Emergency use of cardiopulmonary bypass in complicated transcatheter aortic valve replacement: Importance of a heart team approach

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Objectives: Transcatheter aortic valve replacement (TAVR) expands options for high-risk patients with aortic stenosis but is complex with life-threatening complications. We describe indications for use of salvage cardiopulmonary bypass (CPB) and assess outcomes.

Methods: From 2006 to 2011, 303 patients underwent TAVR, and 12 (4%) required emergency CPB. Approach was transapical (9) and transfemoral (3). Mean age was 82 ± 9 years, median Society of Thoracic Surgeons score was 11 and mean gradient was 46 ± 9 mm Hg. Access for CPB was femoral under fluoroscopy. Principal indication for CPB was hemodynamic instability with or without ischemic changes. These resulted from aortic insufficiency (n = 5), valve embolization (n = 3), coronary malperfusion (n = 2), bleeding requiring pericardiocentesis (n = 1), and bleeding from ventricular apex (n = 1). Additional procedures included valve-in-valve TAVR (n = 5), surgical valve replacement (n = 3), and coronary intervention (n = 2). Additional circulatory support was used in 7 cases: intra-aortic balloon pump (5) and extracorporeal membrane oxygenation (3).

Results: There were 2 hospital deaths. Mean postoperative gradient was 12 ± 9 mm Hg, and median stay was 16 days. There were no myocardial infarctions or renal failure. One patient had stroke with arm weakness, 2 required tracheostomy, and 2 underwent reoperations for bleeding. Median follow-up was 19 months, and there were 5 late deaths.

Conclusions: Complications during TAVR can be life threatening and may necessitate additional procedures. Expeditious use of CPB support provided by a multidisciplinary heart team optimizes rescue after myocardial collapse. (J Thorac Cardiovasc Surg 2014;148:1413-6)

Transcatheter aortic valve replacement (TAVR) expands the options for patients with severe aortic stenosis and has emerged as a less-invasive alternative in high-risk patients.[1-3] Studies have reported good outcomes after TAVR and an early to mid-term survival similar to that seen with surgical aortic valve replacement, but the morbidity is significant.

TAVR is a complex procedure and is often associated with complications that may result in hemodynamic collapse.[1-4] These include severe paravalvular leak, bleeding, valve embolization, coronary occlusion, and aortic dissection. Management of these complications often requires rescue with emergency use of cardiopulmonary bypass (CPB) to support the patient during definitive treatment of and recovery from the complication. The objectives of this study are to describe management of complications and to assess outcomes in patients requiring the use of CPB during TAVR procedures.

MATERIALS AND METHODS

Patients

Between July 2006 and December 2011, a total of 303 patients underwent TAVR for severe aortic stenosis at the Cleveland Clinic. Twelve of these patients (4%) were recorded as having periprocedural complications and requiring the emergency use of CPB support for intraoperative hemodynamic collapse. Mean age was 82 ± 9 years, median Society of Thoracic Surgeons score was 11 (range, 9-19), and preoperative mean gradient was 46 ± 9 mm Hg. Preoperative characteristics are summarized in Table 1. The approach to TAVR was transapical in 9 cases and transfemoral in 3. All patients received balloon-expandable transcatheter bioprostheses (Sapien; Edwards Lifesciences Corporation, Santa Rosa, Calif). The study was approved by the institutional review board at the Cleveland Clinic with patient consent waived.

Indications for Emergency CPB and Perioperative Management

All TAVR procedures were performed in a hybrid operating suite by a multidisciplinary heart team consisting of interventional cardiologists, cardiovascular surgeons, imaging specialists, and cardiothoracic anesthesia, nursing, and perfusion teams. A perfusionist and a prepared CPB pump were always present in the hybrid suite during TAVR procedures. All members of the heart team, including the cardiologists and the cardiac surgeons,

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Abbreviations and Acronyms
CPB = cardiopulmonary bypass
TAVR = transcatheter aortic valve replacement

were always present during the preprocedural huddle. The potential emergency cannulation strategies were discussed, and it was ensured that appropriate patient-specific cannulas and equipment were readily available. In addition, an adjacent surgical table was prepared with the tools necessary for open conversion.

The principal indication for CPB use in all patients was hemodynamic instability during TAVR procedures with or without ischemic changes on electrocardiography. These resulted from aortic insufficiency (n = 5), valve embolization (n = 3), coronary malperfusion (n = 2), aortic rupture (n = 1), and bleeding from a fragile ventricular apex (n = 1). Additional perioperative details are included in Table 2.

Access for CPB was obtained through the femoral artery and vein under fluoroscopic guidance. For all transapical cases, a direct exposure of the vessels was obtained and a stiff 0.035-inch wire was preemptively positioned within the aorta through a 5F sheath. Transfemoral cases were typically prepared for conversion to CPB by having a wire in place. Cardiopulmonary resuscitation with CPB alone was sufficient in regaining satisfactory hemodynamic stability in 3 patients. Of these, 1 had serious bleeding from the apex that required primary repair and the other 2 recovered after a period of rest with pump support. The other 9 patients required 10 additional procedures to manage the complications that led to hemodynamic collapse (Figure 1). These included (1) valve-in-valve TAVR for severe aortic insufficiency (paravalvular leak, n = 4; transvalvular leak, n = 1), with the device embolization in 1 of these patients; (2) open conversion with emergency surgical aortic valve replacement (n = 3), 2 for valve embolization into the left ventricle and 1 for bleeding from a ruptured annulus; and (3) percutaneous coronary artery intervention (n = 2), stenting of the left anterior descending and circumflex coronary arteries in 1 case and balloon angioplasty of the left anterior descending coronary artery in the other (Figure 2). Additional circulatory support was used in 7 of 12 patients. This included use of an intra-aortic balloon pump in 5 cases and extracorporeal membrane oxygenation in 3.

RESULTS

Expeditious use of CPB was achieved in all patients, with a mean flow rate of 3.8 ± 0.2 L/min. There were 2 in-hospital deaths (17%), both of multiorgan failure. One patient had hemodynamic collapse occur during the initial TAVR procedure and was resuscitated with the use of CPB; later the valve embolized into the left ventricle, necessitating surgical conversion for device retrieval and surgical aortic valve replacement. This patient's condition progressively deteriorated after surgical aortic valve replacement, and it was not possible to wean the patient from CPB. This patient had multiorgan failure occur during extracorporeal membrane oxygenation support and died of these complications on postoperative day 5. In the other patient, TAVR was complicated by severe paravalvular aortic insufficiency necessitating CPB support. A valve-in-valve TAVR was performed to address this insufficiency; however, the patient's postoperative course was complicated by disseminated intravascular coagulopathy with excessive bleeding from the cannulation sites. Despite return visits to the operating room to control the bleeding, it was difficult to wean the patient from cardiopulmonary support. The patient was supported by extracorporeal membrane oxygenation for 7 days. The patient died on postoperative day 25 of complications of multiorgan failure.

The mean postoperative gradient was 11 ± 5 mm Hg, and the median hospital stay was 16 days. There were no cases of myocardial infarction or new-onset renal failure. One (8%) patient had a stroke with residual arm weakness, 2 (17%) required tracheostomy for respiratory failure, and 2 (17%) underwent reoperation for bleeding. Median follow-up was 19 months. There were 5 late deaths. One patient died of lung cancer, 2 died of sepsis caused by infection, and the cause of death was unknown for 2 patients. Survivals at 1, 6, and 12 months were 82%, 64%, and 45%, respectively.

DISCUSSION

This experience demonstrates that expeditious use of CPB is a technically feasible, safe, and effective strategy to rescue patients from myocardial collapse as a consequence of the most severe TAVR complications. CPB support is not routinely needed during TAVR procedures, but in this early experience it was used in 4% of cases. This is comparable to studies from other high-volume institutions, which have reported an incidence of 1.2% to 6%.[5,6]

Successful rescue from intraoperative adverse events is dependent on the preparedness of the team. Thorough preoperative planning can avoid complications in most cases and should include careful patient selection on the basis of imaging and management by a multidisciplinary team. In our institution, the heart team meets weekly to discuss and select treatment options for high-risk patients undergoing aortic valve procedures. Even with the most detailed preoperative workup, however, complications can still occur. A rescue strategy should be prepared beforehand. In the hybrid operating room, a member from each

TABLE 1. Preoperative patient characteristics (n = 12)

Age (y, mean and range)	82 (72-91)
Male (n and %)	6 (50%)
STS risk score (median and range)	11 (9-19)
Ejection fraction (%, mean ± SD)	46% ± 10%
Comorbidities (n)	
NYHA functional class >2	12
Chronic obstructive pulmonary disease	5
Diabetes mellitus	9
Peripheral arterial disease	6
Previous cerebrovascular accident	1
Previous myocardial infarction	2
History of malignancy	6
Mitral regurgitation	4

STS, Society of Thoracic Surgeons; *NYHA*, New York Heart Association; *SD*, standard deviation.