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Femoral cannulation: a safe vascular access option for cardiopulmonary bypass in minimally invasive cardiac surgery

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Abstract

Femoral cannulation during cardiopulmonary bypass has become a common approach for many cardiac procedures and serves as an important access option, especially during minimally invasive cardiac surgery. Opponents, however, argue that there is significant risk, including site-specific and overall morbidity, which makes the use of this modality dangerous compared to conventional aortoatrial cannulation techniques. We analyzed our institutional experience to elucidate the safety and efficacy of femoral cannulation. All data were collected from a single hospital's cardiac surgery database. A total of 346 cardiac surgeries were evaluated from September 2012 to September 2013, of which 85/346 (24.6%) utilized a minimally invasive approach. Of the 346 operations performed, 72/346 (20.8%) utilized femoral cannulation while 274/346 (79.2%) used aortoatrial cannulation. Stroke occurred in 1/72 (1.39%) after femoral cannulation, specifically, in a conventional sternotomy patient, while it occurred in 6/274 (2.19%) [p=0.67] after aortoatrial cannulation. When comparing postoperative complications between the femoral cannulation and aortoatrial cannulation groups, the rates of atrial fibrillation [10/72 (13.9%) versus 46/274 (16.8%), p=0.55], renal failure [2/72 (2.78%) versus 11/274 (4.01%), p=0.62], prolonged ventilation time [4/72 (5.56%) versus 27/274 (9.85%), p=0.26] and re-operation for bleeding [3/72 (4.17%) versus 13/274 (4.74%), p=0.84] showed no significant difference. Selective femoral cannulation provides a safe alternative to aortoatrial cannulation for cardiopulmonary bypass and is especially important when performing minimally invasive cardiac surgery. When comparing aortoatrial and femoral cannulation, we found no significant difference in the postoperative complication rates and overall mortality.

Keywords

cardiopulmonary bypass; femoral cannulation; minimally invasive cardiac surgery

Introduction

Cardiopulmonary bypass (CPB) has been used by cardiothoracic surgeons since 1953.[1] Aortoatrial cannulation during open-heart surgery was the standard technique and is the most common approach for CPB. Complex surgical procedures, including redo sternotomy, aortic dissection repair and minimally invasive cardiac surgery (MICS), have led cardiac surgeons to develop new techniques for cannulation. Peripheral artery access for CPB, including femoral and axillary cannulation, has become an important option for surgeons performing complex procedures or MICS.

Femoral cannulation is advantageous in redo sternotomies for multiple reasons. Femoral access provides a faster and easier connection to CPB, subsequently, offering better myocardial protection in the unstable

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patient. The immediate CPB decompresses the heart, reducing the risk of damaging structures while lysing adhesions upon mediastinal entrance. Avoiding aortic cannulation also results in less manipulation of the aorta, which may have multiple proximal anastomoses or extensive atherosclerosis.[2]

Femoral cannulation is also a principal technique used in CPB during aortic dissection repair. Proximal perfusion at the distal aortic arch pushes the inner true lumen towards the outer layer, therefore, decreasing the size of the false lumen and reducing side-branch malperfusion from the preceding dissection.[3] Other options for CPB cannulation in Stanford Type A aortic dissection repair include axillary artery and dissected ascending aortic cannulation. The axillary artery has proven to be cumbersome and time-consuming for surgeons, especially in obese patients, and this technique is not ideal in cardiac tamponade when the patient needs immediate CPB.[4] Cannulating the dissected ascending aorta has the advantage of perfusing the true lumen.[5] However, this method carries the risk of aortic rupture and distal embolization.

Compared to a sternotomy, MICS has been shown to be associated with similar short- and long-term mortality, but decreased pain, transfusions, post operative atrial fibrillation, duration of ventilation and hospital stay.[6] New cannulation techniques have become essential since MICS has necessitated smaller incisions and operative fields. The standard operation employs retrograde arterial perfusion through the femoral artery. Recent data have suggested that this approach during MICS is associated with a higher stroke rate than sternotomy approaches.[7] However, three studies from high-volume institutions have concluded there was no difference in stroke risk with retrograde perfusion compared to antegrade perfusion.[8–10] In this study, we analyzed our institutional experience to elucidate the safety and efficacy of femoral vessel cannulation.

Methods

Patient data

This study was approved by the Institutional Review Board, meeting all ethical and legal requirements without the need for the acquisition of informed consent. All preoperative data, in-hospital outcomes and post-discharge outcomes were collected from the medical records and the institution's database according to The Society of Thoracic Surgeons (STS) National Adult Cardiac Database version 2.81 definitions.

This study was a retrospective, observational, single surgeon experience, cohort study of 346 patients who had cardiac surgeries, including coronary artery bypass graft (CABG), aortic valve replacement (AVR), mitral valve repair (MVR) and aortic dissection between September 2012 and September 2013. During these procedures, 85/346 (24.6%) utilized a minimally invasive operative approach; specifically, mini-sternotomy and mini anterior thoracotomy for AVR and mini anterior thoracotomy for MVR.

Demographics such as age, sex and preoperative comorbidities were compared along with postoperative complications, including stroke, surgical site infection, atrial fibrillation, renal failure, prolonged ventilation time, re-operation for bleeding and overall mortality.

Patient selection

In selecting appropriate patients for femoral cannulation, we excluded patients with severe aortoiliac disease, small femoral arteries and inferior vena cava (IVC) filters.

Technique

After making a groin incision, the common femoral artery and vein are exposed. Using the Seldinger technique, after placement of purse-string sutures, a guide-wire is introduced into the femoral artery and advanced toward the upper descending thoracic aorta via the iliac artery and the abdominal aorta. A transesophageal echocardiography (TEE) probe is placed in the mid-esophageal position and turned until a transverse section of the aorta is visualized. The guide-wire is positioned and confirmed with TEE to ensure that the wire is within the lumen of the aorta and the cannula [Abiomed BVS 5000, 10mm, Ref# 0506-0110-HAR, Danvers, MA, USA] is advanced over the guide-wire until its tip extends to the iliac artery. Venous cannulation is established, also utilizing the Seldinger technique, using a 25 Medtronic [DLP, Ref# 66128, Minneapolis, MN, USA] cannula and the tip is advanced to the level of the right atrium. The TEE probe is used to confirm that the cannula lies in the correct position and that blood flow is present after the establishment of CPB.

Statistical analysis

Patient demographic and aortic valve pathology data were summarized as median and percentages, as appropriate. Chi-square and frequency analysis were performed using SAS 9.3 software (SAS Institute, Cary, NC). A p-value was considered statistically significant when it was less than 0.05.

Results

Patient demographics and preoperative comorbidities were compared between the two cannulation groups and are presented in Table 1. Of the 346 operations

Table 1. Patient Demographics.

Characteristics Median (range) or Number of patients (%)	Total	Fem Can CPB	Conventional CPB
Men	222	43	179
Women	124	29	95
Age	73 ± 13	70 ± 11	73± 13
Smoker			
Current	7.51%	8.33%	7.30%
History	60.7%	59.7%	60.9%
Diabetic	31.2%	33.3%	30.7%
Hypertension	84.3%	87.5%	83.6%
Hyperlipidemia	78.9%	76.4%	79.6%
Chronic Renal Failure	6.36%	5.56%	6.57%
Cerebrovascular Disease	15.3%	13.9%	15.7%
History of CVA	10.1%	11.1%	9.85%
Congestive Heart Failure	37.6%	36.1%	37.9%
Ejection Fraction	53 ± 13%	55 ± 9%	53 ± 13%

CVA: cerebrovascular accident.

Table 2. Types of surgeries with aortoatrial and femoral cannulation.

Type of Surgery	*Type of Cannulation*	
	Aortoatrial	Femoral
CABG	153	1
AVR	23	32
MVR	8	19
Combination	37	0
Other*	53	20

CABG: coronary artery bypass graft; AVR: aortic valve replacement; MVR: mitral valve repair;
*Other: aortic dissection; ventricular assist devices.

performed, 72/346 (20.8%) utilized femoral cannulation while 274/346 (79.2%) utilized aortoatrial cannulation. A comparison between different surgeries and the preceding cannulation technique are presented in Table 2. The majority of cases which employed femoral cannulation were minimally invasive [62/72 (86.1%)] while the remaining 10/72 (13.9%) were operations with conventional sternotomy.

Stroke occurred in 1/72 (1.39%) after femoral cannulation, specifically, in a conventional sternotomy patient, while occurring in 6/274 (2.19%) [p=0.67] after aortoatrial cannulation. There were no cases of surgical site infection in any of the patients analyzed.

When comparing postoperative complications between the femoral cannulation and aortoatrial cannulation groups, the rates of atrial fibrillation [10/72 (13.9%) versus 46/274 (16.8%), p=0.55], renal failure [2/72 (2.78%) versus 11/274 (4.01%), p=0.62], prolonged ventilation time [4/72 (5.56%) versus 27/274 (9.85%), p=0.26] and re-operation for bleeding [3/72 (4.17%) versus 13/274 (4.74%), p=0.84] showed no significant difference amongst all the patients (Table 3).

Overall operative mortality was 5/72 (6.94%) after femoral cannulation, four of which were after minimally invasive surgery and 10/274 (3.65%) after aortoatrial cannulation [p=0.22].

Discussion

In the last five years, serious concerns have been raised regarding higher incidences of stroke and vascular complications with MICS using peripheral cannulation.[8–11] A 2010 study found femoral artery cannulation has the highest rate of mortality, stroke rate and other complications, including retrograde cerebral embolization, organ malperfusion and perfusion of the false lumen, when analyzing 14 papers comparing peripheral and central cannulation techniques.[12] These conclusions have been debated by identifying cofounding factors, such as early experience and burden of aortoiliac disease.[13] In addition, a meta-analysis by this author did not find an increase in stroke rate with femoral cannulation.[14] The stroke rate of 1.39% in our study population reinforces that finding.

Another complication of femoral cannulation is decreased distal limb perfusion, leading to ischemia and, potentially, compartment syndrome of the lower extremity. Early detection and decompressive fasciotomy when necessary should limit the extent of local tissue damage and subsequent rhabdomyolyis and renal failure.[15] One way to minimize this complication is to provide distal superficial arterial perfusion through a separate introducer and connection to a side port of the arterial line.[16] In our institution, we minimize the duration of time that the cannula is in place. We also do not routinely use

Table 3. Postoperative Complications.

Complication	Femoral	Aortoatrial	p-value
Atrial Fibrillation	10/72 (13.9%)	46/274(16.8%)	0.55
Renal Failure	2/72 (2.78%)	11/274(4.01%)	0.62
Prolonged Vent Time	4/72 (5.56%)	27/274(9.85%)	0.26
Re-operation for Bleeding	3/72 (4.17%)	13/274(4.74%)	0.84

snares around the artery, which allows for some distal blood flow. Our experience showed no incidence of lower extremity ischemia following femoral-femoral cannulation.

The small sample size poses a limitation to this study, especially regarding the low stroke rate and absence of peripheral complications; a stronger conclusion could be drawn with a larger number of procedures. Other limitations include the retrospective nature of analysis, the single-center experience and the lack of patient-matched controls for the different cannulation techniques across the time periods. For example, patients were excluded from the femoral cannulation group due to peripheral atherosclerosis; if excluded from the aortoatrial cannulation group as well, the stroke outcomes may have been different.

In conclusion, selective femoral cannulation provides a safe alternative to aortoatrial cannulation for cardiopulmonary bypass and is especially important when performing minimally invasive cardiac surgery. When comparing aortoatrial and femoral cannulation, we found no significant difference in the postoperative complication rates, specifically stroke, local morbidity and overall mortality.

Declaration of Conflicting Interest

The authors declare that there is no conflict of interest.

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