Surgical Techniques

The Warden Procedure through a Posterolateral Thoracotomy Approach

Sowmya Ramanan, MRCS(ED), MCh
Navaneetha Sasikumar, MD, DM
Soman Rema Krishna Manohar, MS, MCh
Kotturathu Mammen Cherian, FRACS

The Warden procedure for the correction of a right-sided partial anomalous pulmonary venous connection to the high superior vena cava is well established. It has the advantages of avoiding sinoatrial node dysfunction and pulmonary and systemic venous obstruction. In the case related here, a 3-year-old girl presented with a superior vena cava type of sinus venosus atrial septal defect and an anomalously draining right upper pulmonary vein, with bilateral superior venae cavae. Our approach to the Warden procedure was through a right posterolateral thoracotomy, which provided additional advantages. ***(Tex Heart Inst J 2014;41(5):499-501)***

Key words: *Heart defects, congenital; heart septal defects, atrial/surgery; pulmonary veins/abnormalities; sinoatrial node/abnormalities; thoracotomy/methods; vena cava, superior/abnormalities*

From: *Departments of Pediatric Cardiac Surgery (Drs. Cherian, Ramanan, and Krishna Manohar) and Pediatric Cardiology (Dr. Sasikumar), Frontier Lifeline Hospital and Dr. K.M. Cherian Heart Foundation, Chennai 600101, India*

Address for reprints: *Sowmya Ramanan, MRCS(ED), Consultant Cardiac Surgeon, Frontier Lifeline Hospital and Dr. K.M. Cherian Heart Foundation, R 30C, Ambattur Industrial Estate Rd., Mogappair, Chennai 600101, India*

E-mail: *drsowmyavr@yahoo.co.in*

The definitive treatment of a right-sided partial anomalous pulmonary venous connection is surgical rerouting of that vessel to the left atrium. The commonly used techniques are the internal patch (1- and 2-patch) and the Warden (caval division with atriocaval anastomosis).[1] The latter, reported in 1984 by Warden and colleagues,[2] is a technique whereby the superior vena cava (SVC) is divided, the cephalic SVC anastomosed to the right atrial appendage (RAA), and the caudal SVC redirected to the left atrium, to serve as a conduit for pulmonary venous drainage. The advantages of the Warden procedure include the avoidance of sinus node dysfunction[1,3,4] and of pulmonary and systemic venous obstruction.[1,3-5] Initially, the surgery was performed through a right anterolateral thoracotomy or a median sternotomy.

Posterolateral thoracotomy is an alternative both to sternotomy and to right anterolateral thoracotomy.[6] The advantages are that a posterolateral scar provides better cosmesis than an anterior scar and will not impede the growth of breast tissue and the pectoralis major.[6] However, the complexity of a cardiac lesion can be a deterrent to the routine use of this approach.

We report the use of a posterolateral thoracotomy to perform the Warden procedure in a 3-year-old girl who had an SVC type of sinus venosus atrial septal defect (ASD), a right-sided partial anomalous pulmonary venous connection, and bilateral SVCs (with the left SVC draining into the coronary sinus).

Surgical Technique

We placed the patient in a left lateral position, under general anesthesia, endotracheal intubation, and invasive monitoring. We then made a limited posterior thoracotomy incision, starting at the posterior axillary line 2 inches below the inferior angle of the scapula. The chest was opened in the 4th intercostal space. The retractor was opened in stages, to avoid rib fractures. The right lung was retracted. The right lobe of the thymus was excised, exposing the pericardium over the ascending aorta. We opened the pericardium anterior to and parallel with the phrenic nerve and anchored the pericardial edges to the chest wall (Fig. 1), thereby fully exposing the aorta and the right atrium and pulling the heart closer to the surgeon. The right SVC was dissected, and marking stitches were positioned on its lateral walls and corresponding points in the RAA, to avoid later distortion of the cavoatrial anastomosis. Heparin was administered and cardiopulmonary bypass was established with aortic and RAA cannulation. We circumferentially dissected the right SVC up to the level of the right subclavian vein. The azygos vein was doubly ligated, clipped, and divided. Low inferior vena cava (IVC) cannulation was performed, and an appendage vent replaced the right atrial cannula. The IVC was snared and the right SVC was clamped high.

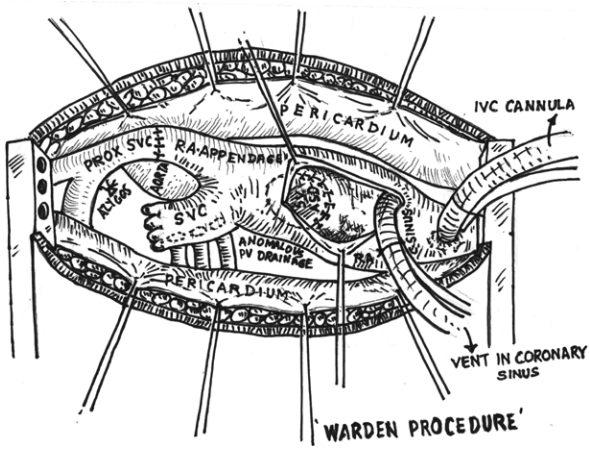

Fig. 1 *Diagram shows the Warden procedure performed through a posterolateral thoracotomy. The right atrium is open. The cavoatrial anastomosis is complete. A pericardial patch closes the sinus venosus atrial septal defect (SVASD), rerouting the superior vena cava into the left atrium. The caudal end of the superior vena cava has been closed with pericardium.*

ASD = atrial septal defect; C sinus = coronary sinus; IVC = inferior vena cava; Prox = proximal; PV = pulmonary venous; RA = right atrial; SVC = superior vena cava

The aorta was cross-clamped and the heart arrested via antegrade administration of cardioplegic solution at the aortic root. The patient was cooled to 28 °C. The right atrium was opened parallel to the atrioventricular groove. Another vent was introduced into the coronary sinus to drain the left SVC, and the appendage vent was removed and introduced into the left atrium through the patent foramen ovale. The anatomy was inspected. Fresh autologous pericardium was used to baffle and reroute the caudal right SVC into the left atrium, thereby closing the sinus venosus ASD. The SVC was divided obliquely above the insertion of the highest anomalous pulmonary vein. The caudal stump was closed with autologous pericardial patch by means of 7-0 Prolene suture. The RAA was amputated and enlarged to the diameter of the proximal right SVC. All bands within the appendage were excised to ensure smooth flow of SVC blood to the right atrium after the anastomosis. The distal end of the right SVC was anastomosed to the RAA with use of 7-0 Maxon™ continuous suture (Covidien; Mansfield, Mass); these sutures were interlocked (Fig. 1) to avoid the purse-string effect upon tying. The right atrium was closed in a single layer. The postoperative recovery was uneventful.

Follow-Up. The patient had no anastomotic or neurologic complications in the immediate postoperative period and was asymptomatic at her one-year follow-up visit. She remained in sinus rhythm, with normal flow in the pulmonary veins and in the SVC, as indicated in follow-up visit echocardiograms.

Discussion

The use of a posterior thoracotomy has the advantages of better cosmesis and reduced incidence of keloid formation (in comparison with sternotomy), and of avoiding periareolar numbness and damage to the breast tissue (in comparison with anterior thoracotomy).[6] However, cosmesis becomes a priority only when the open-heart surgery can be performed safely.

The favorable aspects of our patient's anatomy that helped our repair through the thoracotomy approach were the absence of a brachiocephalic or connecting vein and the presence of bilateral SVCs.

When anomalous pulmonary veins connect to a high SVC, use of an internal patch technique can result in SVC obstruction. At times, a 2nd patch is needed to widen the SVC.[1] The Warden procedure is preferred in such an anatomy. However, the cephalic end of the divided SVC becomes, in these cases, more distant from the RAA, creating the likelihood of tension and later of a stenotic cavoatrial anastomosis. Extensive dissection of the brachiocephalic vein and SVC is then required, in order to reduce that tension on the cavoatrial anastomosis. Absence of the brachiocephalic vein provides extra length for dissection—up to the level of the right subclavian vein, which facilitates tension-free anastomosis.[5]

During the surgery, we clamped the right SVC without proximal cannulation. In a patient with single right SVC, clamping that vessel has the disadvantage of subjecting the brain to high venous pressures. This practice, if associated with low systemic blood pressure, can increase the risk of neurologic damage due to low cerebral perfusion pressure.[7] The presence of bilateral SVC with a fair-sized left SVC (as in this patient) provides adequate cerebral venous drainage and avoids neurologic effects—an anatomic feature that has been used by surgeons in performing a bilateral, bidirectional Glenn shunt as an off-pump procedure.[8] We took the additional precaution of cooling the patient to 28 °C. Continuous monitoring of the pressure in the internal jugular vein above the level of the clamp showed the maintenance of venous pressures at less than 10 mmHg.

We conclude that the Warden procedure is feasible when performed through a posterior thoracotomy in patients with suitable anatomy, and that this approach can provide cosmetic advantages.

References

1. Stewart RD, Bailliard F, Kelle AM, Backer CL, Young L, Navroudis C. Evolving surgical strategy for sinus venosus atrial septal defect: effect on sinus node function and late venous obstruction. Ann Thorac Surg 2007;84(5):1651-5.
2. Warden HE, Gustafson RA, Tarnay TJ, Neal WA. An alternative method for repair of partial anomalous pulmonary venous connection to the superior vena cava. Ann Thorac Surg 1984;38(6):601-5.

3. Park CS, Kwak JG, Lee C, Lee CH, Lee SY, Choi EY, et al. Partial anomalous pulmonary venous connection to the superior vena cava: the outcome after the Warden procedure. Eur J Cardiothorac Surg 2012;41(2):261-5.
4. DiBardino DJ, McKenzie ED, Heinle JS, Su JT, Fraser CD Jr. The Warden procedure for partially anomalous pulmonary venous connection to the superior caval vein. Cardiol Young 2004;14(1):64-7.
5. Kottayil BP, Dharan BS, Menon S, Bijulal S, Neema PK, Gopalakrishnan SK, Jayakumar K. Anomalous pulmonary venous connection to superior vena cava: Warden technique. Eur J Cardiothorac Surg 2011;39(3):388-91.
6. Shivaprakasha K, Murthy KS, Coelho R, Agarwal R, Rao SG, Planche C, Cherian KM. Role of limited posterior thoracotomy for open-heart surgery in the current era. Ann Thorac Surg 1999;68(6):2310-3.
7. Jahangiri M, Keogh B, Shinebourne EA, Lincoln C. Should the bidirectional Glenn procedure be performed through a thoracotomy without cardiopulmonary bypass? J Thorac Cardiovasc Surg 1999;118(2):367-8.
8. Luo XJ, Yan J, Wu QY, Yang KM, Xu JP, Liu YL. Clinical application of bidirectional Glenn shunt with off-pump technique. Asian Cardiovasc Thorac Ann 2004;12(2):103-6.