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Our Experiences in Percutaneous Cannulation and Monitoring in Minimal Invasive Cardiac Surgery

Minimal İnvaziv Kalp Cerrahisinde Perkütan Kanülasyon ve Monitorizasyon Deneyimlerimiz

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ABSTRACT

Background: The aim of the study was to evaluate the patients who underwent minimally invasive cardiac surgery and percutaneous internal jugular vein catheterization in our center, and to discuss the catheterization results and complications in the literature.

Materials and Methods: Between January 2015 and September 2019, 70 female (59.3%) and 48 (40.7%) male patients, who underwent minimally invasive cardiac surgery and percutaneous internal jugular vein cannulation in our center, had a mean age of 37.2±14.5 (19-74 years), data of 118 cases were evaluated retrospectively. It was noted that 17 F jugular venous catheter was placed in patients with body surface area (BSA) <1.87, and 19 F venous catheter was placed in patients with (BSA) >1.87. Cannula positions and echocardiographic findings of the patients during cannulation were evaluated with transesophageal echocardiography (TEE).

Results: All surgical interventions were performed minimally invasively by thoracotomy. Since the adequate surgical field of vision could not be achieved in 3 (2.5%) of the patients, the operation was reverted to sternotomy. No mortality due to cannulation was observed in any of the patients. Local hematoma (1.6%) developed due to carotid artery puncture in 2 patients, transient atrial fibrillation (1.6%) in 2 patients, and pneumothorax (0.8%) in one patient.

Conclusion: Minimally invasive cardiac surgical interventions have become popular nowadays and their importance has increased due to reasons such as faster recovery of patients, less complications, and smaller surgical incision area. Internal jugular cannulation is required in minimally invasive cardiac surgery procedures. In order to avoid possible complications in the percutaneous cannulation process and therefore to reduce mortality, it is very important that cannulation procedures be performed by an experienced team and evaluated with TEE during this time.

Keywords: Minimally invasive surgical procedures, cannulation, jugular veins

ÖZ

Amaç: Çalışmanın amacı, merkezimizde minimal invaziv kalp cerrahisi uygulanan ve perkütan internal juguler ven kateterizasyonu yapılan hastaların değerlendirilmesi, kateterizasyon sonuçları ve meydana gelen komplikasyonların literatürler eşliğinde tartışılmasıdır.

Gereç ve Yöntemler: Ocak 2015-Eylül 2019 tarihleri arasında merkezimizde minimal invaziv kalp cerrahisi geçiren ve perkütan internal juguler ven kanülasyonu yapılan, 70'i kadın (%59,3), 48'i erkek (%40,7) hastadan oluşan ve yaş ortalaması 37,2±14,5 (19-74 yaş) olan 118 olgunun verileri retrospektif olarak incelendi. Vücut yüzey alanı (VYA) <1,87 olan hastalara 17 F juguler venöz kateter, (VYA) >1,87 olan hastalara 19 F venöz kateter yerleştirildiği kaydedildi. Hastaların kanülasyon sırasında kanül pozisyonları ve ekokardiyografik bulguları transözefageal ekokardiyografi (TÖE) ile değerlendirildi.

Bulgular: Uygulanan cerrahi girişimlerin tümü torakotomi ile minimal invaziv olarak gerçekleştirilmiştir. Hastalardan 3'ünde (%2,5) yeterli cerrahi görüş alanı sağlanamadığından operasyon sternotomiye dönmüştür. Hiçbir hastada kanülasyona bağlı mortalite gözlenmemiştir. Hastaların 2'sinde karotis arter ponksiyonu nedeniyle lokal hematom (%1,6), iki hastada geçici atriyal fibrilasyon (%1,6), birinde de pnömotoraks (%0,8) gelişmiştir.

Sonuç: Minimal invaziv kalp cerrahisi girişimleri, hastaların daha çabuk derlenmesi, daha az komplikasyona neden olması, cerrahi kesi alanının küçülmesi gibi nedenlerden dolayı, günümüzde popüler hale gelmiş ve önemi artmıştır. Minimal invaziv kalp cerrahisi

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ÖZ

girişimlerinde internal jugular kanülasyon gerekmektedir. Perkütan kanülasyon sürecinde olası komplikasyonlardan kaçınmak ve mortaliteyi azaltmak için kanülasyon işlemlerinin deneyimli bir ekip tarafından yapılması ve bu sırada TÖE ile değerlendirilmesi oldukça önemlidir.

Anahtar Kelimeler: Minimal invaziv cerrahi girişimler, kanülasyon, juguler venler

Introduction

Conventional cardiac surgery is performed through median sternotomy, which provides a larger surgical area, allowing easy access to cardiac structures for cannulation and cardiopulmonary bypass (CPB). Currently, the ability to perform operations with a less invasive approach through smaller surgical incisions have become more important; rendered possible by the development of technology, technical innovations in surgery and anesthesia and the use of intraoperative transesophageal echocardiography (TEE) Minimally invasive surgery (MICS) significantly reduces surgical stress response, length of stay in the hospital and intensive care unit, scar tissue formation and transfusion requirement. Thus, a significant reduction in the hospital costs occurs (1).

Normally, CPB is established after sternotomy via central arterial and venous cannulation made by the surgeon. However, with the definition of minimally invasive cardiac surgery (MICS), new cannulation techniques have come forward. With use of these techniques, which are performed through percutaneous peripheral cannulation, CPB can be established with a smaller sternal incision or a thoracotomy incision without the need for median sternotomy. Subclavian, internal jugular, femoral and iliac veins or arteries can be used for cannulation (2).

For example, minimally invasive surgeries that do not require right atriotomy, such as coronary artery bypass graft surgery, can be performed with a single venous cannula placed in the right atrial cavity via the femoral vein. However, the placement of the venous cannula into the atrial cavity is not suitable in open heart surgery procedures that require right atriotomy or left atriotomy, such as atrial septal defect (ASD) repair, mitral valve replacement (MVR). In these cases, bicaval cannulation can be provided through the femoral and internal jugular veins (IJVs) (2). Our study aims to analyze the percutaneous IJV cannulations applied in MICSs performed in our institution, in the light of current literature.

Material and Methods

After the approval of the Ethics Committee İstanbul Dr. Siyami Ersek Thoracic and Cardiovascular Surgery Training and Research Hospital, (E-28001928-604.01.01), 118 patients who underwent MICS with percutaneous IJV cannulation in our center between January 2015 and September 2019 were included in the study.

The mean age was 37.2±14.5 years (minimum-maximum: 19-74 years), 70 were female (59.3%) and 48 were (40.7%) male. Patients with MICS contraindication criteria; ascending aortic aneurysm (AA >4 cm), presence of moving plaque in the aorta, severe mitral annular calcification, patients with radiotherapy history, as well as patients who are morbidly obese [body mass index (BMI) >35] and patients requiring emergency surgery were excluded from the study.

Written informed consent was obtained from each patient. The study protocol was approved by the hospital scientific committee. The study was conducted in accordance with the principles of the Declaration of Helsinki. Patient data were scanned retrospectively from perfusion and anesthesia records and patient files in our hospital data system.

Anesthesia Management and Catheterization

All patients routinely underwent IV catheterization with 16 G wide peripheral IV catheter (The Introcan Safety® IV Catheter B. Braun Medical Inc. USA), then 20 G radial artery catheterization (Arrow® Seldinger Arterial Catheter, USA). Monitorization was provided with 5-electrode electrocardiography, peripheral oxygen saturation (SpO_2) and near infrared spectroscopy (Covidien, USA). External defibrillator pads were placed for defibrillation.

After preoxygenation, anesthesia was induced with 2-3 mg/kg propofol, 5 mcgr/kg fentanyl, 1 mg/kg rocuronium. Female patients shorter than 165 cm were intubated with a 35 F, female patients taller than 165 cm were intubated with a 37 F left double lumen tube (Handan FCH Medical Device Technology, China), while male patients taller than 170 cm were intubated at 41 F, male patients shorter than 170 cm were intubated with a 39 F left double lumen tube. An 8.5 F three-way central catheter (Multi-Lumen Central Venous Catheter, Arrow International Inc.PA, USA) was also placed through the left IJV and central venous pressure (CVP) monitoring was performed.

Propofol, fentanyl and sevoflurane were administered for anesthesia maintenance. 1 g vancomycin was routinely given to the patients who will undergo mechanical valve

replacement, for the prophylaxis of infective endocarditis, as recommended by the infectious diseases committee of our center. 1 g IV tranexamic acid was given to all patients and followed by continuous infusion at 7.5 mg/kg/hour.

TEE (Vivid 7 GE Vingmed Ultrasound AS Horten, Norway) probe was placed in all patients for intraoperative TEE.

Before cannulation, 1 mg/kg heparin was administered to the patients. For percutaneous central venous cannulation, the patient's head was deviated 45° to the left, the IJV was punctured with the palpation technique, the guide wire was advanced, and the location of the guide wire was confirmed by TEE, and cannulation was performed with the seldinger technique.

The tip of the cannula was advanced and fixed at the cava-atrial junction with TEE guidance (Figure 1). 17 F jugular venous catheter (Bio-Medicus venous canulae Medtronic, Minneapolis, USA) was used for patients with body surface area (BSA) <1.87, and 19 F venous catheter was used for patients with BSA >1.87 (Figure 2).

Femoral artery and femoral vein cannulation was performed by the surgical team under the guidance of TEE. Before initiating CPB, 3 mg/kg heparin was administered to the patients, to ensure an ACT measurement >450 sec. All operations were performed at 32 °C moderate hypothermia. Myocardial protection was provided by cold blood cardioplegia, given every 20 minutes.

The operations were performed with thoracotomy. At the end of the operation, hemodynamic parameters and blood gas results (pH, PaO_2, $PaCO_2$, hemoglobin, hematocrit, SaO_2, lactate) were evaluated and CPB was terminated under TEE monitoring. Heparin was neutralized 1:1 with protamine and the IJV cannula was withdrawn, the cannulation incision was sutured with circular stitches and jugular compression was applied for approximately 15 minutes. Femoral decannulation was made afterwards, hemostasis was achieved and the incisions were closed. The patients were transferred to the intensive care unit after the operation.

Figure 1. Venous cannula in the bicaval right atrium image at the middle esophageal level in transesophageal echocardiography

Statistical Analysis

Categorical variables are presented as numbers and frequencies. Continuous variables showing normality are expressed as mean ± standard deviation. SPSS software (version 25.0, IBM Corporation, Armonk, NY, USA) was used for statistical analysis.

Results

A total of 118 (n=118) patients, including 70 women (59.3%) and 48 (40.7%) men, were included in the study. Their mean age was 37.2±14.5 (minimum-maximum: 19-74 years), mean body weight was 69.5±12.4 kg, and mean BMI was 25.5±4.3. The mean BSA was 1.77±0.17, and the mean preoperative left ventricular ejection fraction was 57.4±5.8 (Table 1).

Performed surgical operations were; 32 ASD closure, 2 ASD closure + tricuspid ring annuloplasty (TRA), 1 ASD closure + TRA + partial venous return anomaly (PAPVD) correction, 64 MVR, 6 MVR + TRA, 1 MVR+coronary fistula closure, 8 minimally invasive direct coronary artery bypass (MIDCAB), 4 atrial myxoma removal (Table 2). The operation be performed by thoracotomy. The mean duration of CPB

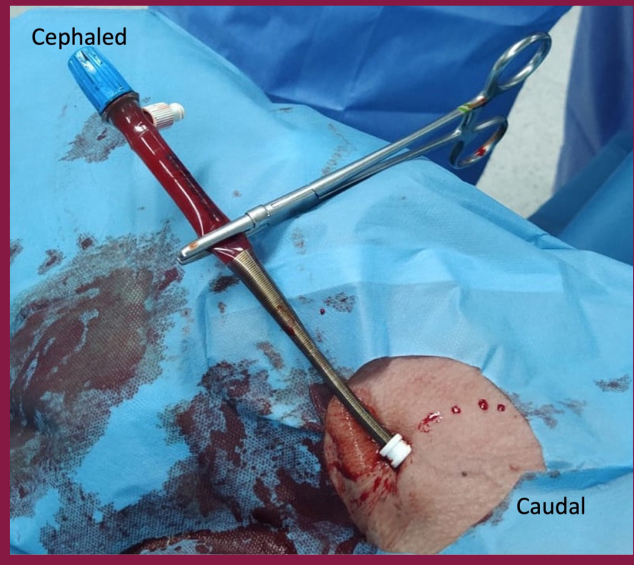

Figure 2. Internal jugular cannulation

was 128.7±76 minutes, the cross-clamp time was 84.4±49 minutes, the pump flow was 2.3±0.17 Lt/m^2/min, and the postoperative stay in the intensive care unit was 1.9±3.2 days (Table 1). The study flow chart is given in Figure 3.

The operation was reverted to sternotomy and central cannulation in 3 patients (2.5%) due to insufficient surgical field of vision, two patients (1.6%) had local hematoma due to carotid artery puncture, and 2 patients (1.6%) had temporary atrial fibrillation and pneumothorax were observed in 1 patient (0.8%). Complications such as vascular injury, hemothorax, mediastinal hematoma that required surgery were not encountered in the patients. Mortality was not observed in any patient due to cannulation (Table 3).

Table 1. Patient characteristics

Characteristics	n (%)/Mean ± SD
Sex (F/M)	70 (59.3%)/48 (40.7%)
Age (year)	37.2±14.5
Weight (kg)	69.5±12.4
BMI (kg/m^2)	25.5±4.3
BSA (m^2)	1.77±0.17
EF (%)	57.4±5.8
Operation data	
CPB duration (min)	128.7±76
Cross clamp duration (min)	84.4±49
Mean pump flow (L/m^2/min)	2.3±0.17
Mean CVP (mmHg) 17 F cannula/19 F cannula	2.9±0.3/3.3±0.4
Maximum CVP (mmHg) 17 F cannula/19 F cannula	6.8±1.2/7.8±1.6
Intensive care unit stay (day)	1.9±3.2

BMI: Body mass index, BSA: Body surface area, EF: Left ventricle ejection fraction, CPB: Cardiopulmonary bypass, CVP: Central venous pressure, SD: Standard deviation

Table 2. Types of operation

Operation	n (%)
ASD	32 (27.11%)
ASD+TRA	2 (1.6%)
ASD+TRA+PAPVD	1 (0.8%)
MVR	64 (54%)
MVR+TRA	6 (5.08%)
MVR+coronary fistula repair	1 (0.8%)
ATRIAL MYXOMA	4 (3.3%)
MIDCAB	8 (6.7%)

ASD: Atrial septal defect repair, TRA: Tricuspid ring annuloplasty, MVR: Mitral valve replacement, PAPVD: Partial anomalous pulmonary venous return, MIDCAB: Minimally invasive direct coronary artery bypass grafting

Discussion

Traditional cardiac surgery techniques are in the direction of evolving into smaller surgical incisions and less invasive approaches supported by the advancements of technology, surgery and anesthesiology, and the use of intraoperative TEE.

Cosgrove and colleagues described the first minimally invasive valve interventions in 1996 and grouped several different approaches as "MICS" (3). Today, MIDCAB, robotic-assisted cardiac surgery, atrial fibrillation ablation surgery and minimally invasive approaches to the mitral valve, left and right atrium and aortic valve, are considered within the scope of MICS.

A long, two-stage superior vena cava (SVC)/inferior vena cava (IVC) cannula, inserted via the femoral vein, is used for venous cannulation of the surgical procedures in which the heart cavities are not completely opened. However, in

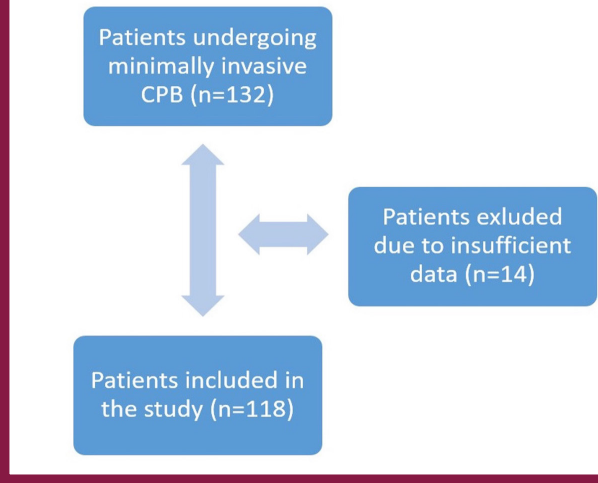

Figure 3. Study of flowchart
CPB: Cardiopulmonary bypass

Table 3. Intraoperative complications

Intraoperative complications	n (%)
Local hematoma	2 (1.6%)
Transient atrial fibrillation	2 (1.6%)
Vascular injury	0 (0%)
Hemothorax	0 (0%)
Pneumothorax	1 (0.8%)
Mediastinal hematoma	0 (0%)
Edema in the upper extremity	0 (0%)
Failed minimally invasive surgery	3 (2.5%)
Mortality	0 (0%)

operations that require opening of the right side of the heart or the left atrium, a possible air leak into the CPB circuit may cause a dangerous air lock in the system. SVC/IVC cannula is also required in transseptal or transatrial MVR, as well as in surgical interventions involving the right atrium, such as tricuspid valve surgery, atrial myxoma removal, ASD or patent foramen ovale repair. The right IJV, which anatomically has a linear path close to the right atrium, is preferred for SVC cannula insertion (4,5,6,7).

In our case series, jugular venous catheterisation preferences were made according to the BSA of the patients. A 19 F jugular venous catheter was inserted in patients with BSA >1.87, and a 17 F jugular venous catheter was inserted in patients with BSA <1.87.

IJV cannulation can be performed with the palpation technique or under the ultrasonography guidance (6,7). In our center, cannulation is performed using the palpation technique. Studies have reported that the palpation method provides 60-95% success, depending on the cannulation site and the physical characteristics of the patient (6,7). It has been reported that although more than 5 million central venous catheters (IJV, SVC, and FV) are inserted annually in the United States alone, mechanical complications occur at a rate of 5% to 19%, and these complications are mostly due to lack of experience and the physical characteristics of the patients (6,7,8,9,10). In our study, local hematoma that did not require surgical intervention due to the carotid artery puncture (1.6%) occurred in 2 patients, pneumothorax that regressed spontaneously in one patient (0.8%), and transient atrial fibrillation (1.6%) in two patients due to a long guide wire, were observed. In the presence of recent data, our complication rate is considerably lower than the complication rates reported in the literature.

However, during IJV cannulation, other than puncture-related complications, more serious and mortal conditions can be seen, especially depending on the cannula size and diameter. In the case report of Hirose et al. (8), a 23 F Avalon cannula was inserted into the IJV in a patient who was planned to have VV-ECMO due to ARDS, but sudden hemodynamic deterioration and cardiac tamponade were encountered.

The emergent operation revealed the cannulation related injury in the apex of the right ventricle (8). The most fair way to avoid such complications is to place the cannula under TEE guidance. Jankovic et al. (9) also reported that V-V bypass was planned due to hepatic cirrhosis, 21 F femoral and 21 F internal jugular catheters were inserted, the IJV cannula punctured the vena cava and penetrated the right pleura approximately 4 cm deep into the right thorax. It has been reported that 1.8 liters of hemorrhagic effusion and 0.7 liters of hemorrhagic effusion were drained from the left thorax (9).

Therefore, the use of large diameter and long cannula without TEE guidance may lead to mortal result (10,11). Hemothorax and vascular injury did not occur in our study. In addition, it is important to provide an effective venous drainage for CPB. For this reason, the diameters of the cannula used must be large enough and drainage holes must be present to prevent vacuuming. Inadequate SVC drainage results in impaired venous return in the head and neck, conjunctival edema, and elevated CVP (12,13,14,15). Such complications did not develop in the patients included in the study. Our mean CVP rates were 2.9±0.3 mmHg for 17 F catheters and 3.3±0.4 mmHg for 19 F catheters, while our maximum CVP values were 6.8±1.2 mmHg for 17F catheters, and 7.8±1.6 mmHg for 19 F catheters.

Study Limitations

The limitations of this study was the limited number of patients.

Conclusion

Nowadays, MICS offers serious advantages to the patients and to the healthcare system. During these interventions, the new cannulation techniques supported by the technology and applications such as TEE are substantial in the prevention of many possible complications. Based on our experience and many studies on this subject, we believe that; an appropriate cannula selection according to the type of the intervention and the physical characteristics of the patient, and use of the appropriate techniques are very important for achieving a successful operation.

Ethics

Ethics Committee Approval: After the approval of the Ethics Committee İstanbul Dr. Siyami Ersek Thoracic and Cardiovascular Surgery Training and Research Hospital, (E-28001928-604.01.01), 118 patients who underwent MICS with percutaneous IJV cannulation in our center between January 2015 and September 2019 were included in the study.

Informed Consent: Written informed consent was obtained from each patient.

Peer-review: Internally and externally peer-reviewed.

Authorship Contributions

Surgical and Medical Practices: M.Ş., Concept: M.Ş., Design: M.Ş., Data Collection or Processing: M.Ş., T.K., Analysis or Interpretation: M.Ş., T.K., Literature Search: M.Ş., Writing: M.Ş., T.K.

Conflict of Interest: No conflict of interest was declared by the authors.

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References

1. Dieberg G, Smart NA, King N. Minimally invasive cardiac surgery: A systematic review and meta-analysis. Int J Cardiol. 2016;223:554-560. [Crossref]
2. Ateş M, Sensöz Y. [Toward the perfect heart-lung machine]. Anadolu Kardiyol Derg. 2002;2:253-258. [Crossref]
3. Cosgrove DM, Sabik DF, Navia JL. Minimally invasive valve operations. Ann Thorac Surg. 1998;65:1535-1539. [Crossref]
4. Turker G, Kaya FN, Gurbet A, Aksu H, Erdogan C, Atlas A. Internal jugular vein cannulation: an ultrasound-guided technique versus a landmark-guided technique. Clinics (Sao Paulo). 2009;64:989-992. [Crossref]
5. Troianos CA, Hartman GS, Glas KE, Skubas NJ, Eberhardt RT, Walker JD, et al. Guidelines for performing ultrasound guided vascular cannulation: recommendations of the American Society of Echocardiography and the Society of Cardiovascular Anesthesiologists. J Am Soc Echocardiogr. 2011;24:1291-1318. [Crossref]
6. Iribarne A, Easterwood R, Russo MJ, Chan EY, Smith CR, Argenziano M. Comparative effectiveness of minimally invasive versus traditional sternotomy mitral valve surgery in elderly patients. J Thorac Cardiovasc Surg. 2012;143(Suppl 4):S86-90. [Crossref]
7. Maltepe F, Metin KS, Hepaguşlar H, Hancı V, Uğurlu B, Oto Ö. Percutaneous internal jugular vein cannulation for cardiac surgery. Türk Göğüs Kalp Damar Cerrahisi Dergisi. 2013; 21:959-965. [Crossref]
8. Hirose H, Yamane K, Marhefka G, Cavarocchi N. Right ventricular rupture and tamponade caused by malposition of the Avalon cannula for venovenous extracorporeal membrane oxygenation. J Cardiothorac Surg. 2012;7:36. [Crossref]
9. Jankovic Z, Boon A, Prasad R. Fatal haemothorax following large-bore percutaneous cannulation before liver transplantation. Br J Anaesth. 2005;95:472-476. [Crossref]
10. McGee DC, Gould MK. Preventing complications of central venous catheterization. N Engl J Med. 2003;348:1123-1133. [Crossref]
11. Prempeh ABA, Jacques S, Justiaan LS. Transesophageal echocardiography in minimally invasive cardiac surgery. Curr Opin Anaesthesiol. 2020;33:83-91. [Crossref]
12. Ni Y, Leskosek B, Shi L, Chen Y, Qian L, Li R, et al. Optimization of venous return tubing diameter for cardiopulmonary bypass. Eur J Cardiothorac Surg. 2001;20:614-620. [Crossref]
13. Mack MJ, Leon MB, Thourani VH, Makkar R, Kodali SK, Russo M, et al. Transcatheter aortic-valve replacement with a balloon-expandable valve in low-risk patients. N Engl J Med. 2019;380:1695-1705. [Crossref]
14. Wilbring M, Charitos E, Silaschi M, Treede H. Minimally invasive mitral valve surgery. Indian J Thorac Cardiovasc Surg. 2018;34:113-116. [Crossref]
15. Kayir S, Ozyalcin S, Dogan G, Diken AI, Turkmen U. Internal Jugular Vein Catheterization: The Landmark Technique versus Ultrasonography Guidance in Cardiac Surgery. Cureus. 2019;11:e4026. [Crossref]