxiphoid approach. Soon after the tip of the catheter reached the right atrium the transducer was rotated 90° counter clock-wise, and was angulated cranially to the position of subxiphoid 4-chamber view. With this po-

sition, the right atrium, left atrium and interatrial septum and its foramen ovale were easily visualized. The tip of the catheter itself was in and out of the view. Then the catheter was passed further, the tip of the catheter was seen in the left atrium. The balloon was then inflated with diluted contrast material and the inflated balloon could easily be seen in the left atrium (see fig.1). The catheter was then pulled back with rapid jerky movement so that the balloon tore the atrial septum. The procedure was repeated several times with the increasingly large inflation of the balloon until a large created atrial septal defect was seen on 2-D echo. We noted increasing arterial oxygen saturation on every attempt to enlarge the foramen ovale, as measured by transcutaneous oxygen saturation monitor, so that by the end of the procedure the arterial oxygen saturation was 65%. This was not stable, however, and fluctuated between 40 to 60% during 2 days after the procedure. Clinically, the infant still look d deeply blue.

Tynan (1972) reported the result of the change of oxygen saturation in infants with transposition before and after BAS. Before BAS, the arterial oxygen saturation of 75 cases showed bimodal distribution with the mean of 43% in the group of patients with interarterial communication only and 56% in the group with additional communication. Immediately after BAS, saturation curve of the 75 patients showed unimodal distribution with the overall mean of 65%, a significant increase compared with pre BAS value. Later evaluation gave the mean oxygen saturation value of 50%, which was significantly lower than the immediate post septostomy value, but still significantly higher than pre-septostomy value.

BAS is a relatively simple procedure. The main difficulty in the standard technique was the difficulty in assessing the femoral vein to insert the balloon catheter (Sastroasmoro and Goh, 1987). However, the procedure still carry a significant risk, i.e. rupture of the balloon, persistent severe arterial desaturation, septicemia and acidosis, inspite of the success in the creation large atrial septal defect. Our case showed clinical deterioration despite fairly good arterial saturation; he developed severe jaundice with high uncontrolled bilirubin serum concentration, rapid respiration and acidemia. We suspect that he had septicemia that contributed cause of his death.

In conslusion, we believe that balloon atrial septostomy can be performed in a safer and more simple way with 2D-echocardiography in the Pediatric Intensive Care Unit. Although Newfeld et al. (1974) recommended to use umbilical vein to insert the balloon catheter only in newborn of less than 72 hours of age, we suggest to try using the umblical approach in newborn of less than 1 week of age.

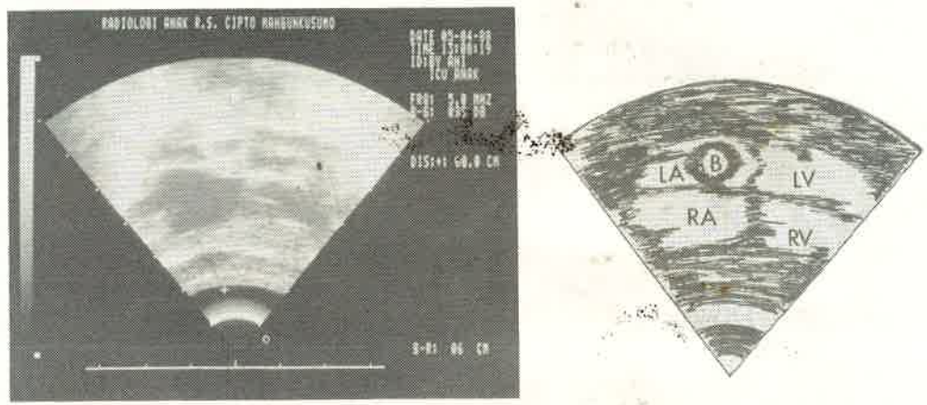

Fig.1. Subxiphoid 4-chamber view. The balloon was inflated with 0,5 ml of normal saline after entered left atrium via the small foramen ovale.

RA = Right atrium
LA = Left atrium
RV = Right ventricle
LV = Left ventricle
B = Balloon

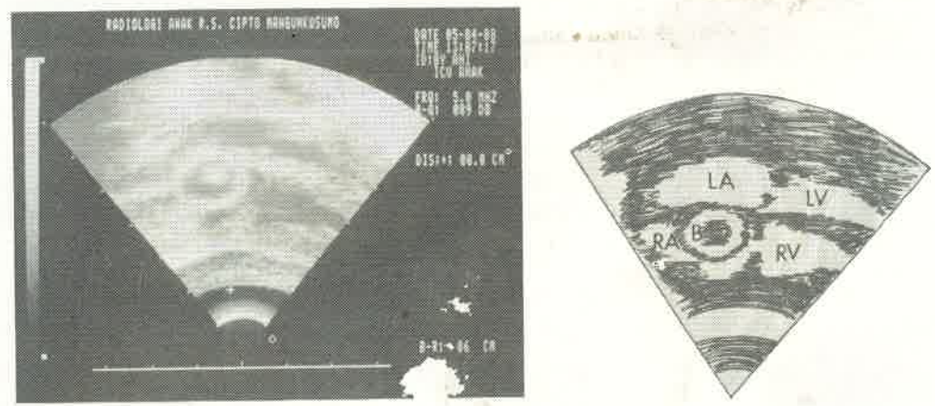

Fig. 2 Subxiphoid 4-chamber view ... catheter was withdrawn so that the balloon tore the atrial septum.

RA = Right atrium
LA = Left atrium
RV = Right ventricle
LV = Left ventricle
B = Balloon

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