Hybrid Muscular Ventricular Septal Defect Closure: Literature and Results

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Ventricular septal defects (VSDs) are the most common congenital cardiac malformation at birth, with an incidence reported in literature between 15 and 40 % of total congenital heart diseases. They are usually an isolated finding; however, they can be also associated to complex congenital heart diseases [1, 2]. VSDs may be also a mechanical complication of myocardial infarction, with an incidence reported in literature of 0.26 % [3].

Nowadays, the treatment of choice is surgical repair, but in suitable cases (muscular or perimembranous VSDs), the percutaneous closure is a feasible alternative [1].

However, both surgery and transcatheter approaches may be associated to complications and limitations. In these cases the hybrid approach may provide a valuable alternative. In fact, Haponiuk showed an increased rate of hybrid therapy from 0 % in 2008 to 8.5 % in 2013 [4].

In particular, hybrid approach may be an interesting option in the following cases:

1. Residual VSDs after surgical closure [5]
2. Multiple VSDs, with some of them inapproachable by surgery such as defects under saepto-marginalis trabecula [6, 7] or apical [8, 9]
3. Intraoperative treatment during surgical correction:
   (a) Before de-banding of the pulmonary artery
   (b) Before the repair of aortic coarctation, during arterial switch for d-transposition of great arteries, or atrial septal defect surgical closure [4, 7, 9]

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G. Butera et al. (eds.), *Fetal and Hybrid Procedures in Congenital Heart Diseases*, DOI 10.1007/978-3-319-40088-4_40

(c) When it is expected from a suboptimal result of individual percutaneous/surgical treatment [4, 7, 10]
(d) To reduce the interventional related trauma, especially in high-risk patients as in small babies less than 5 kg or under 6 months of life
(e) Concomitant correction of other abnormalities [4, 7, 10, 11]
(f) Very high-risk patients because of prematurity, cyanosis, intolerance to drug therapy, failed interventional treatment prior to admission, chronic respiratory failure, mechanical ventilation prior to the procedure, association to noncardiac malformation (e.g., diaphragmatic hernia), or acquired health issues (renal failure, cerebral hemorrhage) [12]

There are several advantages of these techniques when compared to both percutaneous interventions and surgical treatments taken alone [7, 10–12].

In fact, it is possible to avoid ventriculotomy, the risks associated to cardiopulmonary bypass, cardioplegia, and the better accessibility for apical or saepto-marginalis VSDs. Compared to transcatheter treatment alone, there are no limitations related to vascular access or sheath size, less technical difficulties and hemodynamic instability related to arterio-venous circuit, and a more perpendicular approach of the VSD with the delivery system.

The main disadvantage of a hybrid treatment for VSDs is the need of a special hybrid operating theater that involves more expensive infrastructures, trained team, and the peculiar risks of complications related to this therapy. Furthermore, the devices and tools are not especially designed for this approach.

Since the first description in 1998, by Amin et al. [13, 14] in a child with postoperative residual VSD, the most frequent technique of hybrid closure of VSD is the perventricular approach, by the puncture of the free wall of the right ventricle. Success rate of the procedure ranges between 88 and 100 % [4, 6–16].

The hybrid procedure is performed under general anesthesia and echocardiographic guidance, in most cases transesophageal [9]. However, there are cases where the procedure was performed by using transthoracic guidance through the subcostal views, with similar procedural outcome [14], epicardial echocardiography [5–7, 12, 14], or intracardiac echocardiography [3, 14], both in bidimensional and tridimensional views [6].

The dose of anticoagulation is 50 % what needed for cardiopulmonary bypass (1.5 mg/kg/body weight) and has to be continued 48 hours after the procedure [4, 7, 9].

The heart is approached usually by a median sternotomy; however, there are cases described in literature through a lateral thoracotomy or subxiphoid access for apical VSDs [7, 9, 12].

The place of the cardiac puncture is chosen by tipping the right ventricle wall in order to have a perpendicular route over the VSD and to avoid the coronary arteries, major chordae, or papillary muscles [9]. For apical VSDs, the puncture is performed at 1.5 cm by the apex, for the best angle to approach the defect [6].

After the puncture, with fluoroscopy and echocardiographic guidance, the VSD is passed with a guidewire in the left ventricle, and the occluder is placed. The Amplatzer muscular VSD occluder is the more frequently used device.

However, there are cases reported in literature where the Shanghai Shenzhen occluders [14] or the Cardi-O-Fix [11] was used successfully. Another possible approach is by using an atrial puncture access [4, 9, 10].

Although transient arrhythmia and hypotension are common during the procedure [14], there are other complications reported in literature including late malposition of the device [14], immediate embolization [8, 11], aortic regurgitation [14], progressive mitral regurgitation [9], puncture of the left ventricle with pericardial leakage [9], late right ventricle pseudoaneurysm [8], prolonged QRS, or total atrioventricular block [11].

Hybrid treatment of the VSD is an important option in selected cases. Trained team and infrastructure are mandatory. Data from literature are very encouraging.

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