Superior Vena Cava Drainage During Thoracoscopic Cardiac Surgery: Bilateral Internal Jugular Vein Sheaths Versus One Percutaneous Superior Vena Cava Cannula

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Objective: To evaluate bilateral internal jugular vein sheaths as a replacement of one percutaneous superior vena cava cannula for superior vena cava drainage during thoracoscopic cardiac surgery.

Design: A prospective and randomized study.

Setting: Single cardiovascular institute.

Participants: Adults undergoing thoracoscopic cardiac surgery.

Interventions: Patients were randomized into a percutaneous superior vena cava cannula group and a bilateral internal jugular vein sheaths group. The superior vena cava drainage for cardiopulmonary bypass was performed with one percutaneous superior vena cava cannula (14-18 Fr) or the bilateral internal jugular vein sheaths (8 Fr).

Measurements and Main Results: Both interventions reached theoretic flow rate in all patients. In patients weighing < 50 kg ($n = 38$) and 50-70 kg ($n = 64$), the average central venous pressure values during cardiopulmonary bypass of both groups showed no significant differences. The patients weighing > 70 kg ($n = 15$) in the bilateral internal jugular vein sheaths group had a normal average central venous pressure value, but it was significantly higher than that of percutaneous superior vena cava cannula group ([10.5 ± 3.1] mmHg vs. [4.5 ± 4.4] mmHg, $p = 0.013$). The patient satisfaction scale scores for the cervical incisions were significantly higher in the bilateral internal jugular vein sheaths group than in the percutaneous superior vena cava cannula group ([2.6 ± 0.9] vs. [2.1 ± 0.8], $p = 0.002$).

Conclusions: The bilateral internal jugular vein sheaths were a feasible and effective option to replace one percutaneous superior vena cava cannula during thoracoscopic cardiac surgery, with better patient satisfaction.

KEY WORDS: minimally invasive cardiac surgery, cardiopulmonary bypass, superior vena cava

MINIMALLY INVASIVE CARDIAC SURGERY, including thoracoscopic and robotic cardiac surgery, commonly is performed for the benefits of reduced trauma, decreased pain, and improved patient satisfaction.[1] Thoracoscopic cardiac surgery has gained in popularity, especially in developing countries, because of its low costs and rapid learning curve.[2,3]

During thoracoscopic cardiac surgery with cardiopulmonary bypass (CPB), good exposure with a bloodless field is necessary for the ease and success of surgery. Several options are available for venous drainage during CPB. Direct cannulation of the right atrium, superior vena cava (SVC), or inferior vena cava (IVC) can cause crowding of the operative field although some surgeons prefer to cannulate the SVC through a minithoracotomy.[4] A single femoral vein cannula might be sufficient for non-right atrium-opening surgery, but for surgery involving right atrium opening, many surgeons use a double-stage venous cannula in the SVC via the femoral vein.[5–7] The downside of a double-stage venous cannula is that it is large and may impair femoral venous return. In some circumstances, the cannula needs to be moved slightly because of restricted vision of the interatrial septum and tricuspid valve. The traction of the mitral valve and left atrium also may induce buckling of the cannula, resulting in inadequate venous drainage. Femoral vein cannulation combined with percutaneous superior vena cava (PSVC) cannulation via the right internal jugular vein (IJV) eliminates such discomforts and permits satisfactory venous drainage during surgery with or without right atrium opening.[8–21] In this practice, 1 PSVC cannula was replaced by 2 thinner introducer sheaths in the bilateral internal jugular veins (BIJVs). The aim of this study was to compare the BIJV sheaths with one PSVC cannula for effectiveness, safety and cosmetic result of SVC drainage.

METHODS

With the approval of the Institutional Review Committee and informed consent, adult patients (age >18 years) scheduled for thoracoscopic cardiac surgery with CPB between July 2011 and June 2012 were enrolled in this study.

General anesthesia was standardized for all patients. Patients were premedicated with morphine and penehyclidine hydrochloride intramuscularly 30 minutes prior to surgery. Anesthetic monitoring included American Society of Anesthesiologists routine monitors. A 20G or 22G catheter was inserted into the left radial artery for invasive blood pressure monitoring. Anesthesia was induced and maintained with midazolam, fentanyl, propofol, cisatracurium, and sevoflurane. A left-sided double-lumen endotracheal tube was inserted after anesthetic induction and replaced by a single-lumen endotracheal tube before leaving the operating room. A 7.5-Fr triple-lumen central venous catheter (CVC) was placed in the middle part of the SVC using transesophageal echocardiography (TEE) guidance via the right or left IJV to monitor central venous pressure, administer drugs, and infuse fluids. A transducer (Edwards Lifesciences LLC, Irvine, CA) was fixed at the level of the fourth intercostal space in the right midaxillary line and connected to the patient's CVC via fluid-filled extension tubing. The transducer was zeroed to atmospheric pressure, and then continuous central venous pressure (CVP) values were measured in mmHg.

Simple randomization was used to assigned patients into a PSVC cannula group and a BIJV sheaths group. For patients using 1 PSVC

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The work for this article was supported by the Ministry of Health of China's Special Funds [200902001] and Guangdong Medical Research Foundation [A2012058].

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1053-0770/2601-0001$36.00/0
http://dx.doi.org/10.1053/j.jvca.2013.05.043

cannula, the right IJV was punctured and a guidewire was inserted using the Seldinger technique. A purse-string suture was placed around the puncture site. After administration of 100 IU/kg of heparin, a skin incision was made to insert a 14-18 Fr cannula (Fem-Flex, Edwards Lifesciences LLC, Irvine, CA) (Fig 1A). The authors used 14-, 16-, and 18-Fr cannulae in patients weighing <50 kg, 50-70 kg and >70 kg, respectively. TEE was used to position the cannula tip at the right atrium/SVC junction (Fig 1B). A 3/8-inch tubing was connected to the cannula for venous drainage (Fig 1C). The cannula was removed after weaning from CPB. For patients using the BIJV sheaths, two 8-Fr introducer sheaths with the length of 11 cm (SCW Medicath Ltd, Shenzhen, China) were inserted into the BIJVs using the Seldinger technique (Fig 1D). The depth was determined by the length from the puncture point to the ipsilateral sternoclavicular notch, which was the surface landmark of the IJV/subclavian vein junction. Two 1/4-inch tubings and 1/4-inch connectors with Luer-locks were connected to the sheaths for venous drainage after the T-connectors were screwed off (Fig 1E). The T-connectors were screwed on the sheaths after CPB. The position of the sheath tips was confirmed with a chest x-ray after surgery (Fig 1F). The sheaths were removed when patients' hemodynamics were stable in the intensive care unit (ICU).

Following full anticoagulation with heparin, the femoral vein was cannulated for IVC drainage, and arterial cannulation also was performed at the site of the femoral artery. The IVC cannula tip was positioned at the right atrium/IVC junction with TEE. Vacuum-assisted venous drainage (VAVD) of -30 mmHg was utilized in CPB at the discretion of the perfusionist and/or surgeon to maintain the required flow rate. In all cases, the CPB flow rate was maintained at a cardiac index of 1.8 to 2.0 L/min/m^2 during aortic cross-clamp and 2.2 to 2.4 L/min/m^2 during rewarming. The mean arterial pressure was maintained between 50 and 80 mmHg. Perfusion was adequate as assessed by a normal venous saturation during the CPB period.

All operations were performed using video-assisted thoracoscopy. The heart was arrested with cold cardioplegia after cross-clamping of the aorta. When cardiac procedures were completed, patients were transferred to the ICU for monitoring and tracheal extubation.

The following pre- and intraoperative data were gathered for statistical analysis: Age, sex, height, weight, body surface area, with or without right atrium opening, CPB time, aortic cross-clamp time, and operation time. The CVP values were recorded by the perfusionist every 5 minutes during CPB, and any negative values were recorded as 0. Macroscopic hemoglobinuria was evaluated by the perfusionist immediately after surgery. Postoperative outcomes analyzed included mechanical ventilation time, ICU length of stay, in-hospital length of stay, reexploration for bleeding, and reintubation. Postoperative neurocognitive deficits and renal dysfunction requiring hemodialysis also were analyzed.

Patient satisfaction scale (PSS) scores for evaluating the incisions from 1 PSVC cannula and from the BIJV sheaths were taken on the third day after surgery. All patients were given a form showing 4 grades (poor = 1, fair = 2, good = 3, and excellent = 4) and were asked to freely evaluate the incisions. The PSS scores were collected by an independent team that did not take part in the operative procedures.

The continuous variables were presented as mean ± standard deviation. The categoric data were presented as numbers and percentages. Descriptive statistics, including continuous and categoric variables, were analyzed with Student's *t* test or Mann-Whitney *U* test and Chi-square test or Fisher's exact test. All statistical analyses were performed using IBM SPSS Statistics version 20 (IBM, Armonk, NY), and $p < 0.05$ was declared significant.

RESULTS

A total of 117 consecutive patients underwent thoracoscopic cardiac surgery from July 2011 to June 2012. No patient required conversion to a full sternotomy. The breakdown of surgical procedures is summarized in Table 1. Atrial septal defect repairs and mitral valve replacements were the majority of procedures performed. The mean age of patients was 42.1 ± 15.1 years, with a female predominance (65.8%). Patients weighing <70 kg accounted for 87.2%.

Preoperative and intraoperative characteristics are shown in Table 2. There were no significant differences between the 2 groups' demographics, operative approaches, perioperative data, average CVP during CPB, or macroscopic hemoglobinuria. No patient required additional SVC cannulation through the operative field because of inadequate SVC drainage. Forty-five patients (38.5%) underwent left atrial incision without blocking the SVC and IVC. The average CVP of both groups showed no

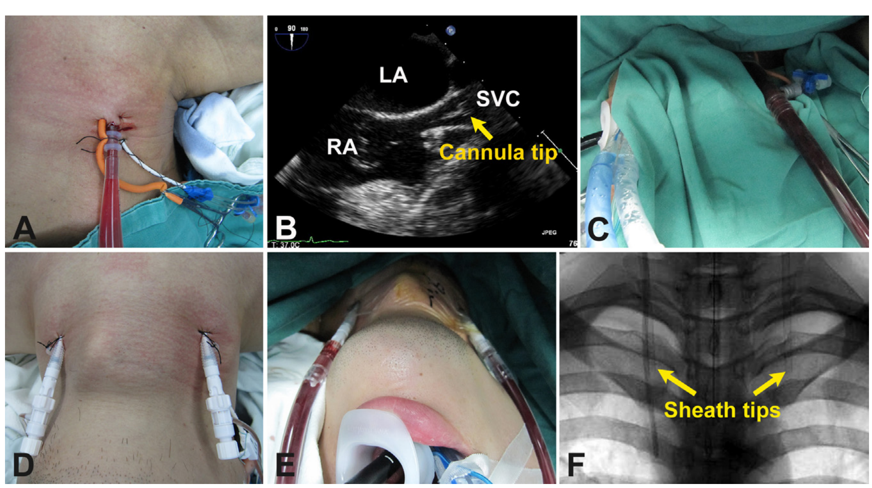

Fig 1. Superior vena cava drainage with PSVC cannula and BIJV sheaths. (A) A 14-18 Fr cannula was inserted into the superior vena cava via the right internal jugular vein. (B) Transesophageal echocardiography was used to position the cannula tip at the right atrium/superior vena cava junction. (C) Venous blood was drained from a connected 3/8 inch tubing. (D) Two 8 Fr sheaths were inserted into the BIJVs. (E) Venous blood was drained from 2 connected 1/4-inch tubings. (F) The position of sheath tips was confirmed near the sternoclavicular notch with a chest x-ray. PSVC, percutaneous superior vena cava; BIJV, bilateral internal jugular veins; LA, left atrium; RA, right atrium; SVC, superior vena cava. (Color version of figure is available online.)