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REVIEW

Spinal Cord Ischaemia in Endovascular Thoracic and Thoraco-abdominal Aortic Repair: Review of Preventive Strategies

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WHAT THIS PAPER ADDS

Spinal cord ischaemia (SCI) and concomitant paraplegia are among the most dreaded complications of TEVAR and thoraco-abdominal aortic repair. Lower SCI incidences are achieved in high volume centres, and paraplegia rates seem to be declining in recent years. This decline has been attributed to the use of rigorous multimodality SCI prevention strategies. This paper aims to provide an overview of the current evidence on the effectiveness of peri-operative strategies to prevent spinal cord ischaemia in endovascular thoracic and thoraco-abdominal aortic repair and to recommend an optimal preventive strategy based on the available data.

Introduction: The incidence of spinal cord ischaemia (SCI) and subsequent paraplegia after thoracic endovascular aneurysm repair (TEVAR) and thoraco-abdominal endovascular aneurysm repair is estimated to be between 2.5% and 8%. The aim of this review is to provide an overview of SCI preventive strategies in TEVAR and thoraco-abdominal repair and recommend an optimal strategy.

Methods: Medline, Embase, and the Cochrane Library were searched for studies on TEVAR, thoraco-abdominal endovascular repair, and the use of SCI preventive measures. The review was reported according to the PRISMA statement.

Results: The final analysis included 43 studies (7168 patients). All studies are cohort studies (non-comparative cohorts $n = 37$, comparative cohorts $n = 6$) and largely performed retrospectively ($n = 27$). The included studies had an average MINORS score of 9 (range 6–13) for non-comparative studies and 15.5 (range 12–18) for comparative studies. Transient SCI occurred in 5.7% (450/7,168, 95% CI 4.5–6.9%), permanent SCI in 2.2% (232/7,168, 95% CI 1.6–2.8%). There was a trend towards increased SCI incidence for more "high risk" cohorts. Avoidance of hypotension resulted in a slightly lower permanent SCI rate 1.8% (102/4216, 95% CI 1.2–2.3%) than the overall cohort. A very low SCI estimate (transient and permanent) was found in the subgroup of studies (2 studies, $n = 248$) using (mild) peri-operative hypothermia (transient SCI 0.8%, permanent SCI 0.4%). In the subgroup using temporary permissive endoleak, there was a transient SCI estimate (15.4%), with a permanent SCI estimate of 4.8%. The remaining preventive measures did not significantly impact transient or permanent SCI estimates.

Conclusion: Low overall transient and permanent SCI rates are achieved during endovascular thoracic and thoraco-abdominal aortic repair. Based on the presented data, the use of selective spinal fluid drainage in high risk patients seems justified. Peri-operative hypotension should be avoided and treated where possible. The use of mild hypothermia is promising in small cohorts, but requires further evaluation. Further high quality data are essential to establish a definitive preventive strategy.

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INTRODUCTION

Since its introduction, endovascular aneurysm repair (EVAR) has evolved and is currently the predominant treatment modality for aortic aneurysms.[1] Improved operating techniques and devices allow for treatment of the majority of aortic lesions including thoracic aortic pathology by endovascular means and has become a preferred alternative to

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open repair with low overall mortality and morbidity.[2–4] Spinal cord ischaemia (SCI) and concomitant paraplegia are among the most dreaded complications of thoracic endovascular aneurysm repair (TEVAR) and endovascular thoraco-abdominal aortic repair.[5] Although the incidence of paraplegia is estimated to be between 2.5% and 8% and is lower than the paraplegia rate after open surgical repair, SCI remains a significant problem.[6] Lower SCI incidences are achieved in high volume centres, and paraplegia rates seem to be declining in recent years.[7] This decline has been attributed to the use of rigorous multi-modality SCI prevention strategies.

The identification of risk factors for SCI the categorisation of specific high risk groups and the development of preventive measures for SCI have been the subject of an extensive body of research. Suggested risk factors for SCI are aneurysm extent, open surgical repair, prior distal aortic operations, and peri-operative hypotension. Furthermore, loss of intercostal arteries and collateral vasculature (e.g., subclavian, hypogastric) and duration of the procedure have been suggested as potential contributing factors.[8] For most of the suggested risk factors, however, conflicting results have been reported. Similarly it remains unclear which specific patients are at risk of developing SCI and ultimately the development of a uniform multimodal preventive treatment protocol remains elusive.

With regard to the preventive measures for SCI after TEVAR and thoraco-abdominal repair, most of these strategies have proven their effectiveness in preventing SCI during open repair. Obviously, not all of the preventive measures used during open surgery are applicable, given the minimally invasive nature of these procedures. Currently used measures to prevent SCI after TEVAR and thoraco-abdominal repair include spinal fluid drainage, avoidance of peri-operative hypotension (both aim to maintain adequate spinal cord perfusion), staging the repair and creating a permissive (temporary) endoleak to allow for temporary aneurysm (and spinal cord) perfusion. Additionally, peri-operative hypothermia and intrathecal medication have been described as adjunctive protective measures.[9] Although not necessarily a preventive measure in itself, intra-operative neuro-monitoring has also been described as a strategy to reduce SCI rates by early

Table 1. Guideline recommendations, including current international recommendations on the prevention of SCI after endovascular thoracic and thoraco-abdominal aortic repair.

Guideline	Spinal fluid drain	Avoidance of hypotension	Hypothermia	Staged procedures	LSA revascularisation	Permissive endoleak	Peri-operative neuromonitoring
Management of descending thoracic aorta diseasesESVS 2017[1]	Selective [a]	Yes	NR	NR	NR	NR	Depending on institutional experience
Guidelines on the diagnosis and management of aortic diseases—ESC 2014[2]	Selective [a]	Yes	NR	NR	NR	NR	NR
Endovascular repair of traumatic thoracic aortic injury—SVS 2011[3]	Therapeutic	NR	NR	NR	Selective	NR	NR
Guidelines for the diagnosis and management of patients with thoracic aortic disease—AHA 2010 [4]	Selective[a]	Yes	Open surgery only	NR	NR	NR	Depending on institutional experience
Management of the left subclavian artery with thoracic endovascular aortic repair—SVS 2009[5]	NR	NR	NR	NR	Yes	NR	NR

NR = not reported

[a]Long segment coverage (> 200 mm), previous AAA repair.

[1] Riambau V et al. Management of descending thoracic aorta diseases: Clinical Practice Guidelines of the European Society for Vascular Surgery (ESVS). *Eur J Vasc Endovasc Surg* 2017;53:4—52.

[2] Erbel R et al. 2014 ESC guidelines on the diagnosis and treatment of aortic diseases. *Eur Heart J* 2014;35:2873—926.

[3] Lee WA et al. Endovascular repair of traumatic thoracic aortic injury: clinical practice guidelines of the Society for Vascular Surgery. *J Vasc Surg* 2011;53:187—92.

[4] Hiratzka LF et al. 2010 ACCF/AHA/AATS/ACR/ASA/SCA/SCAI/SIR/STS/SVM guidelines for the diagnosis and management of patients with thoracic aortic disease. *Circulation* 2010;121(13):e266—369.

[5]Matsumura JS et al. The Society for Vascular Surgery Practice Guidelines: management of the left subclavian artery with thoracic endovascular aortic repair. *J Vasc Surg*. 2009;50(5):1155—8.

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