EMERGING TECHNOLOGY REVIEW

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Transcatheter Aortic Valve Implantation—Part 2: Anesthesia Management

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TRANSCATHETER AORTIC VALVE implantation (TC-AVI) techniques are new therapeutic options to treat patients suffering from severe aortic valve stenosis.[1] These techniques are likely to displace conventional aortic valve replacement even further in the future. The breakthrough development of these aortic valve prostheses was recently achieved and has fundamentally changed the approach to aortic valve replacement in the cardiac operative environment. These procedures require a team approach among the cardiac surgeon, the cardiologist, and the cardiac anesthesiologist. The hybrid operating room has emerged as one of the main venues for TC-AVI.

The anesthesiologist plays a fundamental role in this new environment, with important considerations preoperatively, intraoperatively, and postoperatively. The first article in this series reviewed the development and current status of TC-AVI.[1] In this second article, the anesthetic considerations for each of these 3 phases of TC-AVI are reviewed in detail. This detailed approach is necessary because the entire perioperative management for TC-AVI requires substantial changes in comparison with the anesthetic management for conventional aortic valve replacement.

PREOPERATIVE CONSIDERATIONS

Operative Risk Assessment

The European Association of Cardiothoracic Surgery and the European Society of Cardiology, in collaboration with the European Association of Percutaneous Cardiovascular Interventions, published a position statement recommending that TC-AVI techniques should be restricted to high-risk patients or those with contraindications for surgery.[2] The selection process of patients for TC-AVI requires multidisciplinary consultation among cardiologists, surgeons, radiologists, and anesthesiologists. In this evaluation process, patients are stratified by operative risk calculated by validated risk scoring systems. The most popular scoring systems used in screening patients for possible TC-AVI are the European System for Cardiac Operative Risk Evaluation (EuroSCORE) and the Society of Thoracic Surgeons (STS) Predicted Risk of Mortality (PROM) score. The EuroSCORE was developed in 1999 to predict surgical mortality in cardiac surgical patients and has become a widespread method for cardiac surgical risk assessment. Subsequently, the additive EuroSCORE was introduced whereby the value of each variable is added in a risk calculator to generate the overall operative risk.[3,4] The EuroSCORE is based on 18 patient-, cardiac-, and surgery-related factors. Table 1 shows these variables for calculating the additive EuroSCORE. A limitation of the additive EuroSCORE is that it does not always achieve an appropriate weighting of risk factors, especially in patients at a higher risk. Although the logistic EuroSCORE was developed to address this limitation of the additive EuroSCORE, its calculation is more complex.[5,6] The online risk calculator for the logistic EuroSCORE is available at the EuroSCORE web site (http://www.euroscore.org/calc.html). The STS PROM Score was established in 1989 based on risk models from the extensive STS database. In 1999, the Society of Cardiothoracic Surgeons analyzed the database for single and combined valve surgery.[7] This score presently includes more than 50 preoperative variables on operative mortality. The online risk calculator is available at the STS web page (http://209.220.160.180/STSWebRiskCalc261/).

Osswald et al[8] investigated the EuroSCORE to estimate the risk of conventional aortic valve replacement. They included 1,594 patients with aortic stenosis who underwent isolated surgical aortic valve replacement. Both the additive and the logistic EuroSCORE were calculated for each patient and summed for the expected 30-day mortality. Expected and observed mortalities were compared, particularly with respect to "high-risk" status and era of surgery. The 30-day mortality was low and substantially overestimated by the additive and the logistic EuroSCORE. The observed mortality in the "high-risk" group was 3.6%, whereas the additive and the logistic EuroSCORE predicted 8.3% and 14.8%, respectively. Osswald et al[8] concluded that the predicted mortality, especially in "high-risk" patients, rendered it unsuitable for assessing the risk reduction of percutaneous valve replacement.

Kalavrouziotis et al[9] determined the logistic EuroSCORE for 1,421 aortic valve replacement patients and assessed the observed and expected operative mortality; 16.7% of these pa-

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Table 1. Patient, Cardiac, and Operative Variables Used in the Simple or Additive European System of Cardiac Operative Risk (EuroSCORE)

Patient-Related Factors		Score
Age	Per 5 years or part thereof over 60 years	1
Sex	Female	1
Chronic pulmonary disease	Long-term use of bronchodilators or steroids for lung disease	1
Extracardiac arteriopathy	Any 1 or more of the following: claudication, carotid occlusion or >50% stenosis, previous or planned intervention on the abdominal aorta, limb arteries or carotids	2
Neurologic dysfunction disease	Severely affecting ambulation or day-to-day functioning	2
Previous cardiac surgery	Requiring opening of the pericardium	3
Serum creatinine	>200 μm/L preoperatively	2
Active endocarditis	Patient still under antibiotic treatment for endocarditis at the time of surgery	3
Critical preoperative state	Any one or more of the following: ventricular tachycardia or fibrillation, sudden death, preoperative cardiac massage, preoperative ventilation before arrival in the anesthetic room, preoperative inotropic support, intra-aortic balloon counterpulsation or preoperative acute renal failure (anuria or oliguria <10 mL/h	3
Cardiac-related factors		
Unstable angina	Rest angina requiring intravenous nitrates until arrival in the anesthesia room	2
LV dysfunction	Moderate or LVEF 30%-50% Poor or LVEF <30%	1
Recent myocardial infarct	(<90 days)	3
Pulmonary hypertension	Systolic PA pressure >60 mmHg	2
Surgery-related factors		
Emergency	Carried out on referral before the beginning of the next working day	2
Other than isolated CABG	Major cardiac procedure other than or in addition to CABG	2
Surgery on thoracic aorta	For disorder of ascending, arch or descending aorta	3
Postinfarct septal rupture		4

Abbreviation: LVEF, left ventricular ejection fraction; PA, pulmonary artery; CABG, coronary artery bypass graft surgery.
Adapted from http://www.euroscore.org (accessed March 20, 2010).

tients had a logistic EuroSCORE >20. Among these patients, the mean predicted operative mortality by the logistic EuroSCORE was 38.7%, in contrast to the observed mortality of 11.4%. Dewey et al[10] and Wendt et al[11] found that the STS PROM score for predicted risk of mortality was more accurate for predicting mortality in high-risk patients undergoing aortic valve replacement. Dewey et al[10] investigated 638 patients who underwent isolated aortic valve replacement. They calculated the operative risk using the STS PROM score, the logistic and the additive EuroSCORE, and the Ambler risk score. They defined "high-risk" patients at or above the 90th percentile of risk (8.38% for STS, 33.47% for logistic, 12% for additive, and 14.3% for Ambler). Expected versus observed mortality for the "high-risk" group by algorithm was 13.3% versus 18.8% for STS PROM, 50.9% versus 15.6% for logistic, 14.0% versus 11.9% for additive, and 19.0% versus 13.4% for Ambler. The long-term mortality per high-risk group was 64.1% in the STS PROM, 45.3% in the logistic, 45.2% in the additive, and 40.2% in the Ambler. Wendt et al[11] calculated the mean logistic EuroSCORE (8.5% $\pm$ 7.9%), the mean STS PROM score (4.4% $\pm$ 3.9%), and the mean Parsonnet score (9.8% $\pm$ 8.5%) for 652 patients undergoing isolated conventional aortic valve replacement. One hundred thirty patients had a EuroSCORE between 10% and 20% and a mean STS PROM of 6.5%. The predicted versus the observed mortality for this group of patients was 13.9% for the logistic EuroSCORE and 6.5% for the STS PROM versus the observed mortality of 4.6%. In patients with EuroSCORE greater than 20% (52 patients), the predicted mortality for the logistic EuroSCORE was 28.5%, and for the STS PROM it was 10.1%, which is in contrast to the observed mortality of 3.9% for this kind of patient.

In summary, although both the EuroSCORE and the STS PROM scoring systems are applicable, the STS PROM score appears to predict operative risk more accurately in patients undergoing conventional aortic valve replacement (AVR). As a result, it may be more suitable to stratify risk in patients considered for TC-AVI because only those at considerable surgical risk for conventional AVR should undergo TC-AVI.

Because TC-AVI currently is limited to patients who are high risk for conventional AVR, the anesthesiologist is therefore confronted with elderly patients typically with multiple comorbidities; Table 2 gives a summary of the criteria and the rationale for TC-AVI.[12] The operative risk often is higher in patients with significant comorbidities such as prior stroke, ventricular dysfunction, atrial fibrillation, mitral regurgitation, pulmonary hypertension, advanced lung disease, and renal insufficiency.[10] The degree of surgical risk not only influences which patients are selected for TC-AVI, but also influences the approach to the aortic valve. The transapical approach often is preferred over the transfemoral (TF) approach in the sickest patients who, thus, have the highest operative risk.[13] In a recent study from France, patients selected for transapical TC-AVI