Balloon Atrial Septostomy – Almost Half a Century After
Eliza CINTEZA, Mario CARMINATI

“Carol Davila” University of Medicine and Pharmacy, Pediatric Clinic, Bucharest, Romania
“Marie S Curie” Emergency Children’s Hospital, Pediatric Cardiology Department, Bucharest, Romania
Instituto Policlinico San Donato, Head of the Pediatric Cardiology Department, San Donato Milanese, Milan, Italy

ABSTRACT
Balloon atrial septostomy or Rashkind is a technique described almost half a century ago to dilate a preexisting atrial communication in order to enhance atrial mixing and to decompress the left atrium in congenital heart disease. With the contribution of fetal echocardiography this technique can be preplanned, but, still many complications can arrive. It is done almost routinely in all case of transposition of the great arteries with restrictive interatrial communication. Many other techniques developed, but Rashkind intervention remains a reference in congenital heart interventions in newborn or small infant. It is a challenging procedure that needs trained interventional/congenital cardiologists and a well-prepared catheterization laboratory, with the possibility for surgical or circulatory back-up. Nowadays, few complications can arrive, but are not to be neglected.

INTRODUCTION
Balloon atrial septostomy (BAS) or Rashkind intervention, described almost half a century ago, is an interventional procedure that applies to particular congenital heart disease (CHD) with the purpose of widening a restrictive atrial communication. It is an emergency intervention in nature, allowing the planning for surgery. Rashkind intervention can be planned even before the birth of the child, if in addition to a specific CHD a restrictive atrial communication is noticed in fetal echocardiography. Rashkind procedure is indicated in specific CHD (Table 1), in the presence of a restrictive foramen ovale (Figure 1). The main purposes (class I) of atrial septostomy (1-4) are to enhance atrial mixing and to decompress the left atrium. Also, it may be important to augment the cardiac output in right-side obstruction lesions.

From the first description, 47 years ago by Rashkind and Miller, the technique evolved (5). For preexisting small atrial communication, dilatation can be obtained by several modalities: balloon, low-profile balloon, static balloon, cutting balloon, blade or stenting. In some malformations, procedure may be difficult, due to specific features. For example, in hypoplastic left heart syndrome (HLHS) the atrial septum either is thick, either has some attachments and a balloon atrial septostomy...
may be impossible (1). For many of these situations, the Brockenbrough puncture (needle atrial transseptal puncture) or the radiofrequency wire perforations are indicated (1).

**METHODS**

Since Rashkind and Miller described the balloon atrial septostomy other techniques developed. Many of them have only temporary results, usually preceding the surgical intervention. Only stenting the atrial septum can provide a prolonged result, but with the increased risk for thromboembolic and mechanical complications (3).

**Balloon atrial septostomy.** Two possible options are described in order to perform a balloon atrial septostomy in a newborn. Firstly the location; it may be the catheterization laboratory, under angiographic guidance or the intensive care unit (ICU), under echocardiographic (subcostal four chamber and bicaval views) (6). In many centers, with highly trained specialists, the maneuver is performed in ICU. But, more safely, it is to be done in the catheterization laboratory, with both guidance (angiographic and echocardiographic) (7). Secondly, the vascular access may be by umbilical vein, easily in newborn, but complicated if the venous duct has tortuosities, or by femoral vein.

The recommended method is used in most of the tertiary pediatric cardiology clinics and implies both angio and echo guidance and femoral venous access. After vascular access in obtained and heparin is administrated (100 UI/kg), the Rashkind balloon catheter (Figure 2) is advanced into the right atrium through the femoral vein and inferior cava vein. From the right atrium, the catheter enters the left atrium (Figure 3), through a restrictive atrial communication. Then the balloon is inflated with 2-3 cc of a diluted contrast (20%/80%). After checking the balloon position (not in a pulmonary vein and not interfering with the mitral valve), under both fluoroscopy and echocardiography guidance, with a short and quick movement, the inflated balloon is passed into the right atrium (Figure 4), where it will be immediately deflated. This movement can be repeated several times (usually two or three times), with increasing volume of the balloon, up to 3 cc. Finally, by echocardiography, the outcome is verified: dimension of the interatrial communication atrial and absence of complications (pericardial fluid, damage to the heart).

**Advantages and disadvantages of other derived techniques**

The low-profile balloon atrial septostomy is a variant of balloon, described initially by Hijazi et al. in 1994 in an animal model. Its advantage is the presence of an end hole balloon...
Statistical balloon atrial dilation was described in humans by Shrivastava, after was used in animal models. It is suitable to complement blade atrial septostomy, in thick atrial septum, usually over the age of 6 weeks. The balloon is passed over a wire at the interatrial communication, then is inflated until indentation disappears (9,10).

Cutting balloon atrial septostomy was first described on piglets in 1996 by Coe. It has the advantages that can be used after perforation an atrial septum (by radiofrequency or needle) in small left atrium when the blade catheter can not be useful. This can be followed by a static balloon dilatation (11-13).

Blade atrial septostomy was described for the first time by Park (Park septostomy). It is indicated in patients in the second month of life, with thick atrial septum (also in hypoplastic left heart syndrome), who needs this communication for survival. This derived technique is preceded by transseptal puncture (using the Brockenbrough transseptal needle and a Mullins transseptal dilator), then the Park blade catheter is used on a long sheath. The result can be completed with a static balloon. Lacerations can appear and therefore this technique is very rare used (14,15).

Stenting of the atrial septum is the preferred method to obtain an interatrial communication for long-lasting result. This method needs a good medical judgment because it is associated with many complications: thrombus formation and possible embolic phenomena, especially in patients with Fontan physiology, stent erosion (especially in long stents), stent migration, and stent stenosis (approximately at 3 months distance). Long-term antiplatelet and or anticoagulation regimen should be carefully followed in this group of patients (16-18).

All presented methods have advantages and disadvantages, but some of them more frequently associated with complications are practically limited to certain categories of patients. For all cases initially balloon septostomy should be discussed. If difficulties are to be encountered or the child is already older than 6-8 weeks and has thickened septum, cutting balloon or blade septostomy should be considered. A blade or cutting balloon septostomy can be followed be additional balloon dilatation to complete the result. For these patients, a controlled diameter of the opening is desired. For situations in which blade septostomy is difficult or the septum is subjected to recoil, controlled static balloon dilation of the atrial septum or stenting of the atrial septum could be necessary (3).
DISCUSSIONS

The creation or dilatation of an atrial communication is a risky procedure and therefore should be performed only by highly trained pediatric/congenital cardiologists with expertise in interventional therapy (3,4,19). The surgical and circulatory support backup should not be absent, and if surgical back-up and ECMO support are absent the interventional procedure should not be performed there. It is preferably that the catheterization laboratory should be equipped with biplane fluoroscopy imaging, otherwise the operator needs to rotate the plane in multiple views to assure safety of the procedure. Also, it is mandatory that the catheterization laboratory should be equipped with all the necessities: wires, catheters, balloons (including high-pressure and cutting balloons), retrieval catheters/snares, and devices (3,4,20,21).

Nowadays, the complications are considered to be very rare. Complications encountered during atrial septostomy could be classified into mechanical, traumatical, embolic, and electrical.

Mechanical complications include: rupture of the balloon with or without embolization of balloon fragments (22), for which angiographic or surgical retrieval is necessary, failure in balloon deflation (23), and inflation of the balloon in an inadequate position/place, that can be avoided by using both echocardiographic and biplan fluoroscopy guidance. For failure in balloon deflation there are at least three solutions described in literature: 1. the passage of a stylet wire in the balloon lumen to desobstruct it; 2. the connection of the balloon lumen to an injector followed by 3–5 cc contrast injected under pressure using 300 psi with balloon rupture and retrieving of the fragments, 3. the passage through the contralateral femoral vein with a long sheath and than with the stiff end of a wire, in order to puncture the balloon (3,4).

Traumatical complications include cardiac damage with rupture of the atrial appendage, (in left juxtaposition of the right atrial appendage, avoided by the use of biplane fluoroscopy and the echocardiography), mitral valve injury or vascular injury, of the pulmonary veins or the inferior caval vein.

Stroke, as an embolic complication, was described in association with balloon atrial septostomy (3,24), but there are meta-analyses reported in literature, which states that balloon atrial septostomy is not associated with increased odds for peri-operative brain injury (25-27), or in the follow up hospitalizations (27).

Electrical complications include transitory rhythm disturbances, which are frequent, and the rapid treatment modalities are a must in the catheterization laboratory (4).

Hybrid catheterization facility are now used for bringing the delivery room into the catheterization laboratory in order to avoid desaturation and cerebral hypoxia, which can have long term repercussions (28). In opposition, some centers (29) are trying to avoid Rashkind procedure, for instance in neonates with transposition of the great arteries, with intact ventricular septum and restrictive patent foramen ovale (PFO) with severe metabolic disorders, but with the substantial contribution of fetal echocardiography and a surgery disponibility in the first four hours of life. Although, in a large national analysis of transposition of the great artery patients, the subset treated with Rashkind procedure had a lower mortality (30).

CONCLUSION

Balloon atrial septostomy is the first option regarding dilatation of a persistent foramen ovale in the newborn with indication for atrial septostomy, although other new techniques have developed. It is done almost routinely in all case of transposition of the great arteries with restrictive interatrial communication, many times only by echocardiographic guidance. It is a challenging procedure that needs trained interventional/congenital cardiologists...
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and a well prepared catheterization laboratory, with the possibility for surgical or circulatory back-up. The complications are not to be neglected, but nowadays, they are few.

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