Operative Techniques in Thoracic and Cardiovascular Surgery

Organ Care System for Heart Procurement and Strategies to Reduce Primary Graft Failure After Heart Transplant

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Primary graft failure is a rare, but often fatal complication of heart transplantation. Although exact mechanism of primary graft failure has yet to be elucidated, prolonged ischemia time is one of the risk factors of early dysfunction of the donor heart. Organ Care System is the only device available for ex vivo perfusion of human donor hearts in a warm beating state. In this article, we provide step-by-step instructions of its use.
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KEYWORDS heart transplantation, Organ Care System, ex-vivo heart perfusion, primary graft failure

Introduction

Heart transplantation is the gold standard treatment for end-stage heart failure. However, the number of heart transplantations in the United States has been peaking at roughly 2300 per year, although the number of new active candidates on the waiting list has been increasing. In 2013, 3300 new candidates were listed for heart transplant.[1] One of the limiting factors of maximizing donor heart utilization is distance between the donor hospital and the recipient hospital. Traditionally, the donor hearts are harvested and transported in a cold storage. Prolonged cold ischemia time is known to be one of the risk factors for primary graft failure and early mortality.[2] Therefore, donor hearts have been allocated to the recipient hospitals at the distance at which transport does not take long especially for recipients with mechanical circulatory support or from marginal donors.

Organ Care System (TransMedics, Inc, Andover, MA) is the only ex vivo heart perfusion platform with warm, oxygenated, and nutrient-enriched donor blood. With the Organ Care System, warm oxygenated blood is pumped into the aorta, perfusing the coronary arteries. The coronary sinus flow then passes through the tricuspid valve and is ejected by the right ventricle into a pulmonary artery cannula, and returned to the blood reservoir. The perfusate includes insulin, antibiotics methylprednisolone, sodium bicarbonate, multivitamins, and fresh donor blood. Pulsatile flow is generated by a diaphragmatic pump. The system shortens the cold ischemia time by maintaining the heart in warm perfused state during transport and might increase safe retrieval distance, decrease the incidence of primary graft failure, and potentially allow for increase in number of heart transplantation. A prospective, multicenter, open-label, and randomized trial has confirmed noninferiority of this system compared to the standard cold storage.[3] Here, we review heart procurement by using Organ Care System in step-by-step manner. Owing to limitations of space, we just focus on the surgical part and do not touch how to use and manage the device in detail. It can be found in the vendor's instructions (Figs. 1-11).

Operative Technique

Donor Heart Management During Transport

Hemodynamic (coronary flow, mean aortic pressure, heart rate, and electrocardiography) and chemical parameters (arterial blood gas, electrolyte, and glucose) are checked regularly during the donor heart transport to the recipient hospital. Target mean aortic pressure is between 65 and 85 mm Hg, coronary flow is between 650 and 850 mL/min, and total arterial lactate less than 5 mmol/L. Those parameters are corrected by adjusting pump flow, maintenance solution rate, epinephrine infusion, pacing rate, and gas flow. On arrival to the recipient hospital, the donor heart is arrested with 1 L of cold cardioplegia and disconnected from the system for implantation into the recipient.

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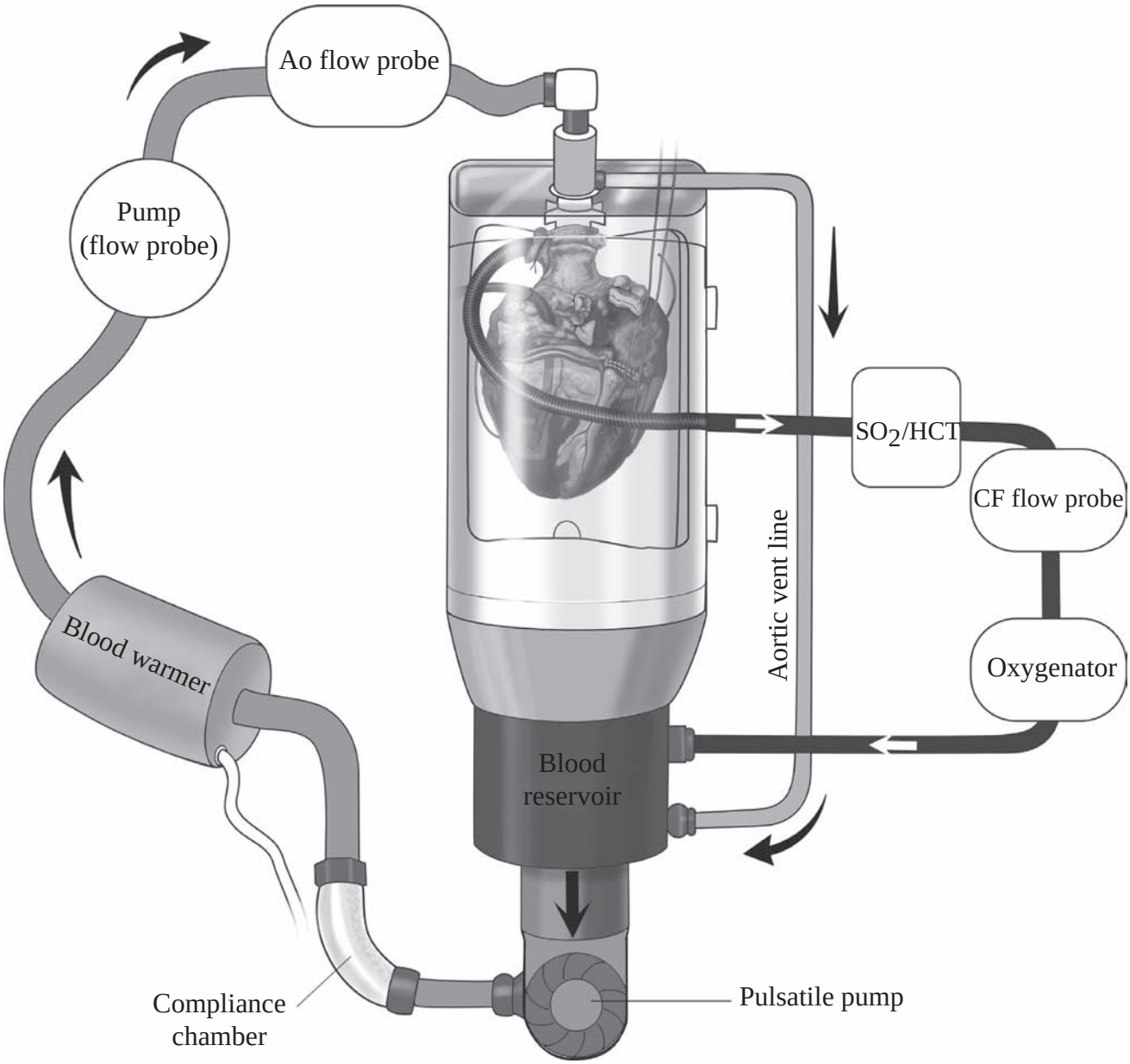

Figure 1 Organ Care System overview.

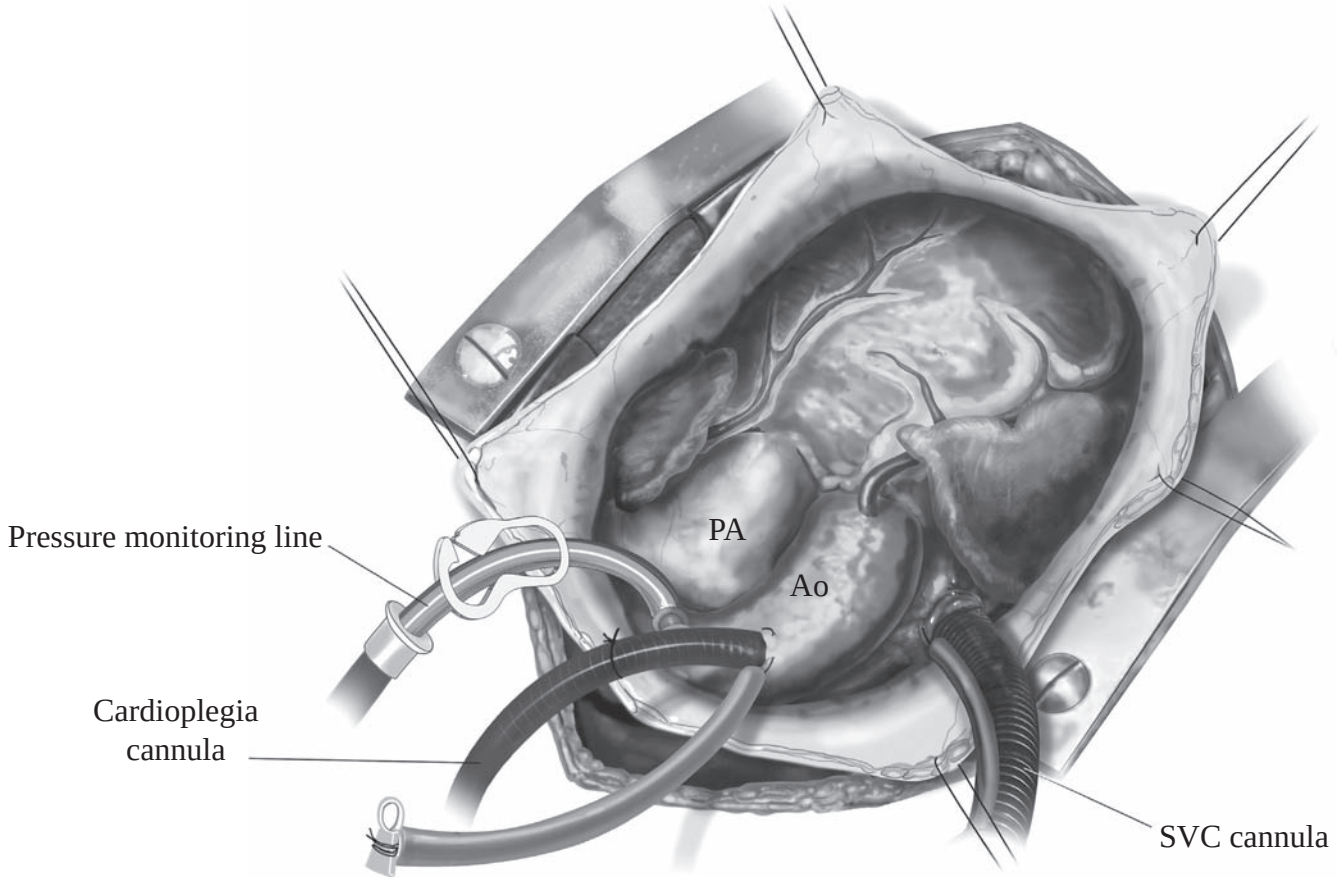

Figure 2 Donor heart harvest. After systemic heparinization (3000 units), SVC is cannulated with a 40 Fr malleable cannula through a 4–0 prolene purse-string stitch at the level of azygous vein for donor blood collection. Deep Trendelenburg position helps to avoid hemodynamic instability. Collected donor blood is used to prime the circuit. Avoid any catecholamine administration during donor blood collection that increases myocardial oxygen consumption. SVC = superior vena cava; PA = pulmonary artery; Ao = aorta.

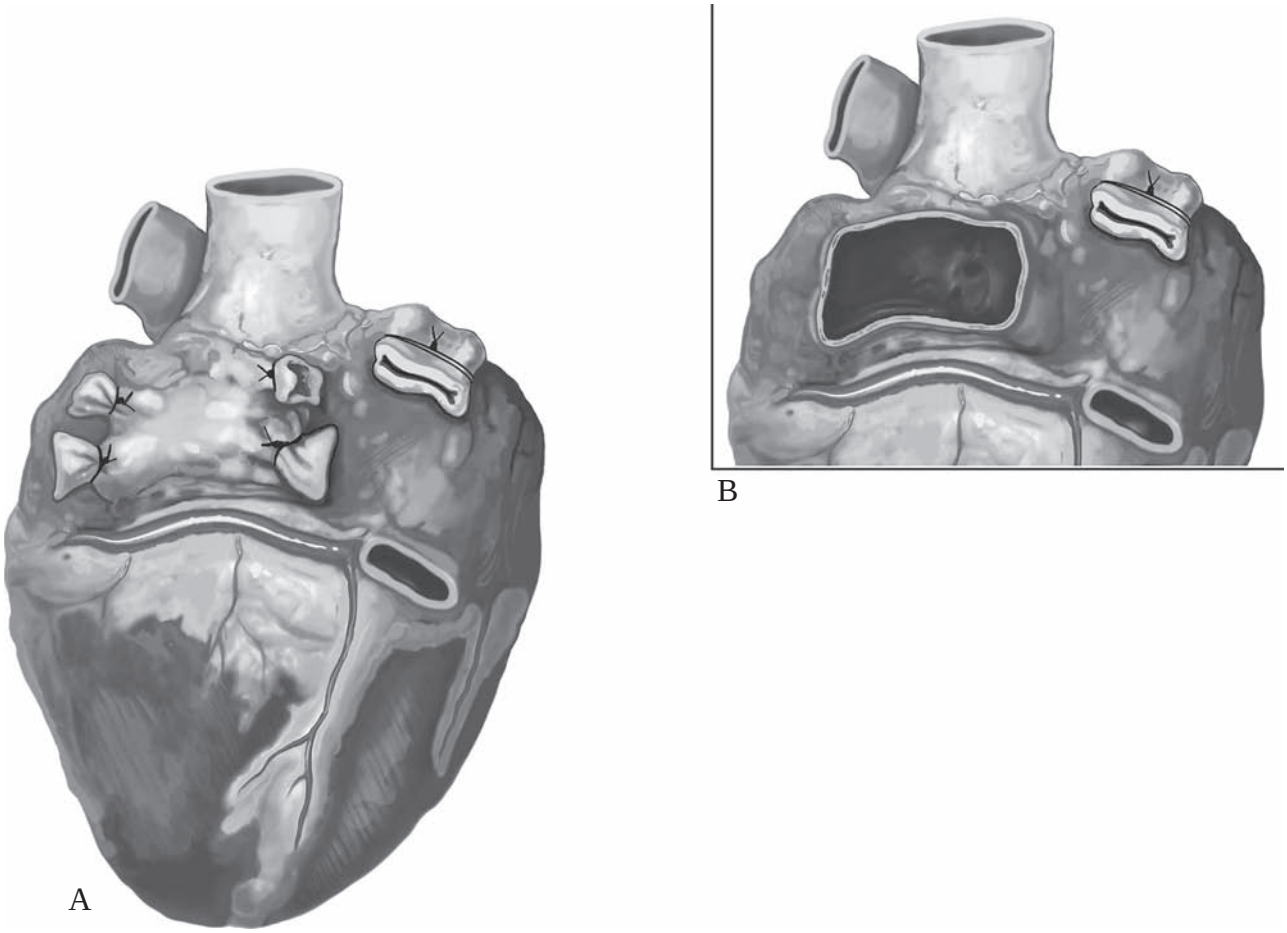

Figure 3 The donor heart is harvested using the cold cardioplegia following the retrieval team's standard procedures. (A) IVC and pulmonary veins are divided if the heart is taken alone. The pulmonary veins are tied off after harvesting the donor heart. IVC = inferior vena cava. (B) If lungs are procured simultaneously transverse incision of the left atrium leaving a sufficient cuff of the left atrium around the orifices of the pulmonary veins is performed. The SVC cannula is removed at this point and SVC is divided. The defect in the left atrium is left alone and the blood return from the lungs after reperfusing the donor heart with Organ Care System will be collected in the reservoir and return to the circulation. SVC = superior vena cava.

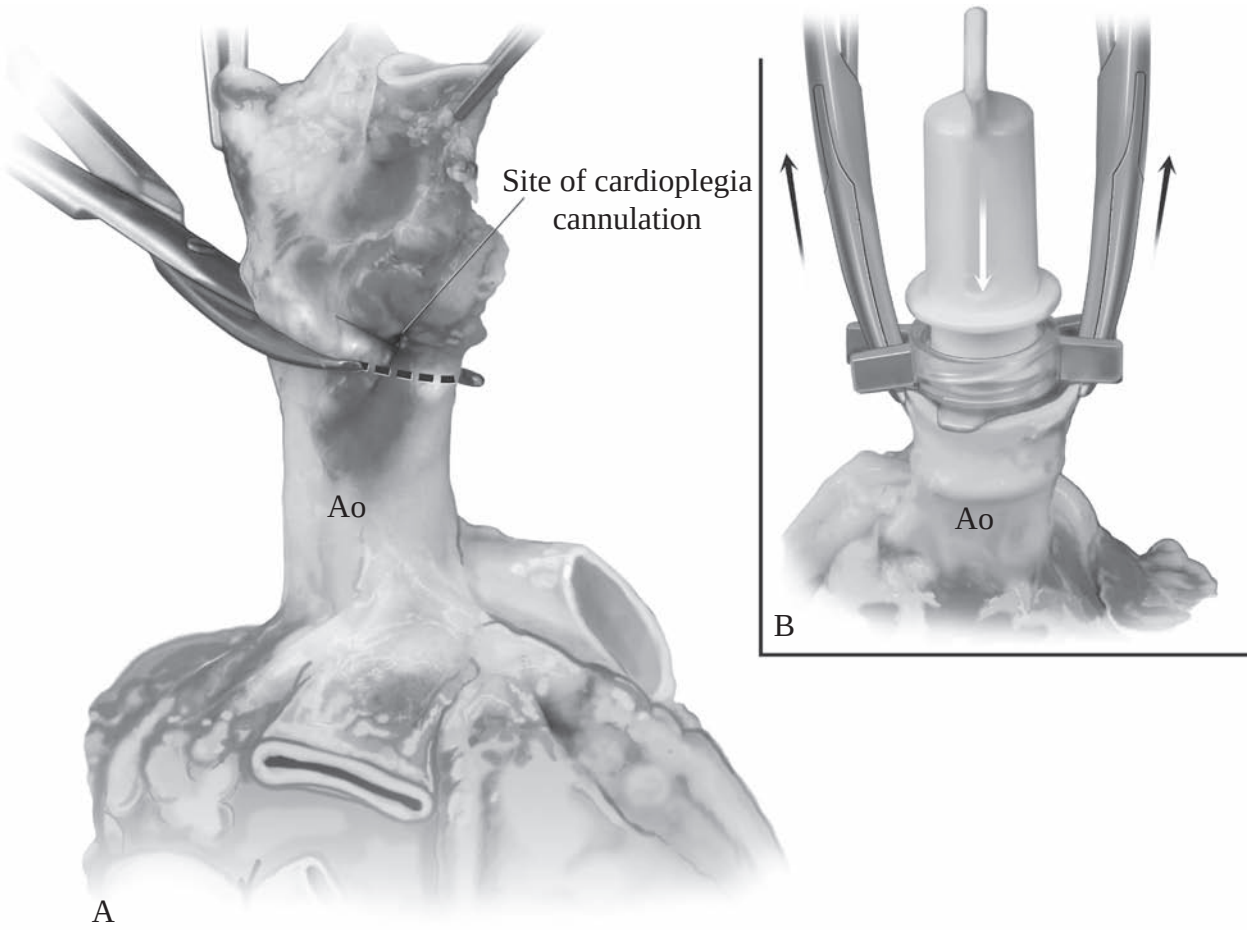

Figure 4 (A) Note that cardioplegia cannula should be inserted as high as possible in the donor ascending aorta. The ascending aorta is trimmed below the stitch for cardioplegia needle to avoid leakage. (B) Place the appropriate-sized aortic tip cannula after attaching it to the aortic tip holder. Holding the edge of aortic stump with clamps may facilitate cannulating and securing the aorta. Ao = aorta.

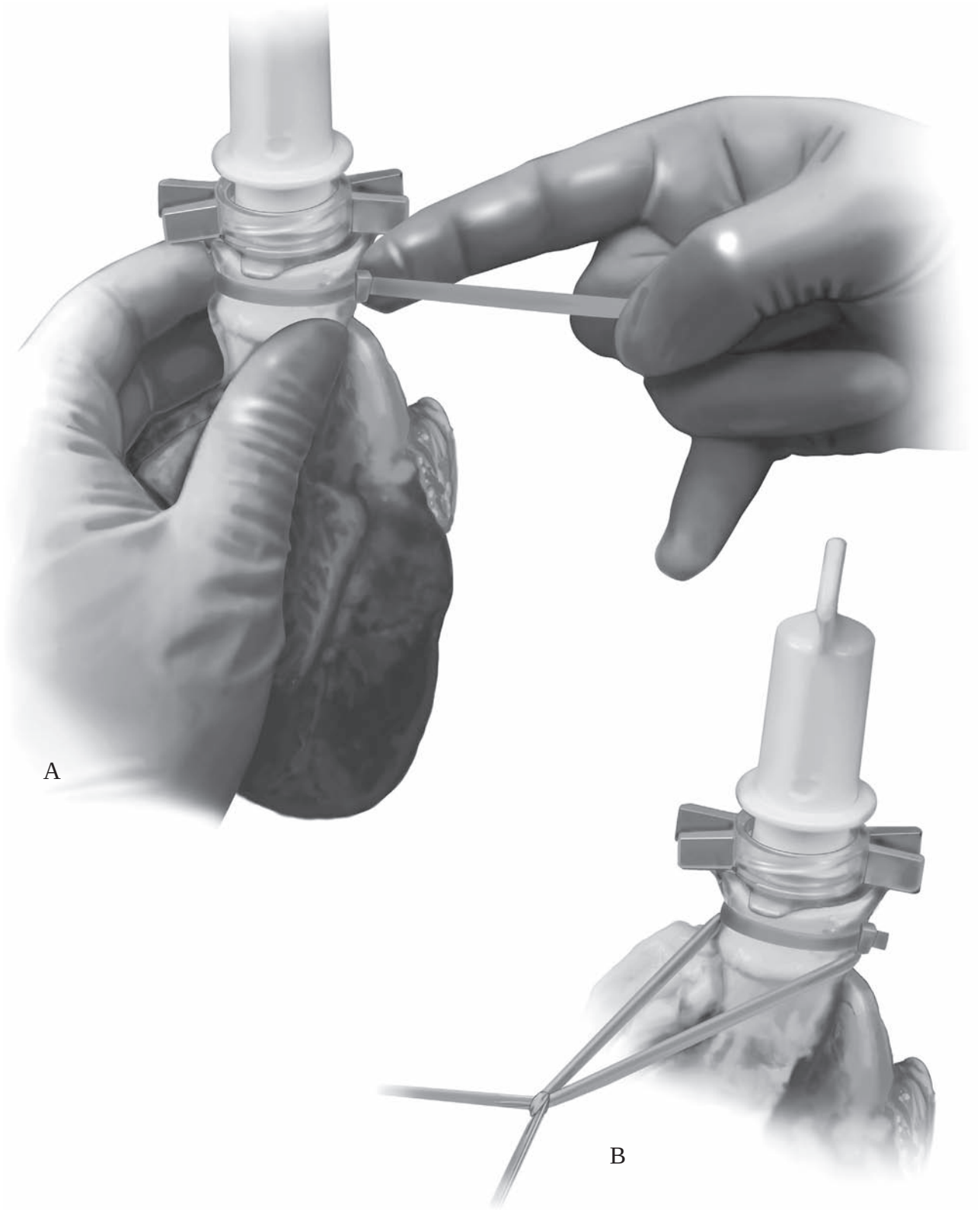

Figure 5 Securing the aorta. Secure cable, tie above cannula ridge (leave at least 2 mm of aortic tissue above the cable tie). Then, tie an umbilical tape below the cable tie.

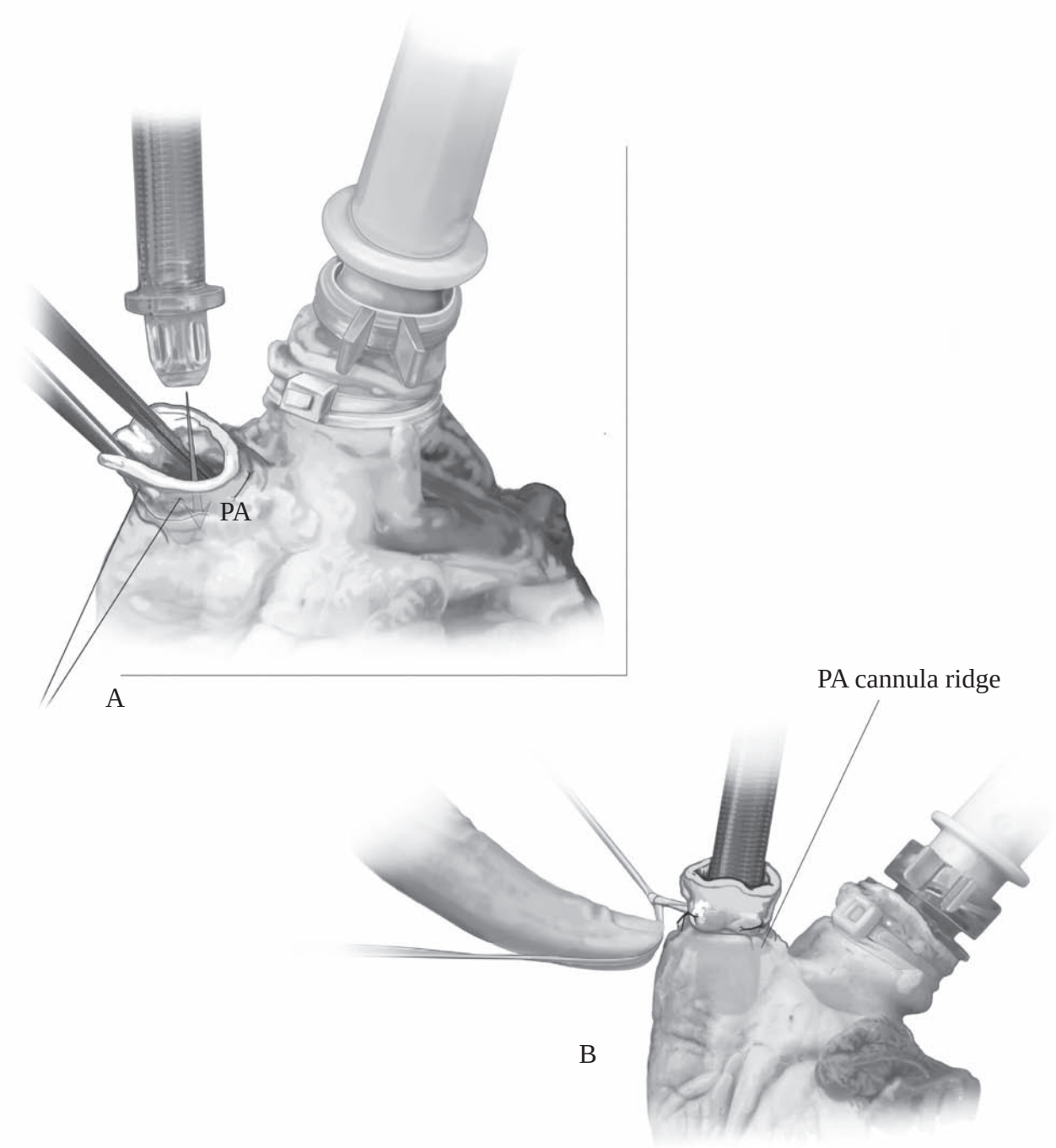

Figure 6 (A) Pulmonary artery cannulation. Place a 4–0 prolene purse-string suture at the rim of the PA stump and insert the PA cannula. Tie the purse-string stitch. (B) Securing pulmonary artery cannula. Tie an umbilical tape above the PA cannula ridge. PA = pulmonary artery.

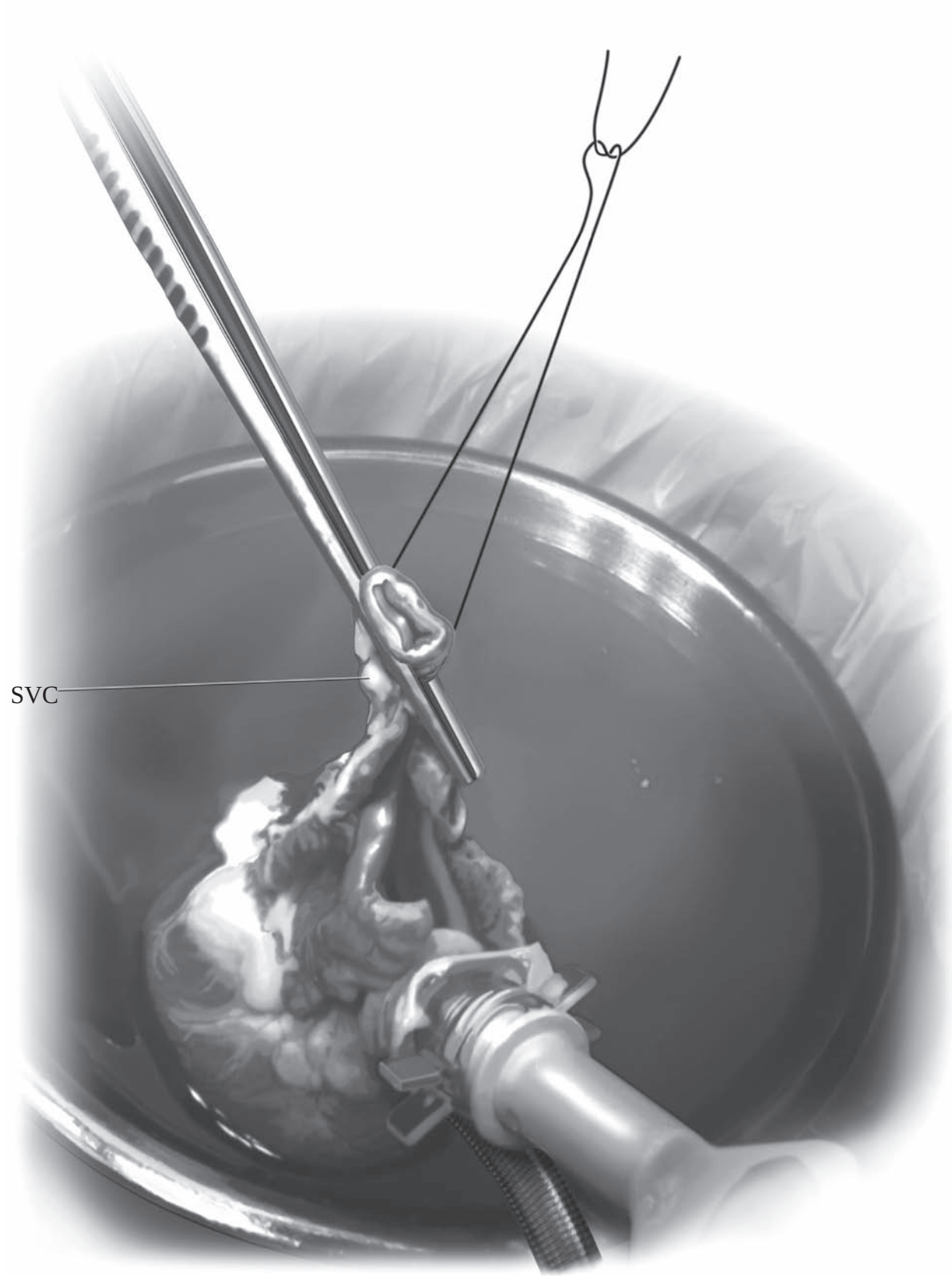

Figure 7 Tie the SVC with a silk ligature. SVC = superior vena cava.

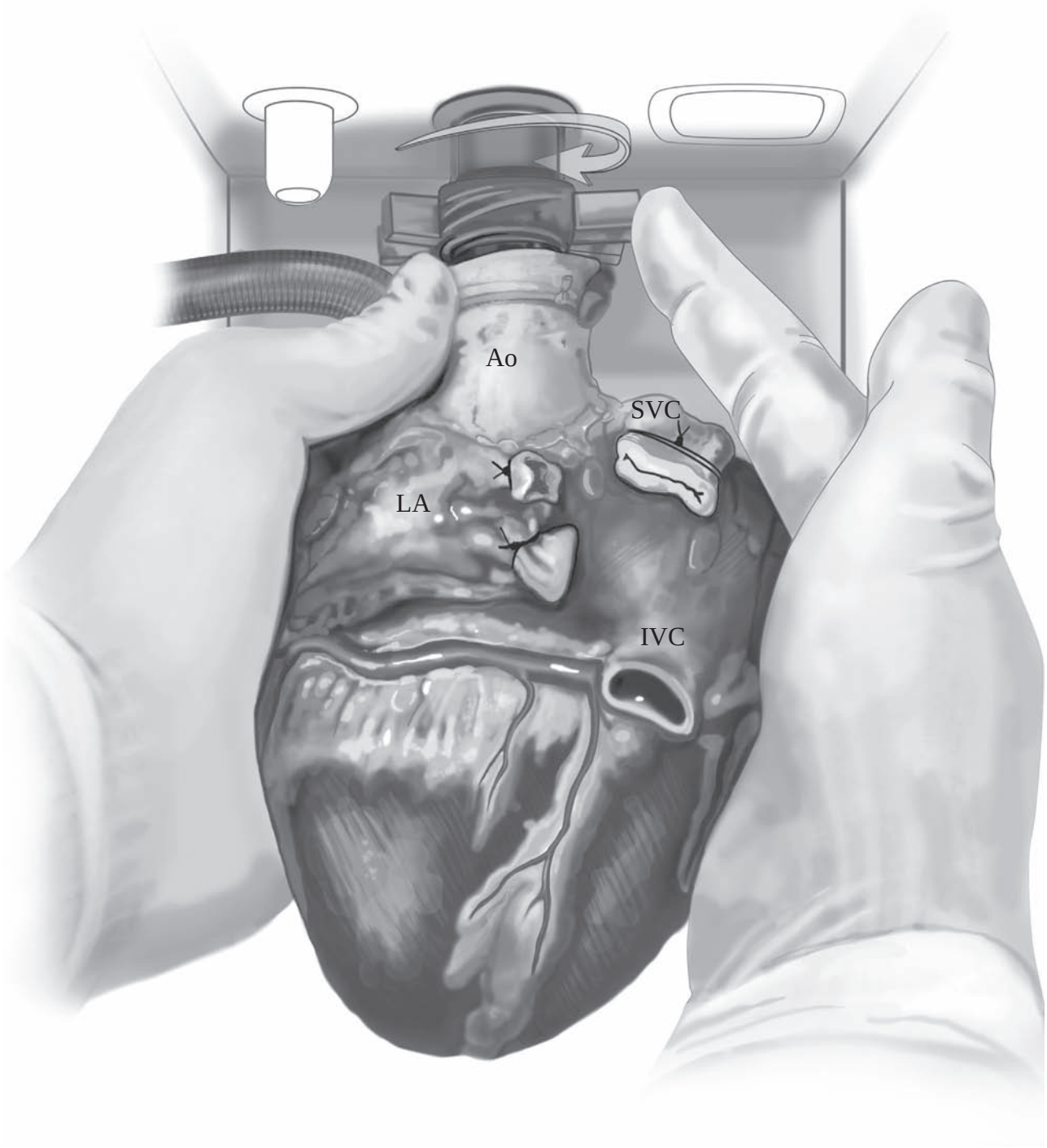

Figure 8 Align the heart and connect the aorta to aortic port of heart chamber. Posterior aspect of the heart faces the surgeon. Fill the aorta and the aortic tip with primed blood when the connection is made to make sure there is no air in the tip. Massage the heart to de-air the PA cannula and connect the PA cannula to the PA connector on the heart chamber. PA = pulmonary artery; Ao = aorta; LA = left atrium; SVC = superior vena cava; IVC = inferior vena cava.

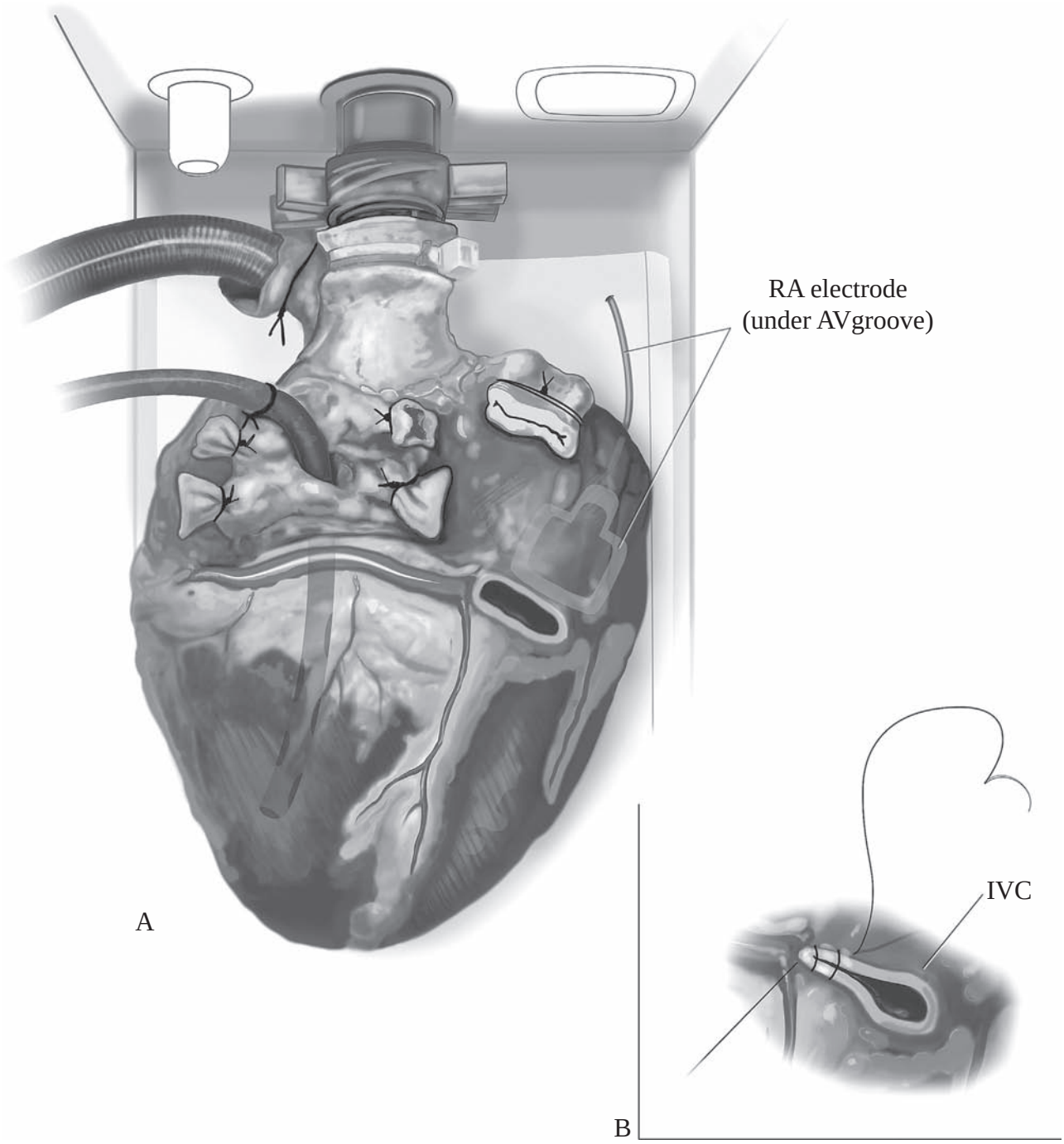

Figure 9 (A) LV vent placement. Insert an LV vent through open LA and secure it using an anchoring stitch in the LA. LA = left atrium; LV = left ventricle. (B) Closing the IVC. Oversew the IVC with a 4–0 prolene running suture. IVC = inferior vena cava.

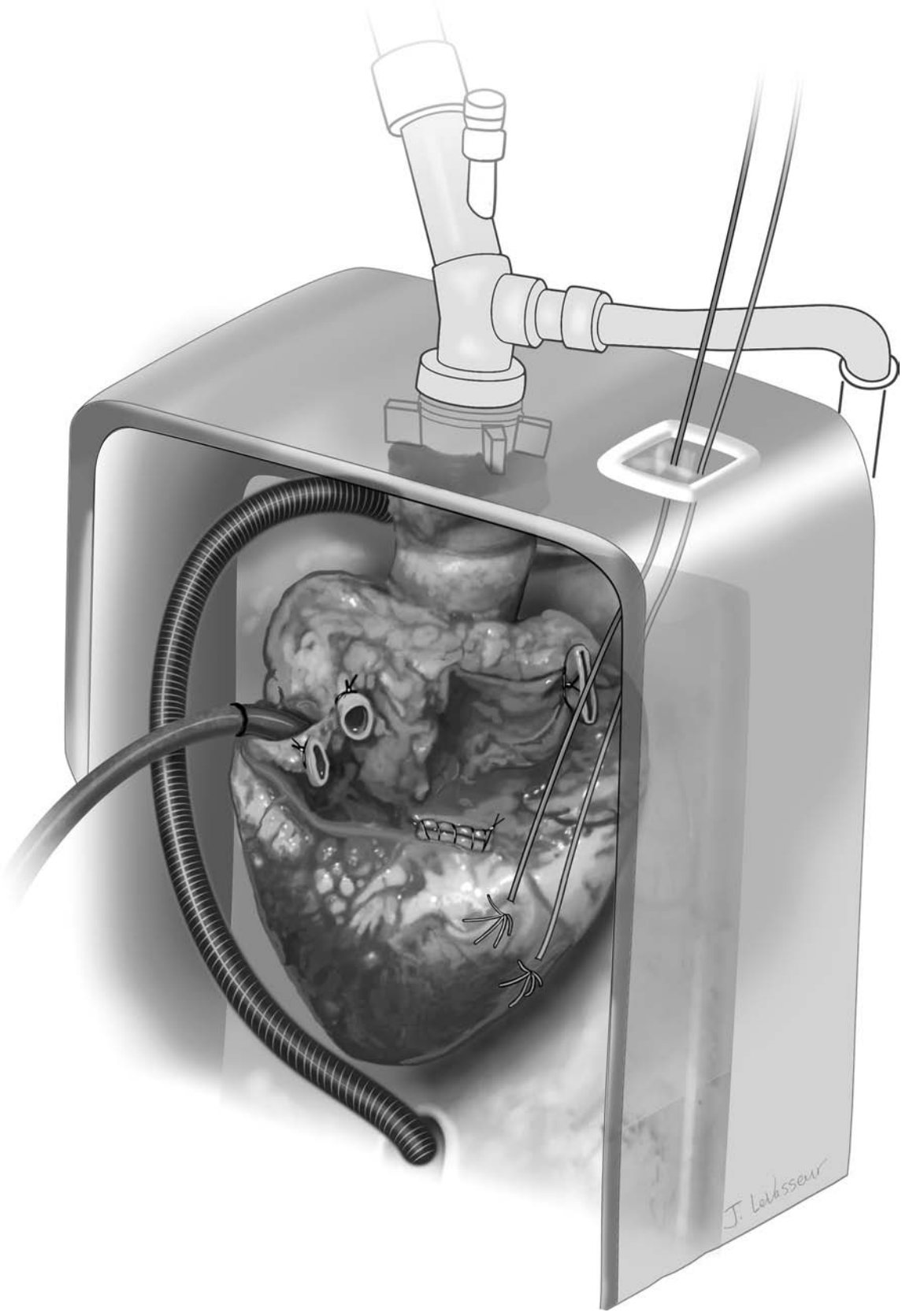

Figure 10 Placing pacing wires.

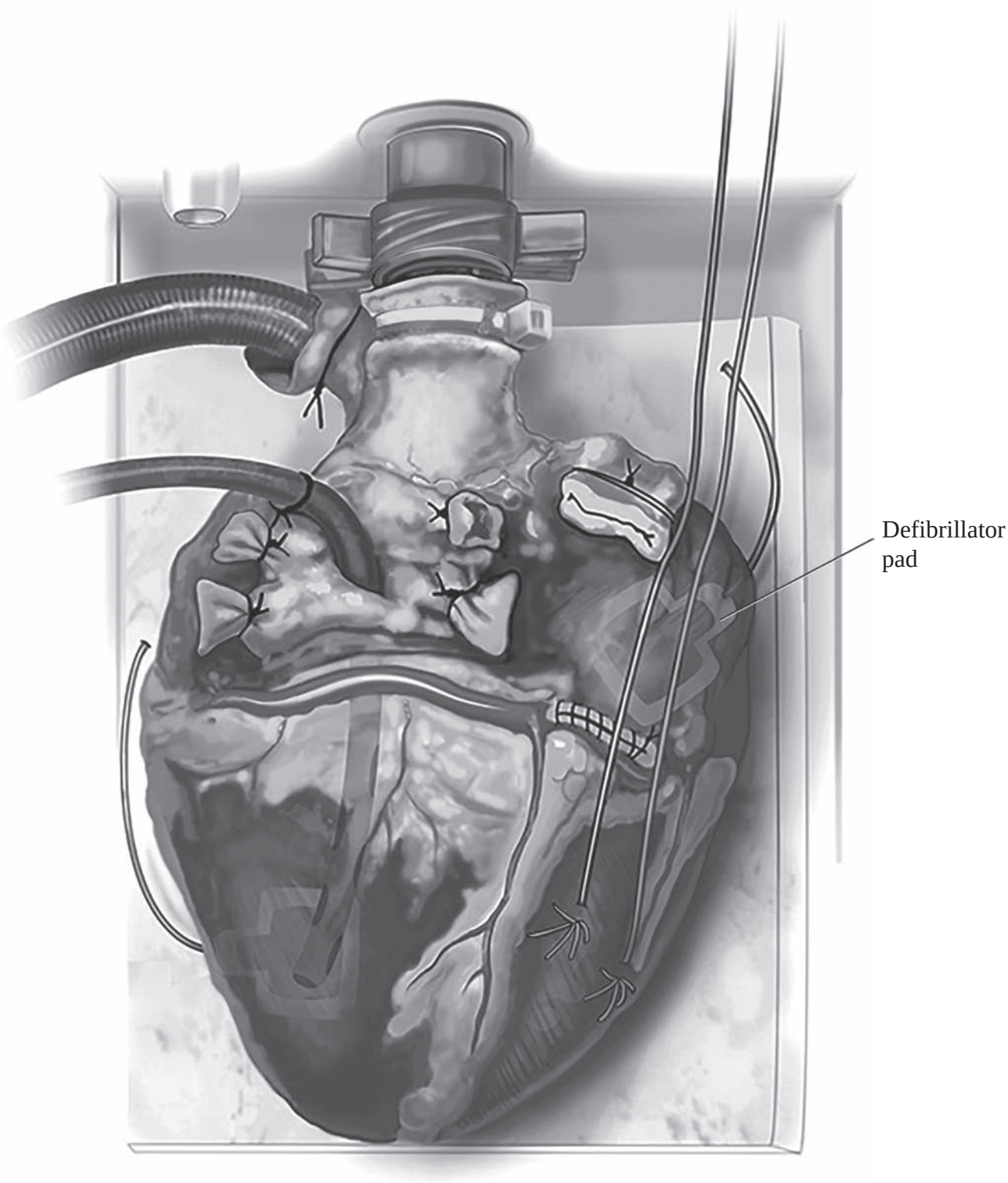

Figure 11 Adjust the defibrillation electrode pads to the LV and RA. LV = left ventricular; RA = right atrium.

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