Impact of preoperative pulmonary function on outcomes after open repair of descending and thoracoabdominal aortic aneurysms

Leonard N. Girardi, MD, Christopher Lau, MD, Monica Munjal, MS, Mohamed Elsayed, MD, Ivancarmine Gambardella, MD, Lucas B. Ohmes, MD, and Mario Gaudino, MD

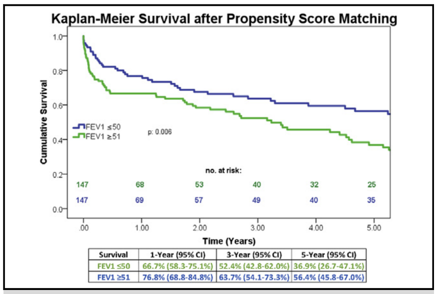
ABSTRACT

Objective: To evaluate the impact of preoperative pulmonary function on outcomes after open repair of descending thoracic (DTA) and thoracoabdominal aortic (TAAA) aneurysms.

Methods: The outcomes of patients undergoing open repair of DTA or TAAA were analyzed in relation to the results of preoperative pulmonary function tests. Receiver operating characteristic was adopted to assess the effect of forced expiratory volume in one second (FEV1) on the incidence of mortality. Logistic regression analysis and propensity score matching were used.

Results: Between 1997 and 2015, 726 patients underwent open DTA or TAAA repair. Pulmonary function tests were available in 711 (97.9%). Receiver operating characteristic analysis revealed the cutoff value of FEV1 to be 50%. Propensity score matching led to 149 pairs of patients with FEV1 below and above 50% with only limited residual imbalance. In the matched population operative mortality was 11.4% and 6.0% in patients with FEV1 $\leq$ 50% and FEV1 $\geq$ 51%, respectively (P = .10). The incidence of major adverse events was 33.1% in cases with FEV1 $\leq$ 50% and 19.5% in those with FEV1 $\geq$ 51% (P = .008). FEV1 $\leq$ 50% was associated with a 6.99× increase in the risk of major postoperative adverse events at logistic regression analysis.

Conclusions: Preoperative FEV1 < 50% is strongly predictive of increased respiratory failure, tracheostomy, and operative mortality in patients undergoing open DTA/TAAA repair. For these very high-risk patients with either extensive TAAAs or anatomy unsuitable for endovascular repair, medical therapy may offer the best long-term survival. (J Thorac Cardiovasc Surg 2016;■:1-8)



Long-term survival of matched patients according to preoperative pulmonary function.

Central Message

Patients with a forced expiratory volume in 1 second < 50% are at high-risk for respiratory failure, tracheostomy, and operative mortality after open descending thoracic aneurysm/thoracoabdominal aortic aneurysm repair.

Perspective

Patients in need of open descending thoracic aneurysm/thoracoabdominal aortic aneurysm repair with extremely reduced pulmonary function and additional comorbidities may be better served with a conservative nonintervention strategy. Patients with an forced expiratory volume in 1 second < 50% are at high risk for respiratory failure, tracheostomy, and operative mortality after open descending thoracic aneurysm/thoracoabdominal aortic aneurysm repair.

Open repair of descending thoracic (DTA) and thoracoabdominal aortic aneurysms (TAAAs) remains a formidable undertaking, with results that can be influenced dramatically by surgical experience and the use of advanced organ-preservation techniques.[1,2] Outcomes have improved dramatically during the last 2 decades[3] and patients requiring these high-risk procedures, even in the setting of rupture, infection, or acute dissection, are experiencing less operative mortality with a significant reduction in major postoperative complications.[4-6]

From the Department of Cardiothoracic Surgery, Weill Cornell Medicine, New York, NY.

Presented at the 2016 AATS Aortic Symposium, New York, May 12–13, 2016.

Received for publication June 20, 2016; revisions received Oct 17, 2016; accepted for publication Oct 31, 2016.

Address for reprints: Leonard N. Girardi, MD, Department of Cardiothoracic Surgery, Weill Cornell Medicine, 525 E 68th St, M 404, New York, NY 10065 (E-mail: lngirard@med.cornell.edu).

0022-5223/$36.00

http://dx.doi.org/10.1016/j.jtcvs.2016.10.055

Scanning this QR code will take you to the supplemental figures, tables, and video for this article.

Abbreviations and Acronyms

COPD	= chronic obstructive pulmonary disease
CPB	= cardiopulmonary bypass
DTA	= descending thoracic aneurysm
FEV1	= forced expiratory volume in 1 second
MAE	= major adverse event
OR	= odds ratio
PSM	= propensity score matching
TAAA	= thoracoabdominal aortic aneurysm
TEVAR	= thoracic endovascular aneurysm repair

It is not surprising that proper patient evaluation and preparation before highly complex surgery can contribute mightily to improvements in surgical outcomes.[7-10] In particular, with the growing age and overall increase in the prevalence of chronic obstructive pulmonary disease (COPD) in the population,[11] insight into and management of a patient's pulmonary status has taken on greater importance in all facets of cardiovascular and thoracic surgery.[7,8,12-14] Upwards of 25% of a large, contemporary group of patients undergoing open DTA or TAAA repair have advanced COPD.[15] And although a greater percentage of patients requiring thoracic aneurysm repair are being treated with endovascular repair (thoracic endovascular aneurysm repair; TEVAR),[16] there are a substantial number of patients that will require open repair because of anatomy, age, or the underlying etiology of the disease. In addition, short- and long-term complications from TEVAR continue to increase, and a majority of these patients will require open repair to treat their aneurysmal disease.[17]

The negative influence of pulmonary disease on outcome after TAAA repair was explored in a previous era[18]; however, with advancements in surgical technique and postoperative critical care, patients previously considered poor candidates for surgery, or those for whom endovascular repair is considered imprudent, are now considered operable. In an effort to better risk-stratify patients with COPD presenting for aneurysm repair, we examined a contemporary cohort of high-risk patients undergoing open repair in a high-volume aortic center. We used propensity matching and logistic regression analysis to eliminate confounding variables to better define the association between preoperative pulmonary function and overall outcomes after open thoracic aneurysm repair.

PATIENTS AND METHODS

Patient Population and End Points

This study was approved by the institutional review board. The need for individual patient consent was waived. A review of prospectively collected data from the Weill Cornell Medicine Department of Cardiothoracic Surgery - Aortic database was conducted to identify all patients who underwent repair of TAAA or DTA from May 1997 to October 2015.

Primary end points were operative mortality and follow-up death from any cause. Secondary end points were the incidence of major postoperative complications (myocardial infarction, stroke, new-onset renal insufficiency requiring dialysis, need for tracheostomy, spinal cord complications) and a composite of postoperative major adverse events (MAEs: operative death and the previously listed major postoperative complications).

All patients referred for repair undergo preoperative pulmonary function testing. An arterial blood gas is drawn on room air to assess baseline partial pressure of oxygen partial pressure of carbon dioxide. Patients with a forced expiratory volume in 1 second (FEV1) < 50%, a diffusion capacity (diffusing capacity of the lungs for carbon monoxide) less than 40%, or with a partial pressure of carbon dioxide greater than 50 are considered high risk for postoperative pulmonary complications and are referred to a pulmonologist for evaluation, treatment, and physiotherapy before surgery. If the high-risk patients are in need of urgent/emergent aneurysm repair, alternative endovascular options are explored and, if unavailable, the patient and family are counseled on the greater potential for prolonged intubation and/or the need for tracheostomy. The Crawford classification was used to define the extent of TAAA. Preoperative renal insufficiency was defined as a creatinine level ≥1.5 mg/dL.[19]

Surgical Technique

After intubation with a single lumen endotracheal tube, insertion of a spinal drain, placement of volume lines, and hemodynamic monitoring, a bronchial blocker is placed into the left main stem bronchus. Once in a modified right lateral decubitus position, positioning of the blocker is confirmed with bronchoscopy and the balloon is inflated to begin left lung deflation. This allows for an assessment of how well the patient will tolerate single-lung ventilation during surgery. If significant hypoxemia occurs, positive end-expiratory pressure, inverse ratio ventilation, and bronchodilators are used. Left lung insufflation may be necessary to return oxygen saturation greater than 90% before aortic cross-clamping. Double-lumen endotracheal tubes rarely are used in an effort to eliminate the need to insert a single-lumen tube and avoid risk of airway loss after surgery when laryngeal, upper airway, and facial edema is significant.

Details of the surgical technique have been published.[6] In summary, a fifth or sixth intercostal space thoracotomy or thoracoabdominal incision was used in all patients. Resection of adjacent ribs was performed when necessary. In patients with impaired pulmonary function, the clamp-and-sew technique was our primary strategy, particularly in case of free rupture or isolated descending aortic pathology. In extent I, III, and IV TAAAs, the clamp-and-sew strategy was used and cold renal perfusion or blood visceral perfusion were added if the visceral and renal vessels were involved. For contained ruptured, extent II aneurysms requiring extensive reconstruction and acute type B dissections, left heart bypass was adopted. Finally, when proximal aortic control was unattainable, cardiopulmonary bypass (CPB) and deep hypothermic circulatory arrest were used. Reinfusion of shed blood was performed with a Belmont warm rapid infusion system (Belmont Instrument Corporation, Billerica, Mass). Core temperature was allowed to decrease to 33°C before crossclamping the aorta. Reimplantation of intercostal arteries was performed with the inlay-inclusion technique. Visceral and renal arteries were either reimplanted or bypassed as dictated by the anatomy. Hemashield Dacron grafts (Macquet Corporation, Oakland, NJ) were used. Preoperative spinal drain insertion was attempted in all hemodynamically stable patients. In unstable patients, spinal drain insertion was performed after surgery before transporting the patient to the intensive care unit. Drains were maintained with an intrathecal pressure less than 12 cm H_2O for 72 hours, and mean arterial pressure was maintained at greater than 85 mm Hg (see Video 1).

Statistical Analysis

For baseline characteristics, variables are summarized as mean for continuous variables and percentage for categorical variables. Data from

ACQ