From the Society for Clinical Vascular Surgery

Use of extracorporeal bypass is associated with improved outcomes in open thoracic and thoracoabdominal aortic aneurysm repair

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ABSTRACT

Objective: There is no consensus on the use or benefit of extracorporeal circulation (EC) during aneurysm repair of the descending thoracic aorta (DTA) or thoracoabdominal aorta (TAA). We evaluated the role of EC during DTA or TAA aneurysm repair using U.S. Medicare data.

Methods: Medicare (2004-2007) patients undergoing open repair of nonruptured DTA or TAA aneurysm were identified by *International Classification of Diseases, Ninth Revision* code. Specific exclusions included ascending aortic or arch repairs, concomitant cardiac procedures, and procedures employing deep hypothermic circulatory arrest. The impact of EC (code 3961) on early and late outcomes was analyzed using univariate analysis and multivariable regression. Survival was assessed using Kaplan-Meier analysis and Cox proportional hazards regression models.

Results: There were 4230 patients who had repair of intact DTA or TAA aneurysms, 2433 (57%) of which employed EC. Differences in baseline clinical features of EC and non-EC patients showed that patients undergoing aortic reconstruction with EC were older (73 ± 1 years vs 72 ± 1 years; $P = .002$), were more likely to be female (53% vs 47%; $P < .001$), and had more hypertension (56% vs 53%; $P = .02$); they had less chronic obstructive pulmonary disease (28% vs 34%; $P < .0001$), peripheral vascular disease (5.7% vs 11.3%; $P < .001$), and chronic kidney disease (7.7% vs 5.5%; $P = .003$). The 30-day mortality (9.7% for EC vs 12.2%; $P = .02$) and any major complication (49% for EC vs 58%; $P < .001$) were significantly reduced with EC use. EC use was associated with a shorter length of stay (13.5 ± 13 days vs 17.2 ± 18 days; $P < .01$) and lower total hospital charges ($151,000 ± 140,000 vs $180,000 ± 190,000; $P < .01$) compared with non-EC patients. EC patients were more likely to be discharged home instead of to an extended care facility (67% vs 56%; $P < .01$). Multivariable regression modeling to adjust for baseline clinical differences showed EC to independently reduce the risk of operative mortality (odds ratio [OR], 0.80; 95% confidence interval [CI], 0.65-0.97; $P = .02$), any complication (OR, 0.67; 95% CI, 0.59-0.76; $P < .01$), pulmonary complications (OR, 0.68; 95% CI, 0.59-0.79; $P < .01$), and acute renal failure (OR, 0.52; 95% CI, 0.44-0.61; $P < .01$). Long-term survival was higher (log-rank, $P < .01$) in EC patients at 1 year (81% ± 0.8% vs 73% ± 1%) and 5 years (67% ± 1% vs 52% ± 1%). Risk-adjusted Cox proportional hazards regression also showed that EC was independently associated with improved long-term survival (hazard ratio, 0.69; 95% CI, 0.63-0.74; $P < .01$).

Conclusions: Although important clinical variables such as DTA or TAA aneurysm extent and spinal cord ischemic complications cannot be assessed with the Medicare database, EC use during open DTA and TAA aneurysm repair is associated with improved late survival and a significant reduction in operative mortality, morbidity, and procedural costs. These data indicate that EC should be a more widely applied adjunct in open DTA or TAA aneurysm repair. (J Vasc Surg 2018;■:1-7.)

Keywords: Thoracoabdominal aortic aneurysm; Descending thoracic aortic aneurysm; Extracorporeal circulation; Atrial-femoral bypass

Aneurysmal dilation of the descending thoracic aorta (DTA) and thoracoabdominal aorta (TAA) most commonly results from primary cystic medial necrosis or secondary degeneration after type B dissection and is classified on the basis of the extent of aortic involvement.[1] Simple "clamp and sew" (CS) repair as championed by Crawford et al[1] emphasizes expediency as the aorta is clamped and replaced with synthetic

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Author conflict of interest: none.

Plenary presentation at the Forty-first Annual Symposium of the Society for Clinical Vascular Surgery, Miami, Fla, March 12-16, 2013.

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The editors and reviewers of this article have no relevant financial relationships to disclose per the JVS policy that requires reviewers to decline review of any manuscript for which they may have a conflict of interest.

0741-5214

https://doi.org/10.1016/j.jvs.2017.12.072

graft in a proximal to distal fashion.[2] Thoracic aortic cross-clamping, however, results in profound physiologic derangement as distal tissues become ischemic. Furthermore, left ventricular preload and afterload rise acutely, resulting in increased left ventricular wall stress, stroke work, and, in turn, myocardial oxygen demand. Ischemia may result in postoperative liver dysfunction, gut necrosis, renal failure, and most devastatingly, paraplegia/paralysis. Indeed, in his benchmark experience, Crawford found that cross-clamp time remained a significant predictor of early death even after multivariable adjustment.[1]

Consequently, a multitude of intraoperative adjuncts designed either to maintain end-organ perfusion or to minimize ischemic tissue metabolic demand during cross-clamping have been employed. Visceral perfusion can be achieved with a pump-powered cannula perfuser or by direct in-line (passive) mesenteric shunting.[3-5] Complete or selective reimplantation of intercostal and lumbar vessels can be used to improve cord perfusion. As cross-clamping also increases cerebrospinal fluid (CSF) pressure and consequently decreases spinal perfusion pressure, CSF drainage can be used to improve cord perfusion and is the only paraplegia-mitigating adjunct supported by level I evidence.[6] Finally, improved global perfusion distal to the cross-clamp can be achieved with the use of mechanical circulatory devices.[6] These extracorporeal circulation (EC) techniques range from left atrial-femoral bypass to full cardiopulmonary bypass. Irrespective of technique, EC provides the added advantage of mitigating the increase in preload and afterload associated with proximal cross-clamping. Some studies, however, have demonstrated no significant advantage with EC compared with the simple CS technique,[7] and many authors have noted that the increased intraoperative technical complexity associated with EC is not worth the perceived benefit.

It becomes clear, then, that there is no standardized approach for the repair of DTA and TAA aneurysms, with the literature revealing conflicting data. Furthermore, most existing studies are limited to single institutions or single-surgeon series, which may fail to account for the various adjuncts and practice patterns, confounding the outcomes associated with use of CS vs EC. The purpose of this study, therefore, was to evaluate the effects of EC on open repair of DTA and TAA aneurysms across multiple institutions and surgeons using the U.S. Medicare database.

ARTICLE HIGHLIGHTS

- **Type of Research:** Retrospective analysis of prospectively collected Medicare data
- **Take Home Message:** In 4230 patients receiving open descending thoracic or thoracoabdominal aortic aneurysm repair, use of extracorporeal circulation in 2433 patients resulted in lower major complication rate (49% vs 58%), shorter hospital stay, and lower total hospital charges.
- **Recommendation:** This study suggests that extracorporeal circulation should be used more frequently during open repair of descending thoracic and thoracoabdominal aortic aneurysms.

METHODS

Study design and cohort. This retrospective cohort study of the Medicare population targeted Medicare patients undergoing intact open repair of DTA aneurysm or TAA aneurysm from 2004 to 2007. The Medicare Provider Analysis and Review specifically covered Medicare Part A claims and included a linkage to Vital Statistics for mortality and long-term survival analysis. *International Classification of Diseases, Ninth Revision* (ICD-9) codes (Appendix) pertaining to nonruptured, open thoracic aortic repair were used to broadly identify the initial cohort. ICD-9 codes were then used to exclude patients lacking a diagnosis of DTA or TAA aneurysm and patients undergoing concomitant cardiac procedures including coronary revascularization, valve procedures, or procedures employing cardioplegia or deep hypothermic circulatory arrest. The remaining cohort was divided into two groups according to ICD-9 codes reflecting use of EC (ICD-9 3961) vs those that did not. Primary outcomes evaluated included 30-day mortality, long-term survival, and predictors of death or late mortality. Secondary outcomes included hospital and intensive care unit length of stay, systemic complications, and predictors of systemic complications. Acute renal failure was defined by ICD-9 code (Appendix). Institutional Review Board approval was obtained for the study. The need for informed consent of the patient was waived by the Institutional Review Board, given the use of deidentified administrative data for the study.

Statistical analysis. All data were analyzed using the SAS statistical software package (version 9.3; SAS Institute, Cary, NC). A univariate cutoff of 0.1 was used for initial inclusion in multivariable models. Stepwise selection was used with an entrance and exit cutoff of .05 to prune the full models to arrive at a final, adjusted, multivariable model. Kaplan-Meier analysis was performed between the EC and no EC groups to determine long-term survival, with the log-rank test used to assess for significance. Cox proportional hazards regression was used to model survival after adjusting for significant covariates and confounders.

RESULTS

Cohort characteristics. There were 18,282 patients identified as having nonruptured open thoracic aortic