Re-redo aortic root replacement utilizing continuous coronary perfusion via bypass grafting in a patient with impaired cardiac function

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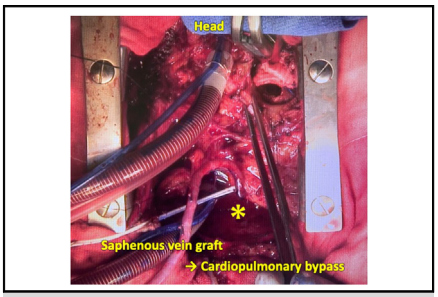


Maintenance of coronary blood flow via anastomosed vein graft (*) during the crossclamp.

CENTRAL MESSAGE

The continuous coronary perfusion via patent bypass grafts and systemic hyperkalemia is a feasible technique to prevent myocardial damage for re-redo root replacement necessitating a long crossclamp.

Video clip is available online.

Redo aortic root replacement after coronary artery bypass grafting (CABG) poses a considerable challenge.[1] Although there have been reports on surgical approaches, such as beating surgery[2] and systemic hyperkalemia,[3,4] these elaborate procedures have not been well reported in complicated cases, such as multiple redo root replacement for prosthetic valve endocarditis (PVE) after CABG.

CASE REPORT

The patient, a 60-year-old man, had previously undergone valve-sparing aortic root replacement (28-mm Gelweave Valsalva graft; Vascutek Ltd) for type A aortic dissection with annuloaortic ectasia 15 years ago, followed by a redo Bentall procedure (Prima PLUS 23 mm; Edwards Lifesciences) for infective endocarditis due to *Staphylococcus* infection 11 years ago. During the redo Bentall procedure, the left main trunk was ligated and CABG was performed using the left internal thoracic artery (LITA).

The patient was admitted with congestive heart failure due to PVE caused by *Cardiovacterium valvarum*, and the left ventricular ejection fraction was 45%. Transesophageal echocardiography revealed a 12-mm vegetation at the prosthetic valve leaflet and severe transvalvular leakage. The preoperative risk of the re-redo root replacement was assessed by the European System for Cardiac Operative Risk Evaluation Score II (24.4%).

Ensuring prolonged and reliable myocardial protection was crucial in this case. Considering the ligated left main trunk and severe adhesion of the LITA to the chest wall (Appendix E1), which made dissection for flow control difficult, antegrade cardioplegia administration was not feasible for myocardial protection, and retrograde cardioplegia was also inadequate due to the risk of washout. Therefore, it was necessary to maintain the blood flow to the right coronary artery (RCA) during the crossclamp.

Following re-sternotomy, cardiopulmonary bypass (CPB) was established by femoral artery and bicaval cannulation, and the saphenous vein graft (SVG) was anastomosed to the RCA. By connecting the SVG to the CPB circuit, myocardial perfusion became completely dependent on the LITA and SVG (SVG flow: 64 mL/min) (Figure 1, *A*). After achieving hypothermia (30 °C), the ascending aorta

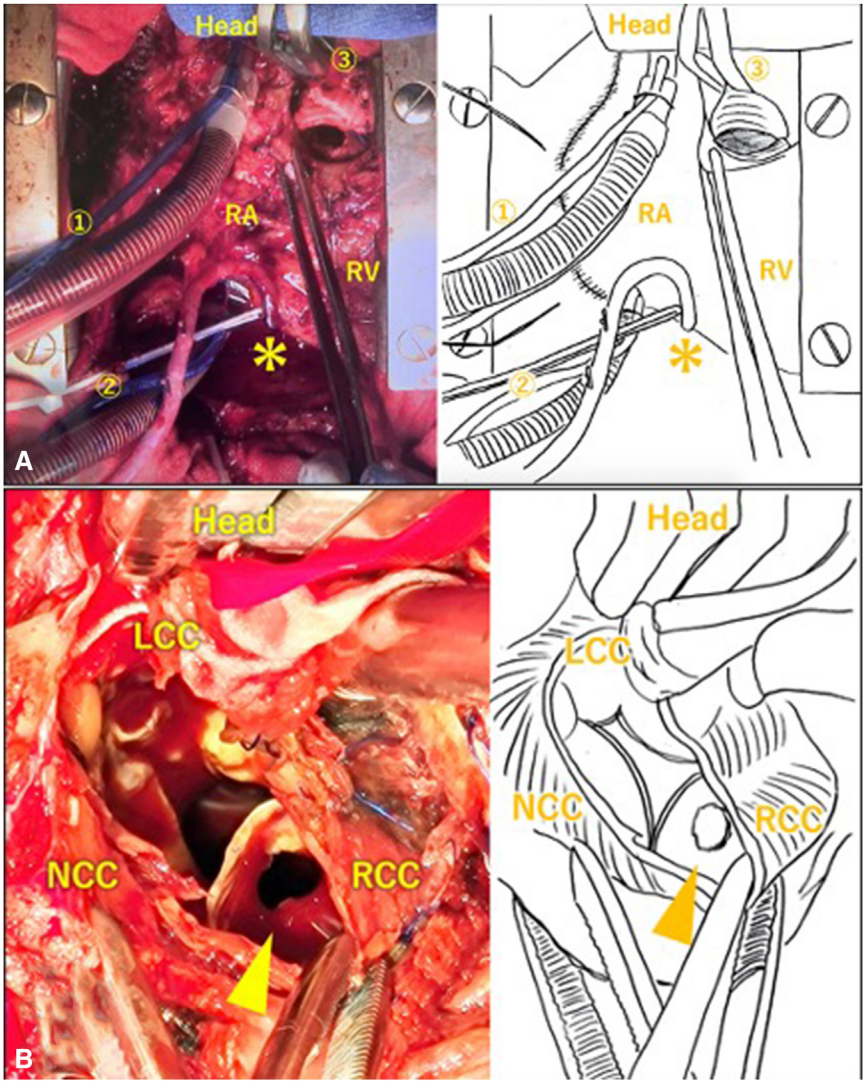
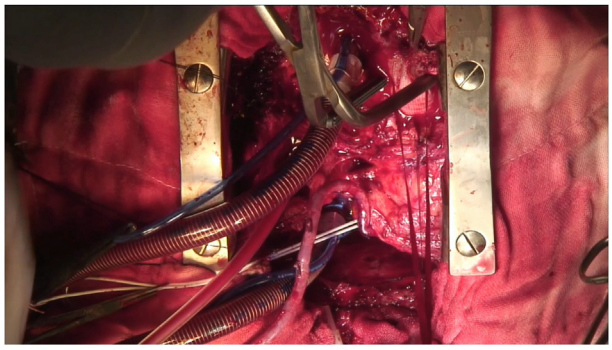


FIGURE 1. A, The SVG (*) anastomosed to the RCA was connected to the CPB circuit. Venous drainage cannulas were placed in the SVC (①) and the IVC (②), and the ascending aorta was crossclamped (③). B, The right coronary cusp leaflet of the bioprosthesis was perforated (*arrowhead*). *RA*, Right atrium; *RV*, right ventricle; *LCC*, left coronary cusp; *NCC*; noncoronary cusp; *RCC*, right coronary cusp.

was crossclamped, and cardiac arrest was initiated by systemic administration of 40 mEq of potassium, resulting in an increase in potassium concentration up to 7.1 mEq/L. Thereafter, myocardial protection was provided by continuous coronary perfusion from the bypass grafts, hypothermia, and systemic hyperkalemia (Video 1), targeting potassium concentrations 6.0 to 7.0 mEq/L, with additional administration of 10 to 20 mEq of potassium every 30 minutes to maintain cardiac arrest. Inspection of the bioprosthesis revealed that the right coronary cusp leaflet was perforated owing to infection (Figure 1, *B*). After complete removal of the prosthetic valve and graft, a new composite Valsalva graft was implanted using the proximal stepwise technique (Appendix E2) due to the extremely narrow and poor operative field of the aortic root caused by severe adhesions. In addition, this made cannulation at the RCA ostium for perfusion difficult and also made reconstructing the RCA button difficult, resulting in ostium ligation. The heart beat spontaneously when the ultrafiltration decreased potassium concentration to 5.3 mEq/L. After reconstructing the SVG to the ascending prosthetic graft, CPB was easily weaned (SVG flow: 65 mL/min). The crossclamp time was 226 minutes. The total potassium administration dose was 110 mEq. Postoperative cardiac function was not impaired, and the creatine kinase-myocardial band isoenzyme peaked at 22.8 U/L. Postoperative cardiac computed tomography showed patency of the LITA and SVG (Figure 2), and the patient was discharged without any complications.



VIDEO 1. SVG was bypassed to the RCA and connected to the CPB circuit to maintain the RCA blood flow during crossclamp. Under the systemic hyperkalemic arrest, re-redo root replacement was safely performed. *RA*, Right atrium; *RV*, right ventricle; *SVG*, saphenous vein graft; *RCA*, right coronary artery; *CPB*, cardiopulmonary bypass. Video available at: https://www.jtcvs.org/article/S2666-2507(23)00266-3/fulltext.

The patient provided written informed consent for publication of this case report. Osaka University Hospital Clinical Research Ethics Committee approved the case report and publication of data (approval number: 16105; approval date: November 2, 2016).

COMMENT

Beating surgery using patent CABG has been reported.[2] However, this method has some procedural difficulties complicated by the beating heart. The achievement of cardiac arrest after CABG by systemic hyperkalemia has been reported,[3,4] with a reported crossclamp time of 126 ± 41 minutes[3] and 101 to 114 minutes.[4] In our case, the operative field was limited by the severe adhesion, which had the potential to prolong the CPB time, necessitating cardiac arrest for secure procedures.

Lee and colleagues[5] reported a greater incidence of reduced cardiac function in the hypothermia with ventricular fibrillation compared with beating surgery. To further reduce myocardial metabolism, in addition to hypothermia, cardiac arrest was induced by systemic hyperkalemia. Consequently, despite the aortic crossclamp time of nearly 4 hours, no myocardial injury was observed (Appendix E3).

The use of concomitant CABG for continuous myocardial perfusion and systemic hyperkalemia is a feasible technique for preventing myocardial damage. This technique may serve as an alternative option for challenging cases requiring a prolonged crossclamp times, such as second redo root replacement for PVE after CABG.

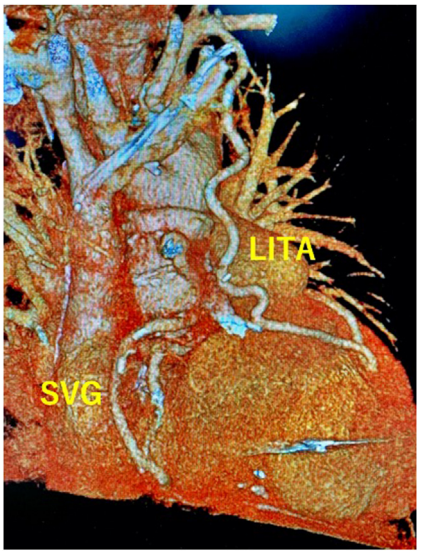


FIGURE 2. Postoperative cardiac computed tomography shows patency of the LITA and SVG. *LITA*, Left internal thoracic artery; *SVG*, great saphenous vein.

Availability of Data and Materials

The authors declare that all data in this article are available within the article.

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APPENDIX E1. PREOPERATIVE CORONARY ARTERY EVALUATION

Preoperative coronary angiography was not performed due to the presence of mobile large vegetations on the aortic valve, which posed a risk of cerebral embolism. Instead, preoperative coronary artery evaluation was conducted using cardiac computed tomography.

APPENDIX E2. SELECTION OF THE GRAFT USED BY RE-REDO AORTIC ROOT REPLACEMENT

Although the use of homograft was considered, its availability is extremely limited to specific facilities in Japan, making immediate use difficult in urgent cases such as the present one. Therefore, a new composite graft consisting of a 26-mm Gelweave Valsalva (Vascutek Ltd) and a 23-mm Inspiris Resilia aortic valve (Edwards Lifesciences) was used for the aortic root replacement. The proximal stepwise technique was performed using a 24-mm Gelweave graft (Vascutek Ltd) at the annulus level for translocation.

APPENDIX E3. THE APPLICABILITY OF THIS MYOCARDIAL PROTECTION METHOD FOR THE COMPLEX CARDIAC SURGERY CASES

The present case demonstrated that this method of myocardial protection, including continuous coronary perfusion, hypothermia, and the induction of cardiac arrest by systemic hyperkalemia, could be easily established during surgery by adding coronary artery bypass grafting in cases in which a prolonged aortic crossclamp period would be anticipated. This approach might serve as a viable option for effective myocardial protection. Even in cases without a history of coronary artery bypass grafting, the establishment of the same myocardial protection system, as seen in this case, could be achieved simply by performing bypass grafts on both the left and right coronary arteries.

Not limited to this specific re-redo aortic root replacement case, when prolonged crossclamp period or multiple crossclamps would be anticipated, regardless of the surgical procedure, we believe that this method of myocardial protection might be highly effective, especially in cases with preoperative impaired cardiac function. Therefore, this case suggested a wide range of potential applications of this myocardial protection method.