Endovascular Stent-Graft or Open Surgical Repair for Blunt Thoracic Aortic Trauma: Systematic Review

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PURPOSE: To evaluate the available data on stent-graft repair of acute blunt traumatic thoracic aortic injury with regard to safety and efficacy compared with conventional open surgical repair.

MATERIALS AND METHODS: The literature on endovascular repair of acute traumatic aortic injury since 1990 was systematically reviewed. Metaanalysis of publications with open and stent-graft repair cohorts was performed to evaluate whether there was a difference in treatment effect with regard to mortality and paraplegia. Case series were included to obtain an adequate population to assess the incidence of stent-graft procedure–related complications.

RESULTS: There were no prospective randomized studies. Nineteen publications that compared the outcomes of 262 endograft repairs and 376 open surgical repairs were identified. The odds ratio for mortality after endovascular versus open repair was 0.43 (95% CI, 0.26–0.70; $P = .001$). The odds ratio for paraplegia after endovascular versus open repair was 0.30 (95% CI, 0.12–0.76; $P = .01$). In the pooled group of 667 endovascular repair survivors from 50 reports, the incidence of early endoleak was 4.2%, and late endoleak occurred in 0.9%. Stroke or transient ischemic attack was reported in 1.2%. Access site complications that required intervention occurred in 4.1%.

CONCLUSIONS: The available cohort and case series data support stent-graft repair as a highly successful technique that may reduce mortality and paraplegia rates by half compared with open surgery. These data support endograft repair as first-line therapy for blunt thoracic aortic trauma.

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Abbreviations: BTAI = blunt thoracic aortic injury, ISS = injury severity score, TEVAR = thoracic endovascular aortic repair

THE past decade witnessed dramatic changes in the incidence, diagnosis, and therapy of blunt thoracic aortic injury (BTAI). Despite a decrease in the incidence of motor vehicle crash injuries (1,2), most trauma centers report an increased number of patients with BTAI (3–7). This may be a result of a decrease in prehospitalization mortality rates from 90% to 63% associated with the implementation of automobile safety measures and improved in-field management and transport (8,9). Between the seminal 1958 report of Parmley et al (10) and the literature of the 1990s, there had been little demonstrable improvement in survival; the need for rapid diagnosis and expedient treatment remained major challenges to successful management (10–12). Advances in helical computed tomographic (CT) angiography throughout the 1990s provided a method of diagnosis as reliable as angiography and far more rapid (13), and medical management of blood pressure to prevent progression and exsanguination from the injury improved survival for hospitalized patients (4,14–16). However, thoracic aortic disruption remains a lethal injury for the 65%–85% who die in the field and for the potentially treatable 20% of immediate survivors who die within hours of hospitalization (11,17,18). The latter patients are those who present in hemodynamically unstable condition or whose condition becomes unstable, as well as those at prohibitively high risk for operation as a result of comorbidity or associated injury (4,7,11,18–22). For those who undergo operative repair, mortality rates range from 7.7% to 28% and there is a 5%–19% risk of paraplegia (3,11,12,21,23–25). Initial reports suggest that stent-graft repair of BTAI is a rapidly performed, less invasive alternative to open repair that can improve survival and decrease morbidity.

Introduced in the 1990s (26–28), the percutaneous transcatheter placement of a graft-covered stent has been

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widely adopted as an alternative to open repair of BTAI (6,18,22,29–75). Thoracic endovascular aortic repair (TEVAR) is a rapidly applied, minimally invasive therapy that can be provided in conjunction with other major resuscitative procedures, and does not require resolution of comorbid injury. Although most studies are of limited numbers of patients with short-term follow-up, the agglomerated data suggest that this is a safe and efficacious procedure. As the published evidence consists of nonrandomized small population studies, and there are no long-term data for this typically young patient population, the role of TEVAR for BTAI has been controversial.

This systematic review entailed a literature search to select studies for a metaanalysis that would produce a summary assessment of the safety and efficacy of TEVAR for BTAI compared with conventional management.

MATERIALS AND METHODS

The study protocol was reviewed and given an exemption by the institutional review board. A comprehensive review of the literature on TEVAR for BTAI published between 1990 and March 2008 was conducted using Medline through PubMed and the National Library of Medicine Gateway databases. The search was performed in March 2008 for combinations of the key words "trauma, thoracic aorta, stent-graft, repair", and their variations. Reference lists of the retrieved reports were also surveyed for additional pertinent studies. As a result of the small number of cases of TEVAR in the cohort reports, case series of TEVAR for BTAI were studied for a better estimate of procedure-specific complications.

Inclusion criteria for study selection were (i) comparison of TEVAR and open repair of BTAI or (ii) description of at least six patients with acute BTAI treated with TEVAR from a remote (ie, outside the thorax) access site. Excluded were reports comprised of patients with (i) multiple etiologies or (ii) various treatments from which specific outcome variables could not be extracted for patients treated for BTAI with TEVAR. When multiple reports could be identified from the same institution, duplicates were excluded. Studies that compared endovascular and surgical cohorts were selected rather than case series, and the later or larger report was used. If specific acute trauma population data were found in only a report of a smaller population, that was selected. Authors of included reports were contacted for clarification of manuscript ambiguities.

Data were extracted from each report by two of the authors, with review by a third in case of disagreement. The collected data included the total number of patients treated, method of treatment, and time from injury to repair. Demographic data included a measure of trauma severity (injury severity score [ISS] or description of injuries), age, sex, mechanism of injury, and length of follow-up. Procedural data included type of anesthesia, type of graft placed, aorta and graft sizes, procedure time, blood loss, fluoroscopy time, contrast agent dose, and access site. Primary outcome variables of survival (at 30 days) and the complication of paraplegia were evaluated by metaanalysis. The secondary outcome measures of endoleak and access-site complications were assessed from all selected reports.

Standard definitions were employed (76). Primary technical success denoted successful introduction and deployment of the graft without type I or III endoleak, no significant obstruction, and no mortality or surgical conversion at 24 hours. We did not differentiate primary assisted technical success, such as an unplanned cuff deployment for treatment of an intraoperative endoleak. Primary endoleak was observed within 30 days of the procedure, and secondary endoleaks were identified after that period.

Cohort data were entered into the Cochrane Review Manager Metaanalysis software, version 4.2 (77), for analysis of stent-graft versus open surgical treatment effect with respect to the outcome variables of death and paraplegia. This analysis also produced a measure of homogeneity and a funnel plot to assess publication bias. To evaluate for temporal selection bias in the open repair cohorts, recent reports of open surgical repair of traumatic aortic injury after 1995 were used to establish a comparison standard (4,5,7,15,23,78,79). The survival and paraplegia rates in the contemporary surgical group were compared with the surgical limb of the cohort studies by the χ^2 test.

RESULTS

The literature review yielded a total of 210 pertinent articles, which reported 1,687 cases of TEVAR of BTAI. When duplicates and chronic injuries were excluded, there were 1,263 unique cases, 722 of which were included in the 50 articles that met inclusion criteria (**Fig 1**). All publications were case reports or retrospective observational series. Inclusion criteria in the reports varied, but all were series of consecutive patients with BTAI treated with a stent-graft. The total number of patients with BTAI admitted or treated during the period of the study was not always specified; in most studies, there was no intent-to-treat criterion. Nineteen studies compared 262 cases of TEVAR with 376 cases of open surgical repair (6,22,29–45,80–82) (**Table 1**); one was excluded as a result of duplicate data (80). Of the remaining 115 case series, 31 met the inclusion criteria (18,46,48–75) (**Table 2**).

Methods of the Cohort Publications

Diagnosis was suspected based on the mechanism of injury or abnormalities on a chest radiograph and definitively made by angiography or CT angiography before 2004; subsequently, all authors relied on CT angiography. Patients diagnosed by emergent thoracotomy or who died in the emergency department before intervention were excluded or categorized separately (6,30,33,36,37,39,41).

Patient selection criteria evolved during the period in which the cohort studies were published. Early in the experience, patients were selected for TEVAR based on contraindications to open repair for a high a risk of mortality from comorbidity and associated injuries; over time, 11 of 16 centers that described indications broadened the application to all patients with suitable anatomy (6,22,29,31,32,34,36,37,41–43,45). In one institution, TEVAR was reserved for those with concomitant brain injury (39).

Procedural methodology was fairly