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A Novel Approach for Off-Pump Atrial Septostomy Applications

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ABSTRACT

Atrial septostomy or septectomy are required to enable atrial mixture in various congenital cardiac lesions. The aim of this article was to introduce a technique where atrial septostomy application could be employed off pump with the aid of a new device. To our knowledge this is the first report for this technique in the literature. We report the results of 7 patients for whom we employed our technique succesfully using a new combined device as an alternative to traditional methods. The major advantage of our approach was avoiding detrimental effects of cardiopulmonary bypass applications.

INTRODUCTION

Although definitive treatment is highly desired, palliative treatment still has a vital place in the treatment of congenital cardiac lesions. Some cardiac anomalies are associated with anomalous systemic or pulmonary blood flow where the patient's survival depends on adequate and uninterrupted blood flow between left and right atria. The transposition of great arteries, total anomalous pulmonary venous return, tricuspid atresia or pulmonary atresia, hypoplastic left heart syndrome, or hypoplastic right heart anomalies are examples of such clinical scenarios [Jamjureek 1997].

The two major reasons for atrial septostomy or septectomy are: (1) to provide interatrial flow and (2) to reduce right and left atrial pressure (decompression). In this respect, atrial septostomy to provide saturated and unsaturated blood flow is one of the major palliative procedures [Mahajan 2002]. Additionally, in recent years balloon atrial septostomy has been performed on patients with primary pulmonary hypertension [Reichenberger 2003; Micheletti 2006] and for the treatment of cardiogenic shock following coronary bypass operations [Kemis 2003].

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The recently employed techniques for atrial septostomy or septectomy are the Park-blade septostomy through catheterization, Rashkind-Miller balloon septectomy, septectomy using surgical cardiopulmonary bypass pump (CPB), Blalock-Hanlon septectomy without CPB (off-pump), and the inflow occlusion method. Additionally, the use of an aortic punch [Mahajan 2002] and forcep have been reported for off-pump atrial septostomy [Murayama 2006].

Our proposed technique that does not require performing CPB is applicable to cases where a balloon atrial septostomy cannot be performed. Atrial septostomy can be performed quickly and safely with this technique and the aid of a simple device. Additionally, the detrimental complications of CPB can be avoided and procedures such as the aorta-pulmonary artery shunt operations, pulmonary artery banding, and aortic coarctation repair can easily be performed.

MATERIALS AND METHODS

The aim of this study was to introduce a novel approach for atrial septostomy. Patients in need of atrial septostomy generally have pressure differences between the right and left atrium due to pulmonary congestion as a result of limited flow at the interatrial septum and left and/or right venticular stenosis. This causes right septal deviation . In this respect, the pressure differences were of pivotal importance for our procedure, and a simple device was developed that comprised a needle connected to the end of a surgical blade with an attachment to a pressure-monitoring device that enabled us to monitor pressure changes during dissection of the inter-atrial wall (Figure 1). Atrial septostomy without cardiopulmonary bypass was performed using this device through a purse-string suture placed around the right atrial appendage. Atrial septostomy without CPB (off-pump) was performed for 7 cases. In addition to atrial septostomy, some operations such as pulmonary artery banding, repair of aortic coarctation, and aorta-pulmonary artery shunt procedures were also performed during the operations through sternotomy. Postoperative echocardiography showed adequate blood flow through the septal defects in all cases with no intraoperative or postoperative complications. Follow-ups at 6 months were uneventful for all patients.

Seven cases underwent operation between December 2003 and 2006 (Table). Aorta-pulmonary artery central shunt

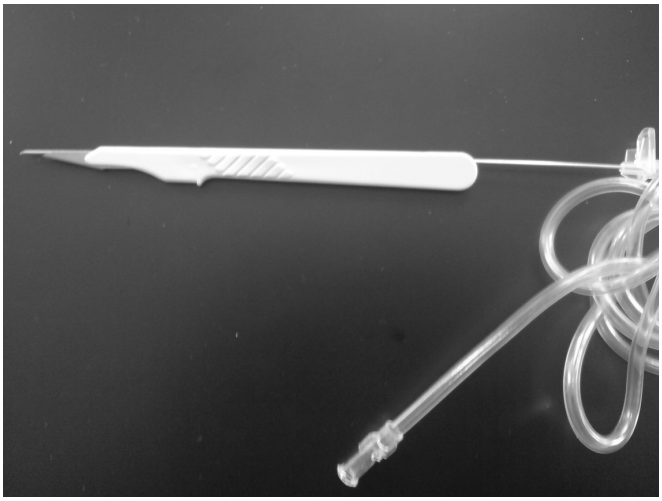

Figure 1. Needle attached to surgical blade connected to pressure monitoring line.

operation, pulmonary artery banding, correction of aortic coarctation, and patent ductus arteriosus (PDA) ligation were performed in corresponding cases with off-pump atrial septostomy. Following the induction of general anesthesia, the central venous pressure (CVP) was monitored using a CVP catheter (in the jugular or subclavian vein) and the arterial pressure was monitored with an arterial catheter (in the radial or bracial artery). An additional line was attached to the monitor to read the pressure values from the septostomy device.

A cardiopulmonary pump was available in case of an emergency. A single dose of heparin was applied at a dose of 100 IU/kg to the patients. In the case of a patient who had an aorta-pulmonary artery shunt operation, 25 IU/kg per hour postoperative heparin was given for the initial 24 hours followed by acetylsalicylic acid at a dose of 3 to 5 mg/kg per day. Following median sternotomy, the pericardium was opened and suspended in all cases. Heart anatomy was reassessed, with particular attention to left and right atria and the location of superior and inferior vena cava. Superior and inferior vena cava were explored and suspended. Purse-string sutures were placed around right atrial appendages. The device was prepared by inserting the pressure transducer line to the needle . There was a 5-mm space in between the needle and surgical blade. This assambled device enabled us to monitor the pressure and operate at the same time. Right atrium, pulmonary vein, and left atrium pressures were measured with this technique. A purse-string suture was inserted into the right atrium in each patient. The purse-string suture was tightened in order to avoid bleeding after this device was introduced into the right atrium. The device was then moved through the atrial septum, and the pressure was monitored. The septum was cut through the inferior vena cava using a surgical blade attached to a needle and the pressure differences correlated with the preoperational readings. In all cases, there was a significant pressure difference between right and left atrium where left atrium pressure was higher than right atrium. The needle connected to the pressure transducer showed dramatic decrease of pressure in the left atrium as a result of the atrial septostomy and the pressure difference was minimized between the right and left atrium. Oxygen saturation was also monitored during the operation as a means to verify the effectiveness of the septostomy. The device was then withdrawn and a purse-string suture inside the right atrium was tightened. The process was finalized by

Patient Data*

Case Number	Age/Sex	Preoperative O_2 Saturation	Postoperative O_2 Saturation	Diagnosis	Atrial Septal Defect Diameter	Operations Performed	Day of Discharge
1	6 months/female	55	86	HRV, VSD, PHT, TGA	6 mm	Atrial septostomy, pulmonary banding	12
2	3 months/male	40	95	TGA, VSD, SPD, PFO	8 mm	Atrial septostomy, aorta-pulmonary shunt (5-mm PTFE tube graft)	56
3	24 months/male	50	90	TGA, VSD, SPD, PFO	6 mm	Atrial septostomy, aorta-pulmonary shunt (5-mm PTFE tube graft)	60
4	3 months/male	55	90	MA, SV, PHT	7.3 mm	Atrial septostomy, aorta-pulmonary shunt (5-mm PTFE tube graft)	16
5	6 months/female	48	88	MA, VSD, PDA, AC, PFO	8 mm	Atrial septostomy, pulmonary banding, correction of coarctation (end-to-end anastomosis), PDA ligation	22
6	7 months/female	68	89	DILV, TGA, MA, PH	6 mm	Atrial septostomy, pulmonary banding	40
7	8 months/male	60	88	TAPVD, DORV, TGA, MA, PDA, HLV	7 mm	Atrial septostomy, PDA ligation, pulmonary banding	20

*HRV indicates hypoplastic right ventricle; VSD, ventricular septal defect; PHT, pulmonary hypertension; TGA, transposition of the great arteries; SPD, subpulmonary stenosis; PFO, patent foramen ovale; PTFE, polytetrafluoroethylene; MA, mitral atresia; SV, single ventricle; PDA, patent ductus arteriosus; AC, aortic coarctation; DILV, double inlet left ventricule; TAPVR, total anomalous pulmonary venous return; DORV, double outlet right ventricle; HLV, hypoplastic left ventricle.

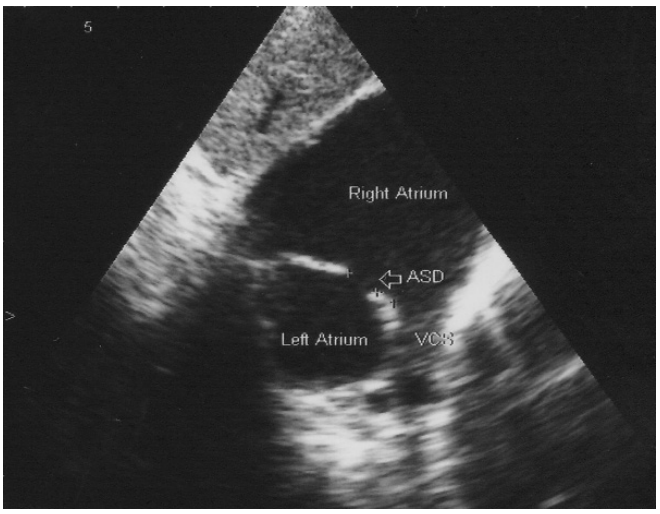

Figure 2. Postoperative echocardiography showing surgically created atrial septal defect. VCS indicates vena cava superior.

comparing preoperative and postoperative left and right atrium pressure differences. In all the cases the difference was removed or minimized. Simultaneous operations such as aorta-pulmonary artery shunt procedure, pulmonary artery banding, and correction of aortic coarctation were also performed. There were no intraoperative or postoperative complications. Postoperative echocardiography was done on days 1 and 7 and at 6 months for all patients. Postoperative follow-up was performed in the pediatric intensive care unit and pediatric out-patient clinic from the second day of operation to 6 months.

RESULTS

Necessary operations such as aorta-pulmonary artery shunt, pulmonary artery banding, correction of aortic coarctation, and PDA ligation were also performed synchronously during the operations in addition to off-pump atrial septostomy. Atrial septostomy was performed succesfully in all the cases. Postoperative echocardiography showed adequate bloodflow from the atrial septum in all cases (Figure 2). The age of the patients ranged from 3 to 24 months. Three of our patients (patients 2-4) were operated on under emergency circumstances. These patients had anoxic spell attacks frequently; additionally, pulmonary congestion symptoms developed in patient 4. Patients 2 and 3 were underwent operation urgently following an unsuccessful balloon septostomy attempt, then atrial septostomy and aorta-pulmonary shunt (5-mm polytetrafluoroethylene tube graft) were performed. Blood oxygen saturation quickly increased to adequate levels following atrial septostomy.

Postoperative follow-up was uneventful for all patients. The length of stay at the hospital was between 12 to 60 days. Two patients (number 2 & 3) were discharged from the hospital after 60 days. Their extended stay was due to lung infection, sepsis, and extended mechanical ventilator problems. Adequate atrial septal defect was verified through echocardiography taken during the postoperative follow-up at 6 months. Minimum 30 to 50 mmHg pressure gradient was achieved in all the cases where pulmonary artery banding was performed. Continous flow in the aorta-pulmonary artery graft was monitored in the cases where an aorta-pulmonary artery shunt operation was performed.

Pulmonary artery banding, aortic coarctation repair, PDA ligation, and aorta pulmonary artery shunt were also performed when it was necessary in addition to atrial septostomy using this technique during the operation. There was no intraoperative or postoperative mortality .

DISSCUSSION AND CONCLUSIONS

Creating atrial septal defects to increase the atrial flow was introduced by Blalock without using CPB [Blalock 1950]. Major complications of this technique was arterial desaturation, hypotension, bleeding, and mortality.

Balloon septectomy was introduced by Rashkind-Miller [Mahajan 2002] and in this technique, a balloon-headed catheter inserted into the left atrium through the right atrium was inflated and then withdrawn back to the right atrium. As a result of this procedure, the patent foramen ovale was enlarged.

Septostomy methods hat are used at catheter laboratories are also available. However, some problems such as vascular access, patent foramen ovale requirement, and unsuccessful applications due to the tickness of septal wall can be encountered with these applications [Mahajan 2002].

Another approach is an open septostomy application with CBP. However, detrimental effects of CPB are widely known and alternatives to these traditional techniques such as using an atriotomy blade with the beating heart [Van Son 1995], using forceps with the beating heart or utilizing an aortic punch [Mahajan 2002] without CBP-accompanied transesophageal echocardiography have been developed.

The major advantage of our approach was avoiding CBP application ,which might cause cellular damage as well as other complications [Seghaye 1996; Huang 2003]. Another advantage was that the pressure-monitoring line could easily be inserted by the surgical blade with reasonable applicability to enable pressure assessment during the operation. The device moved as a single unit, which gave it flexibility during the operations and was very easy and safe to manipulate within the atrium. There is also room for further improvements in addition to cutting and pressure-monitoring capabilities of this device. This approach, which uses median sternotomy, is likely to also be applicable using right anterior toracotomy, as the superior and inferior vena cava right atrium are easily accessible through this approach. As a result of the capability of this technique, additional procedures other than atrial septostomy can be performed using this approach, especially for the treatment of congenital heart diseases.

Although transesophageal echocardiography is traditionally used for adult heart surgery, pediatric heart surgery applications have been increasing recently [Kyo 1990;

Stevenson 1995; Komai 1999]. In our center, transesophageal echocardiography capabilities were unavailable; however, our procedure was performed succesfully without transesophageal echocardiography. Incorporation of transesophageal echocardiography may increase the effectiveness of our approach.

The aim of this paper was to develop a novel off-pump atrial septostomy technique as an alternative to traditional methods, using a new combined device.

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