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Short-term Outcome of Spinal Cord Ischemia after Endovascular Repair of Thoracoabdominal Aortic Aneurysms

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WHAT THIS PAPER ADDS

This paper analyses spinal cord ischemia (SCI) after thoracoabdominal EVAR. It suggests that SCI development is associated with more extensive repairs, but not with the acuteness of the operation. Moreover, it shows the positive impact of the use of standardized post-operative protocols for the early detection and treatment of spinal cord ischemia. Finally, it reinforces the need of finding more strategies for preventing this serious complication.

Objective: To analyze the incidence and short-term outcome of SCI after endovascular repair of thoracoabdominal aneurysms (eTAAA).

Methods: All patients undergoing eTAAA with branched and fenestrated stent grafts between 2008 and 2014 were retrospectively reviewed concerning pre-, intra- and post-operative clinical data and imaging.

Results: Seventy-two patients (53 males, 68 [64—73] years old) underwent eTAAA (51 elective, 21 acute including 7 ruptures). Patients were classified anatomically according to Crawford: type I ($n=11$), type II ($n=26$), type III ($n=18$), and type IV ($n=17$). Thirty-day mortality was 6.9 % (3.9% for elective, 7.1% for symptomatic and 28.6% for ruptures, including one intra-operative death). Twenty-two of the 71 patients who survived the operation (31.0%) developed SCI: type I ($n=2$, 20.0%), type II ($n=13$, 50.0 %), type III ($n=3$, 16.7%), type IV ($n=4$, 23.5%). SCI incidence decreased in the latter part of the experience (23.7% vs. 39.4%, $p = .201$). SCI development was independently associated with Crawford type II TAAA (OR 4.497 (1.331—15.195), $p = .016$) and higher contrast volume (OR 3.736 [1.054—13.242], $p = .041$). Fifteen of these 22 patients with SCI showed some improvement of their deficits before hospital discharge. The introduction of a standardized protocol in the last 38 patients aiming at the early diagnosis and treatment of SCI led to more frequent regression of SCI symptoms (100% vs. 46.2%, $p = .017$) and a higher rate of regaining ambulatory capacity (55.6% vs. 15.4%, $p = .027$). After the introduction of this protocol, the residual SCI rate at hospital discharge was 13.2% as opposed to 33.3% in the initial group.

Conclusion: eTAAA has low peri-operative mortality, but SCI incidence is high albeit that it decreased with increasing experience. More extensive repair and use of larger volumes of contrast were associated with higher risk of SCI. Acute repair does not significantly increase SCI risk. A standardized protocol for early diagnosis and treatment of SCI leads to a higher recovery rate with a greater likelihood of regaining ambulatory capacity.

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INTRODUCTION

Endovascular aneurysm repair of thoracoabdominal aneurysms (eTAAA) has shown good results making it an alternative to open repair in experienced centers.[1] However, spinal cord ischemia (SCI) after eTAAA remains a major complication of the technique, with an incidence ranging from 0 to 30%.[2] In addition, there seem to be significant differences in recovery rates from SCI depending on the initial degree of the neurological deficit and on the outcome of patients depending on the residual symptoms.[3—5] Several strategies have been proposed to reduce SCI after eTAAA, including cerebrospinal fluid (CSF) drainage, optimizing blood pressure, and procedure staging.

The purpose of this article is to evaluate the short-term outcome after eTAAA focusing on SCI. Furthermore, the effect of the introduction of a standardized peri-operative protocol to allow early diagnosis and treatment of SCI is also assessed.

METHODS

Patients and definitions

All patients who underwent endovascular TAAA repair with branched and/or fenestrated stent grafts at a single tertiary

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university centre between 2008 and July 2014, were identified from the hospital registries. Patient charts and imaging were retrospectively reviewed according to a pre-set protocol based on the reporting standards for endovascular aneurysm treatment of abdominal and thoracic aortic aneurysms.[6] Procedures were classified as elective or acute (symptomatic and ruptured). Aneurysms were classified according to the Crawford classification grading the anatomy and not the endovascular repair. Technical success was defined according to the reporting standards,[6] including the patency of the visceral branches and/or fenestrations and the absence of type I and III endoleaks. In addition, all moderate and severe complications were included.[6]

Imaging

All patients underwent pre- and post-operative thin slice contrast enhanced computer tomography (CTA). Aneurysm diameter was measured on axial imaging using the perpendicular to the larger diameter in cases of elliptical appearance to avoid overestimation of size because of vessel tortuosity. Significant stenosis was assumed whenever the stenosis was >50 %. Hypogastric occlusion for the regression model was assumed whenever one of these arteries was occluded.

Endovascular procedure

eTAAA was done under general anesthesia in a hybrid operation room (Siemens, Erlangen, Germany). Iodine contrast was routinely used, except for SMA and celiac trunk visualization where CO_2 was used. Since 2013, 2D-3D imaging fusion has been used in all cases.[7] Arterial access was obtained from the right axillary artery and both femoral arteries. Stent grafts incorporating branches, fenestrations, or a combination of both (Cook Inc, Bloomington, IN, USA) were used according to what was considered most appropriate to the patient's anatomy. Both the procedure and stent grafts have been described in detail previously.[8] To limit the ischemic time of the lower limbs and development of post operative reperfusion injury, the large femoral sheaths used for stentgraft delivery were removed as soon as all the main aortic stent grafts had been deployed and fenestrations were mated with the respective target arteries by means of balloon expandable covered stents. The connection of the caudally oriented branches to their respective target arteries was done as the final step of the procedure from an axillary approach using self expanding covered stents. The left subclavian artery was revascularized whenever it had to be covered to achieve an adequate proximal seal.

Spinal cord ischemia and protection protocol

A CSF drain was inserted in the operating theatre before the induction of anesthesia. Contraindications to drain insertion were assessed by the anesthetic staff and included non-corrected coagulopathies, previous major spinal surgery, and symptomatic spinal stenosis. Passive CSF drainage at 10 cm H_2O was routinely used for non-emergent patients and maintained for 36–48 hours in the absence of SCI symptoms. The development of clinical signs of SCI prompted prolonged CSF drainage up to 5 days. CSF drainage volume was limited to 15 mL/h and the mean arterial pressure (MAP) was maintained above 80 mmHg in asymptomatic patients. Clinical signs of SCI during the post-operative phase prompted more aggressive management: 1) a decrease in the CSF drainage pressure level to maximize the drainage volume up 15 mL/h; 2) increase of MAP pharmacologically to 90–100 mmHg; and 3) hemoglobin level maintained or raised to above 120 g/L. Whenever SCI was suspected, a CT scan of the head and spine was performed to exclude a cerebral event or spinal hematoma. An independent neurologist established the diagnosis and outcome of SCI. Regression of symptoms was defined as partial or complete compared with the clinical symptoms at the time when the SCI diagnosis was made. The SCI deficit level was categorized into ambulatory or non-ambulatory on hospital discharge. Since March 2014, all defects identified on the coagulation study (ROTEM, Tem International Gmbh, Germany) have been corrected on exclusion of the aneurysm with the aid of plasma and/or platelet transfusions.

All patients stayed in the intensive care unit at least while CSF drainage was being used. Initially in this series, patients were clinically assessed on an individual basis, but since March 2012 a standardized protocol has been introduced aiming at an early diagnosis of any SCI deficits. This consists of hourly control of the neurological status during the first 48 post-operative hours and immediate implementation of the above mentioned measures to counteract any possible SCI. Since January 2014 motor evoked potential monitoring (MEP) has been used with test occlusion of the last side branch before the exclusion of the aneurysm to evaluate spinal cord perfusion and provide the possibility of leaving a perfusion branch open.[9] No specific spinal perfusion branches were incorporated in the design of the stentgrafts used in these patients.

Statistical analysis

Normal distribution was not assumed and values are presented as medians with interquartile ranges within parentheses. Chi-square tests with exact approximation and Mann–Whitney *U* tests were used. Non-parametric correlation according to Spearman test was used. Logistic regression was used to evaluate associations with SCI development. All variables with p values $< .10$ or theoretically or previously related to SCI, were included in the model. The exceptions were variables clearly related in-between themselves (dependent), where only the most representative were introduced into the regression model after assessing the relationship between them. Continuous variables were introduced into the model as dichotomous variables using their median as cut off for creating two groups. Odds ratios are presented with 95% confidence intervals in parentheses. Exact p values are presented and were considered significant whenever $< .05$. Statistical