Left Subclavian Arterial Coverage and Stroke During Thoracic Aortic Endografting: A Systematic Review

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Stroke is a devastating complication of thoracic endovascular aortic repair (TEVAR). Whether left subclavian artery (LSA) coverage and LSA revascularization affect stroke rate is debated. Whether patients with aneurysms or dissections undergoing TEVAR have higher stroke rates is also debated. We report a systematic review of 63 studies comprising more than 3,000 patients. We conclude that stroke risk after TEVAR is increased by LSA coverage, and that LSA revascularization reduces stroke risk. LSA revascularization may lower the rate of posterior stroke. TEVAR for aneurysm is associated with increased stroke risk compared to TEVAR for dissection.

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Thoracic endovascular aortic repair (TEVAR) has become an attractive alternative for thoracic aortic pathologies since its report by Volodos and colleagues [1] in 1988. TEVAR has become the preferred treatment option for selected patients with various thoracic aortic pathologies of the descending thoracic aorta including aortic aneurysm, dissection, and transection [2–5]. TEVAR has been associated with decreased short-term morbidity and mortality when compared to open repair, but stroke remains a major debilitating complication. The etiology of stroke after TEVAR is multifactorial. Most periprocedural strokes are caused by aortic wall atheroemboli, which can be dislodged by wire and device manipulation [6]. Stroke may also be caused by low-flow ischemia without atheroembolism, such as ischemia in the left vertebral artery distribution following coverage of the left subclavian artery (LSA).

There is debate on whether LSA coverage leads to stroke after TEVAR. The current management of preoperative LSA revascularization in cases with planned coverage is not uniform as most of the data on morbidity is derived from single institutional series. The Society of Vascular Surgery formulated clinical practice guidelines [7], indicating that coverage of the LSA without revascularization was associated with a much higher risk of arm and vertebrobasilar ischemia compared with patients who did not undergo LSA coverage [8]. There was also a trend toward an increased risk of paraplegia and anterior circulation stroke. In the present meta-analysis, we directly compare LSA revascularization with LSA nonrevascularization to determine the current status of the literature. Furthermore, the anatomic distribution of strokes following LSA coverage in either the anterior circulation or the posterior or vertebrobasilar circulation is examined, as this remains a critical issue in assessing the need for preoperative LSA revascularization, and rates of neurologic disability and mortality after anterior and posterior strokes are described. Finally, we investigate whether TEVAR for aneurysm was associated with a different stroke rate than TEVAR for dissection. Understanding these outcomes is critical for prevention of stroke after TEVAR.

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Patients and Methods

Eligibility Criteria

A retrospective review of patients undergoing TEVAR for treatment of thoracic aortic pathologies including aneurysm, acute and chronic type B aortic dissection, and traumatic aortic injury was conducted. Rigorously reported studies with 30 or more patients that indicated whether LSA coverage was performed were included for analysis. These studies were used to compare LSA coverage with device deployment distal to the LSA. We then performed a separate analysis of all series that described stroke outcome according to whether the LSA was revascularized prior to coverage. In this separate analysis, a minimum of 5 patients with LSA coverage without revascularization was required, to establish a baseline stroke rate with intentional coverage and to ensure adequate sample size. We then examined stroke rates after TEVAR for aneurysm and dissection.

Outcomes of interest were total number of strokes, anterior circulation stroke, posterior circulation stroke, and stroke-related morbidity and mortality. The rate of permanent neurologic deficit was noted when provided.

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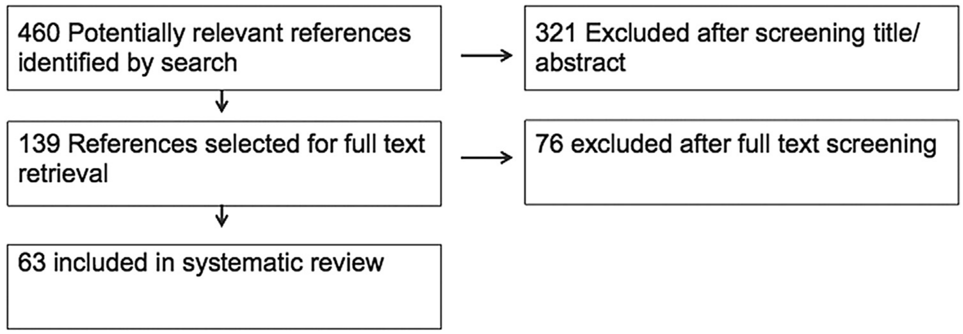

Fig 1. Study identification process.

Importantly, hybrid strategies for treatment of zone 1 or 0 aortic arch pathologies were excluded, owing to the difficulty in establishing the cause of incident strokes. As a result, treatment of aortic pathology requiring deployment of a stent-graft across or proximal to the left common carotid artery, or open operation proximal to the LSA, were excluded from analysis.

Study Identification

An electronic search was performed using the MEDLINE, PubMed, and Embase databases through October 2014. The MeSH search terms *stroke*, *cerebrovascular accident*, *cerebrovascular ischemia*, *TEVAR*, *thoracic endovascular*, and *subclavian* were used in combination with the Boolean operators AND or OR. Reference lists of obtained articles were also searched. Review articles, editorials, and case reports were excluded. Each of the 139 papers we retrieved that was a series of TEVARs was then investigated to see whether it described stroke rates in patients who had undergone TEVAR. Reasons for exclusion were failure to list stroke rates, and lack of description whether strokes occurred with or without LSA coverage. In addition, series that provided the stroke by zone often did not state whether the strokes occurred in patients with or without revascularization. Finally, for analysis of TEVAR in aneurysm and dissection, papers that provided the stroke rate by pathology type were included for analysis. A total of 63 papers remained for analysis.

Data Collection

Data were collected by 2 authors (SW, DC) regarding demographics, comorbidity, indication for TEVAR, landing zone of deployment, procedural characteristics, stroke incidence, and stroke morbidity and mortality. The territory of stroke was noted where provided, as anterior or posterior circulation, and left or right hemispheric.

Statistical Analysis

Clinical data were recorded and tabulated with Excel software (Microsoft Corp, Redmond, Washington). Data were extracted in subgroups with stroke rate tabulated according to landing zone of stent-graft and presence or absence of preoperative LSA revascularization. Separate emphasis was placed on studies that described the cerebral distribution of stroke following LSA coverage. Fisher's exact test or Pearson's chi-squared test were used to generate 2-tailed p values.

Results

Study Identification

A total of 63 papers from December 2002 to October 2014 were included for analysis. Figure 1 describes our search identification process. Thirty-three papers from January 2005 through October 2014 were included for analysis of left subclavian coverage, containing 4,485 patients. Table 1 provides a description of included studies and notes the number of patients, the overall stroke rate, and stroke rates by landing zone. A total of 44 papers from December 2002 to January 2013 including 5,593 patients were included for analysis of stroke rate after TEVAR for dissection and aneurysm (Table 2).

Stroke Incidence by Landing Zone and LSA Revascularization Status

The aortic landing zone classification system (Fig 2) is widely used to categorize the landing zone for TEVAR, with partial or complete LSA coverage compared to more distal device deployment. We examined a total of 33 series (Table 1). Eight series provided data on LSA coverage only, excluding more distal deployment, leaving 25 studies for direct comparison of LSA coverage to more distal coverage. Six series provided data on LSA coverage but not on whether strokes occurred in revascularized or nonrevascularized patients, leaving 27 studies for analysis of LSA revascularization.

Twenty-five series directly compared LSA coverage to more distal deployment (Table 1). The overall stroke rate for TEVAR following LSA coverage was 7.4% (87 of 1,177). The overall stroke rate for TEVAR performed distal to the LSA with zone 3 or 4 deployment was 4.0% (107 of 2,661; Fisher's exact test $p < 0.0001$; Table 1).

Twenty-seven series provided data on whether LSA revascularization was performed prior to coverage (Table 1). The overall stroke rate for TEVAR following LSA coverage was 4.8% (59 of 1,237). In these series, when the LSA was covered without revascularization, the stroke rate was 5.6% (46 of 824), and when it was covered with revascularization by either carotid-subclavian bypass or subclavian-carotid transposition, the stroke rate was 3.1% (13 of 413; Fisher's exact test $p = 0.0657$).