Eur J Vasc Endovasc Surg (2015) 49, 248—254

Editor's Choice — The Impact of Early Pelvic and Lower Limb Reperfusion and Attentive Peri-operative Management on the Incidence of Spinal Cord Ischemia During Thoracoabdominal Aortic Aneurysm Endovascular Repair

B. Maurel [a], N. Delclaux [a], J. Sobocinski [a], A. Hertault [a], T. Martin-Gonzalez [a], M. Moussa [a], R. Spear [a], M. Le Roux [a], R. Azzaoui [a], M. Tyrrell [b], S. Haulon [a,*]

[a] Aortic Centre, Hôpital Cardiologique, CHRU de Lille, INSERM U1008, Université Lille Nord de France, 59037 Lille Cedex, France
[b] King's Health Partners, London, UK

WHAT THIS PAPER ADDS
This paper reports the impact of an optimized spinal cord protection strategy on spinal cord ischemia rates after endovascular thoracoabdominal aneurysm repair performed in a high volume center.

Objective/background: Spinal cord ischemia (SCI) is a devastating complication following endovascular thoracoabdominal aortic aneurysm (TAAA) repair. In an attempt to reduce its incidence two peri-procedural changes were implemented by the authors in January 2010: (i) all large sheaths are withdrawn from the iliac arteries immediately after deploying the central device and before cannulation and branch extension to the visceral vessels; (ii) the peri-operative protocol has been modified in an attempt to optimize oxygen delivery to the sensitive cells of the cord (aggressive blood and platelet transfusion, median arterial pressure monitoring >85 mmHg, and systematic cerebrospinal fluid drainage).
Methods: Between October 2004 and December 2013, 204 endovascular TAAA repairs were performed using custom made devices manufactured with branches and fenestrations to maintain visceral vessel perfusion. Data from all of these procedures were prospectively collected in an electronic database. Early post-operative results in patients treated before (group 1, $n = 43$) and after (group 2, $n = 161$ patients) implementation of the modified implantation and peri-operative protocols were compared.
Results: Patients in groups 1 and 2 had similar comorbidities (median age at repair 70.9 years [range 65.2—77.0 years]), aneurysm characteristics (median diameter 58.5 mm [range 53—65 mm]), and length of procedure (median 190 minutes [range 150—240 minutes]). The 30 day mortality rate was 11.6% in group 1 versus 5.6% in group 2 ($p = .09$). The SCI rate was 14.0% versus 1.2% ($p < .01$). If type IV TAAAs were excluded from this analysis, the SCI rate was 25.0% (6/24 patients) in group 1 versus 2.1% (2/95 patients) in group 2 ($p < .01$).
Conclusion: The early restoration of arterial flow to the pelvis and lower limbs, and aggressive peri-operative management significantly reduces SCI following type I—III TAAA endovascular repair. With the use of these modified protocols, extensive TAAA endovascular repairs are associated with low rates of SCI.

Article history: Received 24 August 2014, Accepted 25 November 2014, Available online 6 January 2015
Keywords: Endovascular repair, Peri-operative management, Spinal cord ischemia, Thoracoabdominal aortic aneurysm

INTRODUCTION

The repair of descending thoracic and thoracoabdominal aortic aneurysms (TAAAs) exposes the spinal cord to ischemic injuries with resultant paraplegia or paraparesis.[1] Although intuitively less invasive than open repair, endovascular thoracic and TAAA repairs are nonetheless still associated with high rates of spinal cord ischemia (SCI), described, in a recent meta-analysis, in up to 13% of patients after thoracic endovascular aortic repair (TEVAR).[2]

The mechanisms that cause SCI are thought to be infarction secondary to absolute low perfusion (loss of intercostals and poor collateral supply); reperfusion injury after transient per-procedural low perfusion; and microembolic "trash" arising from intra-aortic manipulation. The first two are theoretically amenable to modification by adjunctive therapies. While TEVAR has been studied, few reports to date have focused on SCI after TAAA endografting when evaluating these protocols aimed at spinal cord protection.[3,4]

A branched and fenestrated endograft programme for the treatment of atherosclerotic TAAA and chronic

* Corresponding author.
E-mail address: stephan.haulon@chru-lille.fr (S. Haulon).
1078-5884/© 2014 European Society for Vascular Surgery. Published by Elsevier Ltd. All rights reserved.
http://dx.doi.org/10.1016/j.ejvs.2014.11.017

dissections was started at Aortic Centre, Hôpital Cardiologique, CHRU de Lille, in 2004. Before 2009, <20 endovascular TAAA repairs were performed annually. After 2009 the number of procedures increased to >30 annually. At the beginning of 2010 the endograft implantation technique (early restoration of blood flow to the pelvis and the lower limbs as soon as aortic components are implanted) was changed and a routine per- and post-operative proactive spinal cord protective protocol was adopted.

The purpose of this analysis was to assess the clinical impact of these spinal cord protective protocols.

METHODS

All TAAA endovascular repairs performed at the Aortic Centre, Hôpital Cardiologique, CHRU de Lille, between October 2004 and December 2013 were identified from a prospectively maintained electronic endovascular aortic database. Demographics, medical history, and procedure related data were extracted for analysis. The time of onset and severity of the neurologic deficit were determined by review of the electronic medical charts. Complications were defined using the Society for Vascular Surgery's reporting standards for endovascular aortic aneurysm repair.[5] Emergency procedures were excluded from the current analysis. The Crawford classification system was used to categorize the extent of the aortic coverage by the endograft (I—IV).[6—8] Patients with three fenestrations (both renals and superior mesenteric artery [SMA]) and one scallop for the celiac trunk (CT), and a >20 mm proximal sealing zone above the SMA were included in the type IV TAAA group. Patients with type I—III TAAAs treated between February 2010 and March 2012 were included in the "Windows 2" prospective multicenter trial.[9]

Patient groups

Patients treated between 2004 and 2009 were included in group 1, and those treated from 2010 to 2013 were included in group 2. Since 2010, >30 TAAA endovascular repairs have been performed at the Aortic Centre, Hôpital Cardiologique, CHRU de Lille, annually. The year 2010 also coincides with the optimization of the device implantation technique and the systematic application of the proactive spinal cord protective protocol as described below.

Endovascular technique

One experienced vascular surgeon performed or supervised all of the procedures (S.H.). Prior to December 2012, all cases were performed in an operating room with a mobile motorized C-Arm (OEC 9900 Elite MD; GE OEC Medical Systems, Inc., Salt Lake City, UT, USA). More recently, they have been performed in a dedicated hybrid operating room (Discovery; GE Healthcare, Chalfont St Giles, UK) under image fusion guidance. The endovascular devices were all custom made three or four branched or fenestrated endografts, with proximal thoracic and/or distal abdominal bifurcated extensions when required. A dose of 100 UI/kg of intravenous heparin was injected at the beginning of the procedure. The anticoagulation was monitored by activated clotting time (ACT). The ACT target was >250 seconds during the entire procedure. A detailed description of the implantation procedure for fenestrated procedures has been published previously.[10]

Implantation protocol

In all cases, the branch/fenestration bearing component was implanted, and any fenestrations (cannulation and stenting) were completed in cases with a combination of fenestration(s) and branch(es). In group 1, any branches were then completed by implantation of the bridging stents into their respective branches from an axillary artery approach. Finally, procedures were completed by implantation of the bifurcated body and iliac limbs. Critically, the large sheaths were not withdrawn from the femoral and iliac arteries before the end of the procedure. In group 2, however, the implantation sequence was changed so that after implantation of the branch/fenestration bearing component and completion of any fenestrations, the bifurcated body and limb extensions were immediately completed to allow the early withdrawal of the large caliber (iliac occlusive) sheaths in order to permit the early restoration of blood flow to the pelvis and lower limbs and to reduce ischemia/reperfusion damage. The branches were then completed from an axillary arterial access as the final step.[10]

Staged and adjunctive procedures to preserve spinal cord flow in group 2

Following the demonstration of the potentially beneficial effects of a staged repair to encourage spinal cord preconditioning during extensive TAAA repair,[11] the thoracic endovascular component was implanted during the first procedure in all cases in which the anatomy was suitable (i.e., when a distal sealing zone with a maximum diameter <42 mm was present). Every effort was made to maintain the perfusion of at least one internal iliac artery (IIA); if required, iliac branched devices were employed. When left subclavian artery (LSA) coverage was deemed necessary for proximal seal, carotid subclavian transposition or bypass was performed as an initial procedure. These "first stage" procedures were performed 6—10 weeks before definitive TAAA repair.

Proactive spinal cord protective protocol in group 2

Cerebrospinal fluid drainage. Since January 2010, a preoperative cerebrospinal fluid (CSF) drain has been systematically established for all TAAA types I—III (not for type IV). A spinal drain is inserted in the operating room by a dedicated cardiovascular anesthesiology team. Owing to the risk of compressive neuraxial hematoma, the French Society of Anesthesiology recommends a minimum 6 hour delay between the placement of the CSF drain and injection of heparin. It is thus more convenient to place the spinal drain the day before the procedure.[12] CSF pressure was maintained at <10 cmH_2O during and for at least 48 hours after