Surgical Techniques

Left Brachiocephalic Vein Cannulation in Bicaval Venous Drainage

Is Safe, Effective, and Technically Advantageous

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Direct cannulation of both venae cavae (bicaval venous cannulation) is the gold standard for right atrial isolation in intracavitary surgery, but there has been no consensus about an alternative site. Therefore, we studied an alternative method for bicaval venous drainage in which the left brachiocephalic vein (LBCV) is cannulated instead of the superior vena cava.

From 2012 through 2014, we performed routine LBCV cannulation in 150 consecutive patients as part of bicaval venous drainage before right atrial isolation. We prospectively collected demographic information, operative data, total pump and LBCV cannula flows with their respective calculated and indexed rates, central venous pressures, and perioperative complications.

All patients survived surgery. There were no adverse technical outcomes or functional deficits associated with the technique. The mean indexed LBCV cannula flow was 1,520 ± 216 mL/min/m², representing an LBCV cannula-to-calculated pump-flow ratio of 64%. The mean central venous pressure during right atrial isolation was 3.7 ± 1.9 mmHg.

Cannulation of the LBCV is intrinsically a safe and reproducible procedure with proven hemodynamic adequacy. Its versatility can be an asset to surgical techniques and perfusion methods. Furthermore, the hemodynamic results in our series promise alternative intrathoracic and extracardiac cannulation sites for mini-extracorporeal circulation, on-pump beating-heart procedures, and short-term circulatory assist device implementation. ***(Tex Heart Inst J 2016;43(2):144-7)***

Key words: *Brachiocephalic veins; cardiac surgical procedures/methods; drainage/methods; extracorporeal circulation/methods; hemodynamics; treatment outcome*

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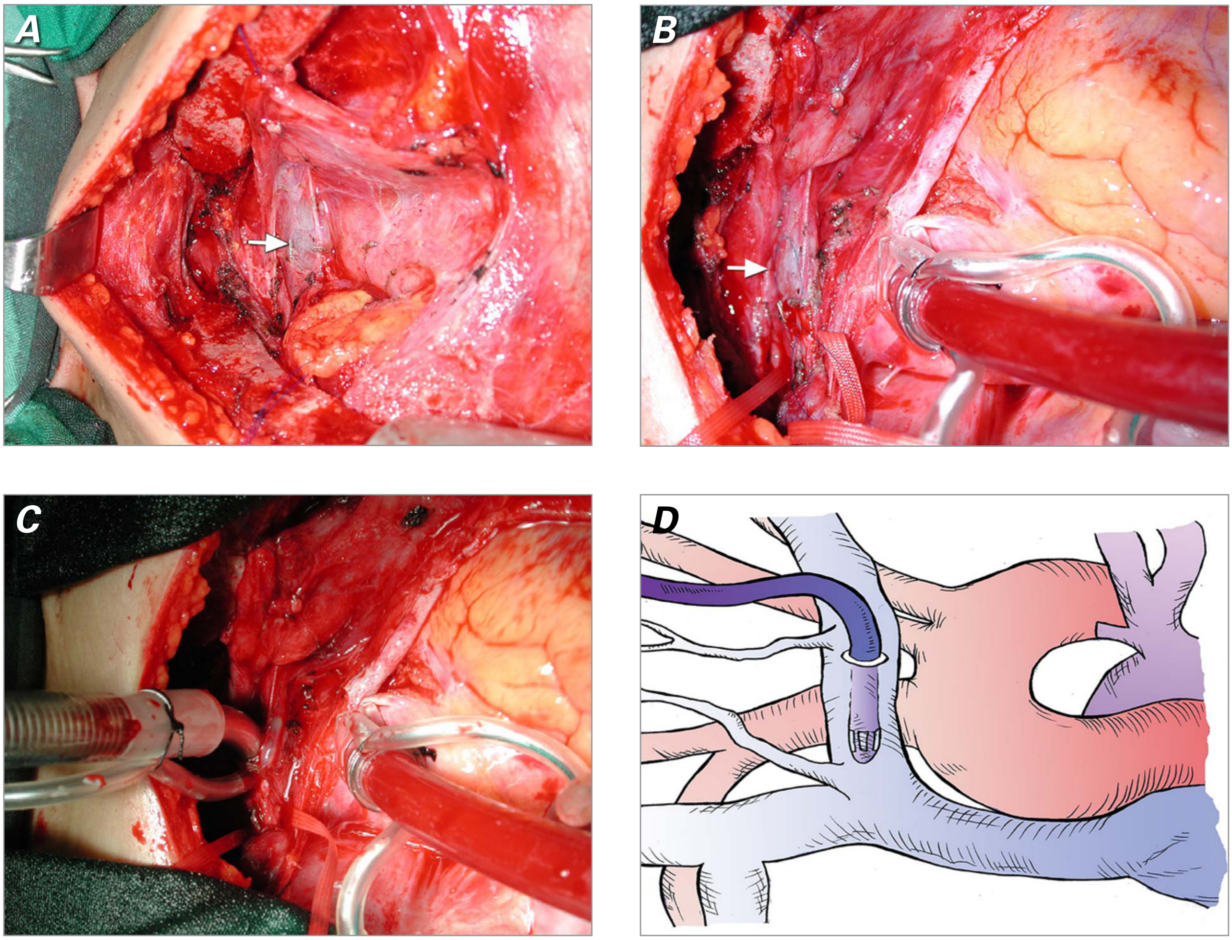
Cannulation of the superior vena cava (SVC) and inferior vena cava is the mainstay of bicaval venous drainage before right atrial isolation.[1,2] It is widely accepted that the femoral vein is an alternative to direct inferior vena cava cannulation; however, no consensus has emerged regarding an alternative to the SVC access site.[1,2] Herein, we report the technical aspects, operative safety, reproducibility, hemodynamic adequacy, and potential technical advantages of left brachiocephalic vein (LBCV) cannulation as part of bicaval venous drainage in adult cardiac surgery.

Patients and Methods

From 2012 through 2014, we routinely performed LBCV cannulation as part of bicaval venous drainage during intracavitary surgery in 150 consecutive patients (mean age, 49 ± 14.8 yr; female, 44%; mean preoperative left ventricular ejection fraction, 0.45 ± 0.1). Table I lists the indications for right atrial isolation. The patients were informed about the procedure, and all provided written consent.

After median sternotomy, the thymic lobes were dissected, and the thymic veins were ligated and dissected from the LBCV (Fig. 1A). The mid portion of the LBCV was dissected from its vascular sheath. Next, aortic cannulation was performed, and a 5-0 monofilament purse-string suture was placed on the anterior aspect of the LBCV (Fig. 1B). Thereafter, each patient was positioned in a slight Trendelenburg position, and an incision was made inside the LBCV to enlarge the purse-string suture with use of fine dissectors. A 90° right-angled or flexible venous cannula was introduced and the tip positioned toward the Pirogoff junction (Figs. 1C and D). The venous cannula was then secured to skin, to prevent unintentional withdrawal (Fig. 1E). Right atrial isolation was accomplished by using caval taping. Before the start of bicaval venous drainage, the LBCV cannula was drained (before and after snaring the SVC) so that its maximal flow and the appropriateness of the upper-body drainage



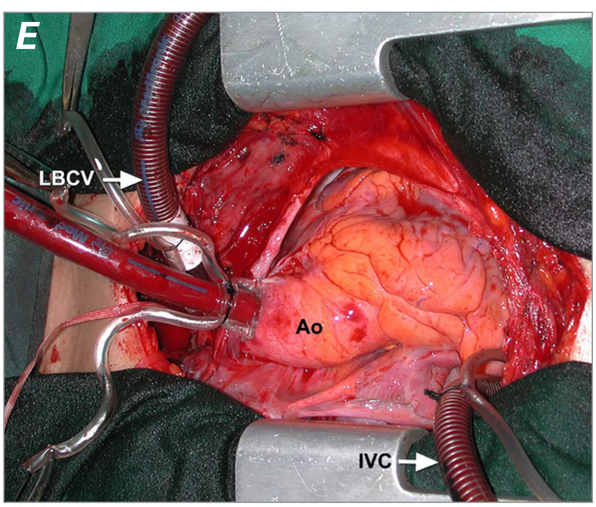


Fig. 1 *Intraoperative photographs show* ***A****) the intact pericardium and the extrapericardial left brachiocephalic vein (LBCV) (arrow);* ***B****) the placement of a purse-string suture on the anterior surface of the skeletonized LBCV (arrow) after aortic cannulation; and* ***C****) a right-angled cannula placed in the LBCV.* ***D****) Illustration shows the cannula tip positioned toward the Pirogoff junction.* ***E****) Intraoperative photograph shows the LBCV and IVC cannulas in place and a clear surgical field.*

Ao = ascending aorta; IVC = inferior vena cava

could be evaluated. Meanwhile, central venous pressure (CVP) was closely monitored. After the procedure and the withdrawal of the LBCV cannula, the purse-string suture was reinforced with 5-0 monofilament suture.

Statistical Analysis

An indexed reference value of 2,400 mL/min/m^2 was chosen as the basic normal required flow from which to calculate and index total pump and LBCV cannula flows. The patients' demographic information, operative data, total pump and LBCV cannula flows with their corresponding calculated and indexed flows, and CVP levels were collected and entered prospectively in SPSS version 19 (IBM Corporation; Armonk, NY). Data were presented as mean ± SD for continuous variables, and as number and percentage for categorical

TABLE I. Procedures and Results in the 150 Patients

Variables	Values
Procedures	
Valve procedures* ± CABG	58 (38.7)
CABG	59 (39.3)
Root replacement	4 (2.7)
Heart tumor resection	5 (3.3)
Adult congenital procedures	24 (16)
Surgical Status	
Elective	117 (78)
Urgent or emergency	28 (19.3)
Repeat operation	5 (3.4)
Hemodynamic Status	
Body surface area, m^2 (range)	1.72 ± 0.2 (1–1.9)
Calculated flow rate, mL/min	4,128 ± 498
LBCV drainage, mL/min	2,607 ± 456
Indexed LBCV drainage, mL/min/m^2	1,520 ± 216
LBCV drainage/calculated flow ratio, % (range)	64 (40–80)
Complications	
Intra-aortic balloon pump insertion	4 (2.7)
Reoperation	10 (6.7)
Bleeding	6 (4)
Sternal dehiscence	1 (0.7)
New postoperative AF in CABG	5/59 (8.5)

AF = atrial fibrillation; CABG = coronary artery bypass grafting; LBCV = left brachiocephalic vein

*Including valve replacement or repair of 1 or more heart valves ± modified maze procedure or ascending aorta surgery.

Unless otherwise stated, data are presented as number and percentage or as mean ± SD.

variables. The study was performed in compliance with the guidelines of the authors' institution.

Results

The patients' mean body surface area was 1.72 ± 0.2 m^2 (range, 1–1.9 m^2), and the mean calculated flow rate was 4,128 ± 498 mL/min. A 22F venous cannula was used in 97% of the patients. The mean LBCV cannula flow was 2,607 ± 456 mL/min, and its mean indexed flow was 1,520 ± 216 mL/min/m^2—resulting in an LBCV cannula-to-calculated pump-flow ratio of 64% (median, 60%) (Table I). The mean CVP was 3.7 ± 1.9 mmHg during right atrial isolation. The mean pump and ischemic times were 167 ± 77 and 111 ± 63 min, respectively.

All patients survived surgery. Four patients needed perioperative insertion of an intra-aortic balloon pump, and 6 patients needed reoperation for bleeding unrelated to the LBCV cannulation site (Table I). There were no instances of LBCV injury or functional side effects (for example, left-arm edema), nor were there any neurologic deficits caused by inappropriate drainage of the jugular veins.

Discussion

Bicaval venous drainage is mandatory for intracavitary procedures, and it is advised for improving myocardial and organ protection.[1-3] Upper-body drainage is usually undertaken by means of SVC cannulation through right atrial appendage access or the direct SVC approach.[1,2] As alternatives to direct SVC cannulation, jugular vein and LBCV cannulations have been advocated. Jugular vein cannulation is used primarily as an extrathoracic remote cannulation site, mainly in robotic or minimally invasive cardiac surgery, extracorporeal membrane oxygenation, or repeat surgery.[4-7] Cannulation of the LBCV has been used in the correction of congenital heart defects or as a means of assisted venous drainage during minimally invasive cardiac surgery.[8,9] Nonetheless, the existing medical literature lacks reports on LBCV cannulation's routine and systematized implementation in bicaval venous drainage.

We consider cannulation of the LBCV to be technically safe and reproducible: we recorded no instances of vein injury or reoperation necessitated by venous purse-string bleeding in our series. Nevertheless, although we found no reports of neurologic disturbances (caused by inappropriate drainage of the cerebral territory) or postoperative left-arm edema, the post-cannulation functional status of the LBCV should be investigated further. Moreover, the small diameter of the LBCV cannula raises doubts about the adequacy of the provided venous drainage.[10,11] We typically used a 22F cannula and found that LBCV cannulation yielded an LBCV drainage-to-calculated pump-flow ratio of 64% (range, 40%–80%) without a rise in CVP.

From a technical standpoint, LBCV cannulation has advantages in comparison with SVC cannulation. The LBCV, an extrapericardial vessel (Fig. 1A), can be safely approached in emergency situations (such as acute aortic dissection); when partial unloading of the heart seems advisable (for example, in acute pulmonary embolism or acute interventricular septal defects); and when approaching the SVC or right atrium is difficult anatomically (such as in repeat surgery or ascending aorta aneurysm). Moreover, LBCV cannulation affords improved exposure to proceed with SVC-related surgeries, such as those to correct partial anomalies of pulmonary venous return. Greater degrees of SVC mobilization can be obtained by means of LBCV cannulation. This is of technical value when access to the right pulmonary artery or left atrial roof is needed.

Concurrent femoral and LBCV cannulation prevents the inadvertent dislodgment of intracardiac masses by avoiding heart manipulations up to the point of reaching fully calculated pump flow, cardiac arrest, or both. When proceeding to coronary artery bypass grafting, the appropriate length of the grafts should be measured preprocedurally on the fully beating heart, to reduce errors in estimating graft lengths under the unloaded heart.[12]

We expect that the hemodynamic data provided by the current series will have a positive impact on future perfusion strategies. This technique's 64% ratio of the mean indexed LBCV drainage-to-calculated pump flow should aid decision-making with regard to emerging intrathoracic—yet extracardiac—connections for partial and mini-extracorporeal circulation technology, on-pump beating-heart approaches, and short-term circulatory assist-device implantation.

Considering our results and the observed technical advantages, we conclude that LBCV cannulation is a safe and reproducible alternative to SVC cannulation in adult patients undergoing cardiac surgery.

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References

1. Kouchoukos NT, Blackstone EH, Hanley FL, Kirklin JK. Cardiac surgery. 4th ed. Philadelphia: Elsevier Saunders; 2013. p. 67-132.
2. Hessel EA II. Circuitry and cannulation techniques. In: Gravlee GP, Davis RF, Stammers AH, Ungerleider RM, editors. Cardiopulmonary bypass principles and practice. 3rd ed. Philadelphia: Lippincott Williams & Wilkins; 2008. p. 63-99.
3. Buckberg GD, Beyersdorf F, Allen BS, Robertson JM. Integrated myocardial management: background and initial application. J Card Surg 1995;10(1):68-89.
4. Luciani N, Anselmi A, De Geest R, Martinelli L, Perisano M, Possati G. Extracorporeal circulation by peripheral cannulation before redo sternotomy: indications and results. J Thorac Cardiovasc Surg 2008;136(3):572-7.
5. Javidfar J, Wang D, Zwischenberger JB, Costa J, Mongero L, Sonett J, Bacchetta M. Insertion of bicaval dual lumen extracorporeal membrane oxygenation catheter with image guidance. ASAIO J 2011;57(3):203-5.
6. Aybek T, Dogan S, Wimmer-Greinecker G, Westphal K, Mortiz A. The micro-mitral operation comparing the Port-Access technique and the transthoracic clamp technique. J Card Surg 2000;15(1):76-81.
7. Field ML, Al-Alao B, Mediratta N, Sosnowski A. Open and closed chest extrathoracic cannulation for cardiopulmonary bypass and extracorporeal life support: methods, indications, and outcomes. Postgrad Med J 2006;82(967):323-31.
8. Suzuki T, Masuoka A, Uno Y, Iwazaki M, Yamagishi S, Katogi T. Cardiopulmonary bypass through a left thoracotomy using venous drainage from the innominate vein in congenital heart surgery. J Card Surg 2013;28(5):591-4.
9. Zlotnick AY, Gilfeather MS, Adams DH, Cohn LH, Couper GS. Innominate vein cannulation for venous drainage in minimally invasive aortic valve replacement. Ann Thorac Surg 1999;67(3):864-5.
10. Corno AF. Systemic venous drainage: can we help Newton? Eur J Cardiothorac Surg 2007;31(6):1044-51.
11. Grigioni M, Daniele C, Morbiducci U, D'Avenio G, Di Benedetto G, Del Gaudio C, Barbaro V. Computational model of the fluid dynamics of a cannula inserted in a vessel: incidence of the presence of side holes in blood flow. J Biomech 2002;35(12):1599-612.
12. Aazami MH, Abbasi-Teshnizi M, Amini S, Lotfinejad NS. Right-sided reverse T composite arterial grafting to complete revascularization of the right coronary artery. Rev Bras Cir Cardiovasc 2014;29(4):657-62.