

Surgical Closure of Sinus Venosus Atrial Septal Defect Using A Single Patch—Transcaval Repair Technique

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ABSTRACT ***Objective:*** **We would like to share our experience of surgical repair of sinus venosus atrial septal defect (ASD) using a simple "transcaval repair technique."** ***Method:*** **Between January 2007 and October 2010, 48 consecutive patients of sinus venosus ASD underwent surgical repair using transcaval repair technique at our institute. Their ages ranged from 5 to 15 years and male to female ratio was 1.6:1. The principles of the technique were longitudinal incision over the lateral aspect of superior vena cava (SVC) at the entry point of anomalous right pulmonary veins, use of a single autologous untreated pericardial patch, and finally closure of the caval incision in such a way that the patch gets sandwiched between two caval lips.** ***Results:*** **All 48 patients came off cardiopulmonary bypass in sinus rhythm. The average pressure gradient across the patch was 3 mmHg. Immediate postoperative electrocardiograms and echocardiograms showed all patients were in sinus rhythm with no residual shunt and no pulmonary or systemic venous obstruction respectively, except in one patient who required SVC augmentation. The follow-up was done at three months (100%), one year, and two years. All patients were asymptomatic and their electrocardiograms and transthoracic echocardiograms revealed sinus rhythm, no residual shunt, and no obstruction to systemic or pulmonary venous drainage, respectively. There was no early or late mortality.** ***Conclusion:*** **We conclude that this technique is safe and simple for the repair of selected cases of sinus venosus atrial septal defect with partial anomalous pulmonary venous connection and it preserves the sinoatrial node function after surgery.** doi: 10.1111/j.1540-8191.2011.01270.x *(J Card Surg 2011;26:429-434)*

Sinus venosus atrial septal defect (ASD) with partial anomalous pulmonary venous connection accounts for approximately 10% of patients presenting for surgery of an ASD. Various surgical techniques are being used to repair this defect. Most of them are associated with sinus node dysfunction and development of new and persistent atrial arrhythmia in approximately 30% of patients as reported in the literature.[2,5] Obstruction to the superior vena cava (SVC) and pulmonary veins is also reported. We are describing here our experience and some of the important technical details of a "transcaval repair technique." This technique was originally described by Nicholson et al.[5] In this technique, the approach is through a longitudinal incision on the lateral aspect of the SVC and use of a single autologous untreated pericardial patch to close the sinus venosus ASD in such a way that anomalous pulmonary veins are rerouted to the left atrium.

Conflict of Interest: None.

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MATERIAL AND METHODS

From January 2007 till October 2010, 66 consecutive patients of sinus venosus ASD got operated at our institute. Of 66 patients, 48 patients underwent transcaval repair of sinus venosus ASD with partial anomalous pulmonary venous correction. Their ages ranged from 5 to 51 years. Male (n = 29) to female (n = 19) ratio was 1.6:1. Clinical presentation included one of the following complaints: shortness of breath NYHA class II in 32 patients and NYHA class III in 16 patients. Recurrent respiratory tract infection was present in 28 patients. Physical examination revealed wide and fixed splitting of second heart sound at pulmonary area with flow murmur across the tricuspid valve. Chest radiography showed cardiothoracic ratio ranging from 55% to 70% with increased pulmonary vacularity. Electrocardiogram revealed sinus rhythm and right ventricular hypertrophy. Transthoracic and transesophageal echocardiography revealed sinus venosus ASD with partial pulmonary venous connection of right upper and middle lobe pulmonary veins with mild-to-moderate pulmonary hypertension. Six patients had small patent foramen ovale or ostium secundum type of ASD and two patients had large ostium secundum ASD.

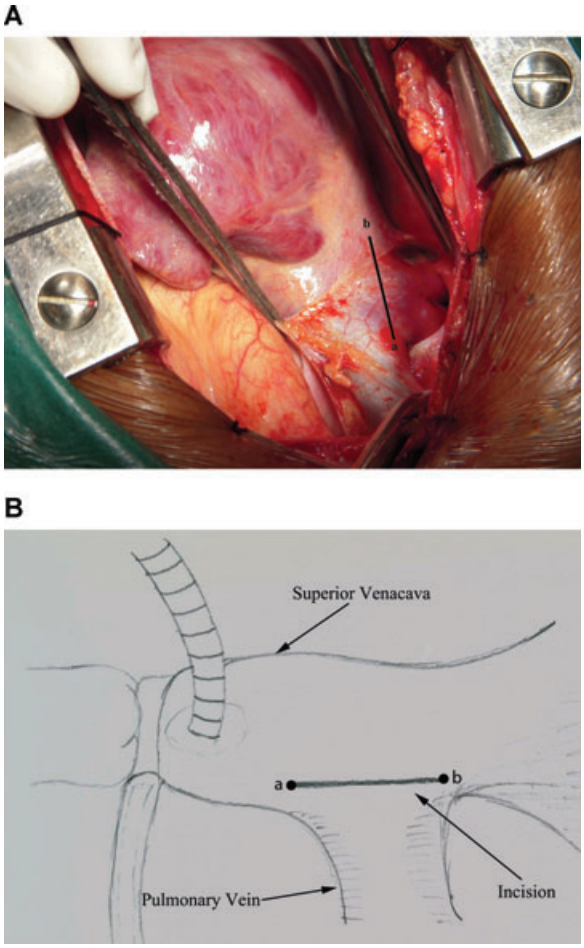

Figure 1. *(A) External anatomy assessment in the form of anomalous pulmonary venous drainage into the SVC and the size of SVC. (a) SVC is dissected up to the innominate vein, which helps in clearing the site for SVC cannulation and detection of abnormal drainage of additional pulmonary vein higher up in SVC. (b) Incision is placed on the anteriolateral wall of the SVC at the site of anomalous pulmonary venous drainage (a to b). (B) Line diagram showing the external anatomy and site of incision on the lateral aspect of SVC. SVC = superior vena cava.*

Operative technique

The anaesthesia, preparation, and positioning of the patient was performed in usual ways. A shorter length of central venous catheter was placed in the internal jugular vein, so that the end of the catheter remains above the proposed patch. Intraoperatively this catheter has helped in measuring the pressure gradient across the patch.

After median sternotomy, the pericardium was cleared of the pleural reflection. The pericardium was opened toward the right and stay sutures were placed. The external anatomy was assessed in the form of site of pulmonary venous drainage in SVC, size of SVC, and presence of left SVC (LSVC) (Fig. 1A). The SVC was dissected up to the innominate vein; this has helped by clearing the area for SVC cannulation, identification of an additional pulmonary vein opening higher up in the SVC, and looping of SVC above the pulmonary venous opening (Fig. 1A).

The pursestring sutures were taken on aorta, SVC, and inferior vena cava (IVC). After heparinization, aorta and IVC were cannulated. The IVC was cannulated first because it helped with safer, smoother, and easier cannulation of SVC. The SVC was cannulated with smaller sized angled cannula near the SVC-innominate vein junction. The presence of LSVC required separate cannulation or a clamp after monitoring the pressure in cases where central venous cannula was put in the left internal jugular vein.

Cardiopulmonary bypass (CPB) was established and aorta was cross-clamped. A single dose of cold blood cardioplegia was infused through the aortic root. The patient was cooled to 32°C . An incision was made on the lateral aspect of the anterior wall of SVC (Fig. 1A and B). The incision was extended in both the directions, superiorly up to the upper border of the pulmonary vein and inferiorly up to the lower margin of sinus venosus atrial septal defect (SV ASD). The cavoatrial junction was kept intact; 4-0 silk stay sutures were taken on the lips of SVC incision. This maneuver has helped in giving better exposure without traumatizing the sinoatrial node (SA node).

The anatomically important landmarks were identified at this stage (Fig. 2A and B). After assessing the anatomy, the measurements of the patch were taken (Fig. 3A–C) and an autologous pericardial patch of measured size was cut (Fig. 4). A double armed 5-0 polypropylene suture on 13-mm needle was used to suture the pericardial patch. The suturing was started at the inferomedial border of the SV ASD (Fig. 5A and B) and continued superiorly on to the transition zone (Fig. 6A and B) till it came out at the superior angle of the incision. The other end was continued in the same manner up to the inferior angle of the incision. At this stage, the patch was reassessed for redundancy and the excess portion of the patch was trimmed. The patch was now incorporated between the caval lips from both ends (Fig. 7A and B). The de-airing procedure was done simultaneously for both sides of the heart. After aortic declamping, weaning from CPB and decannulation was done in a usual way. A dry gauze piece was placed on the suture line till the heparin was reversed. Gradient across the patch was checked by simultaneous monitoring of pressure in internal jugular vein catheter and temporary pressure line in right atrial appendage. A gradient up to 3 to 4 mmHg was accepted. The final appearance (Fig. 8) and schematic presentation after final repair is shown in Figure 9. After hemostasis, pericardium over the aorta and chest were closed in a usual manner.

The presence of small atrial septal defect or patent foramen ovale was closed from same incision or required a separate atriotomy for larger ostium secundum ASD. Average clamp time was 24 minutes and pump time was 32 minutes. All patients underwent electrocardiogram and echocardiogram on the operative day night as well as just before the discharge from the hospital. Holter monitoring was not required in any case.

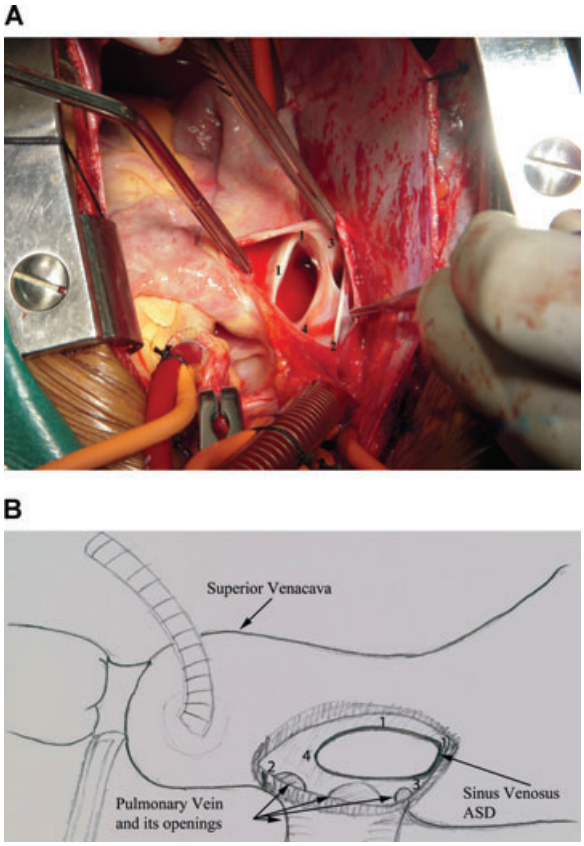

Figure 2. *(A) Anatomically important landmarks for repair: (1) The margins of the ASD; (2) the junction of the most superior anomalous pulmonary vein with the SVC; (3) the junction of the most inferior anomalous pulmonary vein with the SVC; and (4) the important transition zone from medial margin of ASD into the posterior wall of SVC up to the upper margin of the most superior pulmonary vein. (B) Line diagram showing the important landmarks for repair. SVC = superior vena cava; ASD = atrial septal defect.*

RESULTS

All 48 patients came off CPB in sinus rhythm. The average pressure gradient across the patch was 3 mmHg. The electrocardiogram and transthoracic echocardiogram were done in the intensive care unit on the day of operation and just before the discharge. Electrocardiogram showed sinus rhythm in all patients and transthoracic echocardiogram revealed sinus rhythm, no residual shunt, and nonobstructive pulmonary and systemic venous flow with no gradient across the patch, except in one patient. In the immediate postoperative period, one patient developed SVC obstruction and thrombosis due to redundant patch and required an SVC augmentation by a second patch medial to the previous suture line (Fig. 8). The Holter monitoring was not done for any patient as all patients came off CPB in sinus rhythm and their periodic electrocardiograms in intensive care unit and ward showed sinus rhythm. Follow-up was done at three months (100%), one year, and two years. All patients underwent electrocardiogram and echocardiogram at follow-up. All of them were asymptomatic and their electrocardiograms and transthoracic echocardiograms revealed sinus rhythm, no residual shunt, and no obstruction to systemic or pulmonary venous drainage, respectively. There was no early or late mortality.

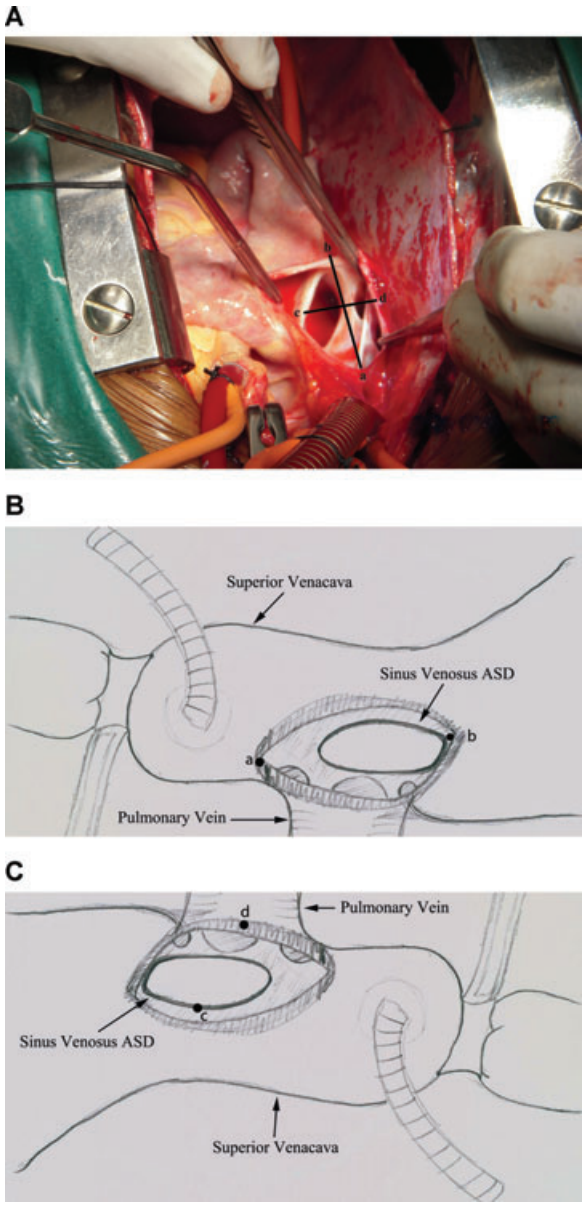

Figure 3. *(A) Measurement for the patch to be taken as the vertical distance between the upper edge of the superior pulmonary vein and the lower border of the ASD (a to b) and horizontal distance is measured between the medial margin of ASD and the lateral edge of the caval incision (c to d). (B) Line diagram showing the vertical distance between the upper edge of the superior pulmonary vein and the lower border of the ASD (a to b). (C) Line diagram showing the horizontal distance between the medial margin of ASD and the lateral edge of the caval incision (c to d). ASD = atrial septal defect.*

DISCUSSION

The sinus venosus ASD with partial anomalous pulmonary venous connection is characterized by one or more of right pulmonary veins abnormally opening into the SVC or SVC-RA junction. The goal of surgical repair

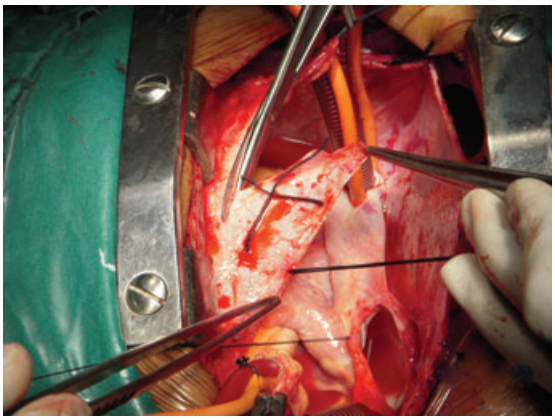

Figure 4. *An autologous pericardial patch is been cut according to the measurements.*

is to close the defect in the interatrial septum in such a way that it creates an unobstructed systemic and pulmonary venous drainage. Several techniques have been described in the literature and they include single-

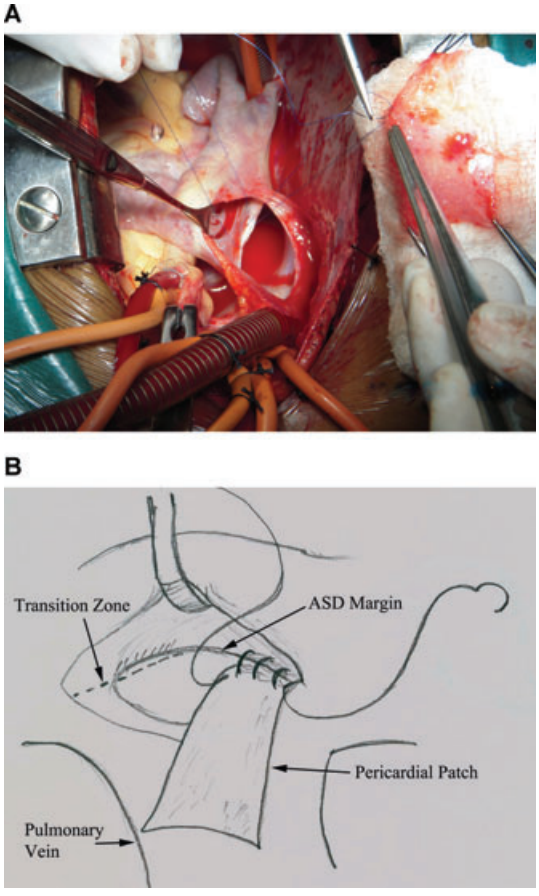

Figure 5. *(A) The pericardial patch is kept on the surgeon's side and a 5–0 polypropylene suture on 13-mm needle is taken to suture the patch. The suturing is started at the inferomedial margin of the ASD and continued in the superior direction across the transition zone and exteriorized at superior angle of the incision. (B) Line diagram showing the suturing of pericardial patch started at the inferomedial margin of the ASD. ASD = atrial septal defect.*

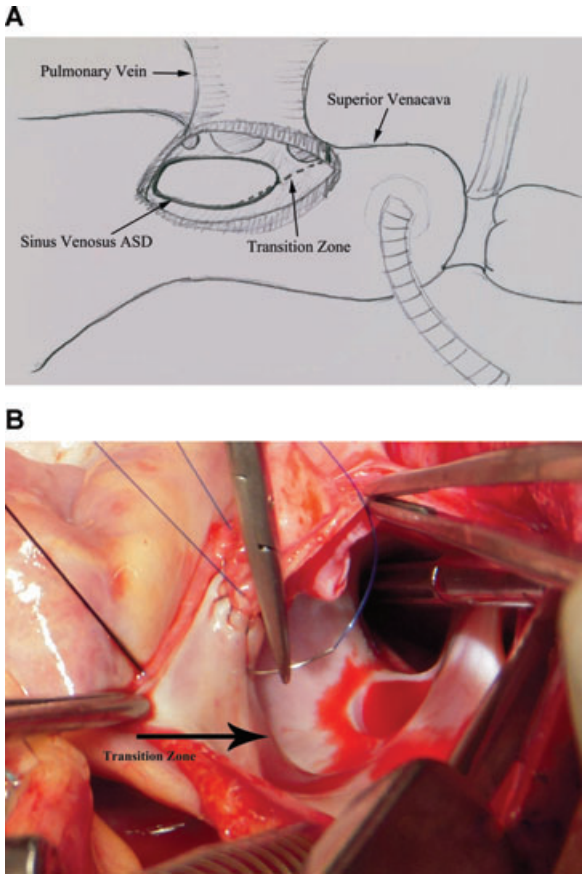

Figure 6. *(A) Line diagram showing an important transition zone. (B) The transition zone starts from the center of the medial margin of ASD and runs on the posterior wall of the SVC up to the superior margin of upper most pulmonary vein. ASD = atrial septal defect.*

or double-patch technique,[1,2,8,9] use of right atrial free wall muscle flaps,[3] and a Warden technique.[4,6]

All these techniques are associated with important surgical morbidity such as obstruction to the systemic and pulmonary vein orifices, sinus node injury, and atrial bradyarrhythmias, but more recent series have reported more favorable outcomes with minimal or no morbidity.[5,7,8–11]

Atrial arrhythmias are commonly reported both early and late after closure of an ASD. Sinus node dysfunction may occur from an incision on the sinus node directly or due to injury to the sinus node artery. The sinus node artery runs in the region of the cavoatrial junction or in the lateral free wall of the right atrium. Therefore an incision that crosses the cavoatrial junction or the lateral free wall of the right atrium has the potential to damage the sinus node arterial supply. Retraction of the sinus node without vascular injury may also contribute to postoperative sinus node dysfunction.[5]

A limited lateral transcaval approach popularized by Nicholson and colleagues[5] for the sinus venosus syndrome avoids an incision in the region of the sinus node artery and still allows excellent visualization of the vital anatomic landmarks of the repair. Stays on both

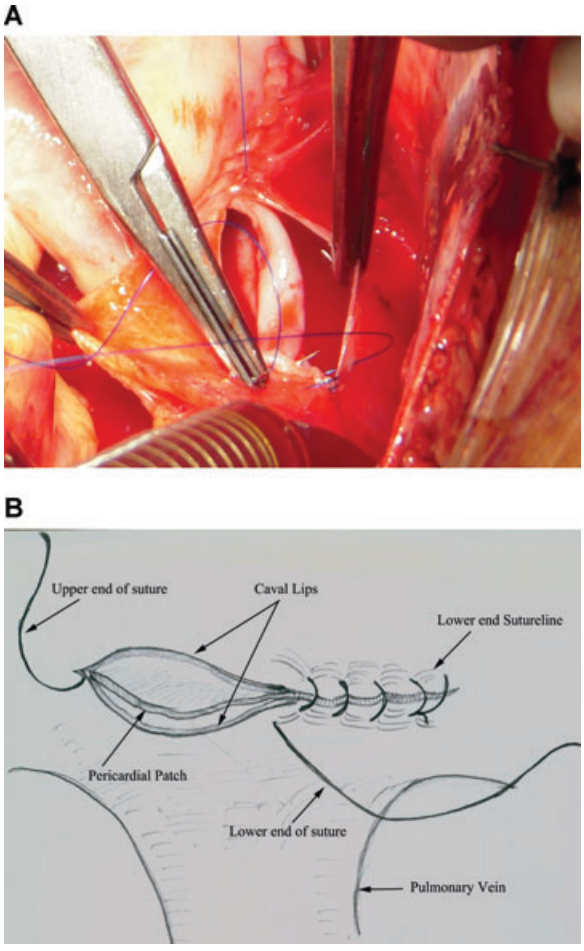

Figure 7. *(A) The pericardial patch is being sandwiched between the two lips of the caval incision. (B) Line diagram showing the caval closure in such a way that patch remains between the two lips of the superior vena cava.*

the lips of caval incision avoids retraction, thus pressure on the sinoatrial node. This approach is simple for the baffling of anomalous pulmonary venous return through the sinus venosus defect to the left atrium

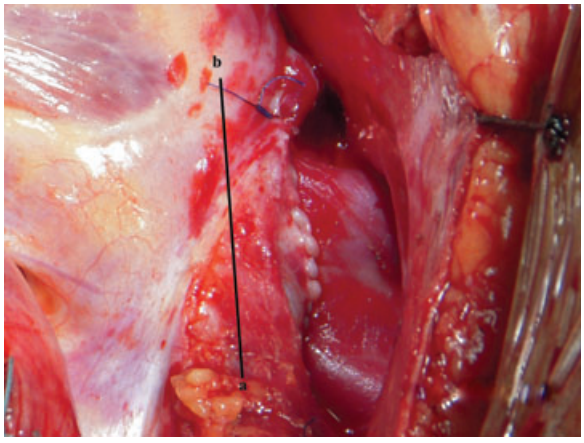

Figure 8. *Final external appearance of the repair: (1) The site of incision and SVC augmentation in case of SVC obstruction (a to b). SVC = superior vena cava.*

Figure 9. *Schematic diagram of the final repair; a cross-section of the SVC at the level of repair, looking from SVC into the right atrium showing the pericardial patch bridging the deficient portion of the interatrial septum in such a way that the anomalous right pulmonary veins drain into the left atrium (arrows).*

with single pericardial patch. An adequate sized patch prevents obstruction to the SVC. The SVC is usually dilated in the region of the anomalous pulmonary veins, and the pericardial patch used as a baffle simply replaces the deficient posterior wall of the SVC without producing pulmonary venous obstruction. This technique is used only when the pulmonary veins drain at the lower end of SVC or at the SVC-RA junction. In case of pulmonary veins draining high up in the SVC, two-patch techniques or caval transaction and cavo-right atrial appendage anastomosis are advisable. The commonest complication of this technique is SVC obstruction apart from other complications such as pulmonary venous obstruction (rare) or arrhythmia. SVC obstruction occurs either due to redundant patch or small-sized SVC (very rare). Intraoperatively, this can be detected by high central venous pressure (more than 8 to 9 mmHg) and gradient across the patch more than 3 to 4 mmHg,[12,13] if the patient is in sinus rhythm. Russell et al. described in their report that the gradient across the SVC-RA junction up to 4 mmHg is acceptable and >4 mmHg requires intervention.[12] Sojak et al. described in their report that two of their patients developed SVC stenosis and pressure gradient >5 mmHg required reintervention.[13] In the intensive care unit, this condition presents as a progressive rise in the central venous pressure and edema of the face, eyes, and upper limb. Echocardiography with color Doppler is diagnostic. Obstruction can be relieved by an additional pericardial patch medial to the previous suture line on CPB.

CONCLUSION

The "transcaval repair technique" is simple, safe, quick, and reproducible; it does not cause sinus node dysfunction and with careful hands avoids systemic and pulmonary venous obstruction.

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