Masters of Cardiothoracic Surgery

Spinal cord injury after frozen elephant trunk procedures—prevention and management

Giacomo Murana[1], Francesco Campanini[1], Costanza Fiaschini[1], Giuseppe Barberio[1], Gianluca Folesani[1], Davide Pacini[1,2]

[1]Division of Cardiac Surgery, Cardiac Surgery Department, IRCCS, Azienda Ospedaliero-Universitaria di Bologna, Bologna, Italy; [2]Department of Experimental, Diagnostic and Specialty Medicine, DIMES, University of Bologna, Bologna, Italy

Correspondence to: Prof. Davide Pacini, MD, PhD. Chief, Division of Cardiac Surgery, Cardiac Surgery Department, IRCCS, Azienda Ospedaliero-Universitaria di Bologna, Via Massarenti 9, 40138, Bologna, Italy; Department of Experimental, Diagnostic and Specialty Medicine, DIMES, University of Bologna, Bologna, Italy. Email: davide.pacini@unibo.it.

Submitted Mar 02, 2023. Accepted for publication Aug 22, 2023. Published online Sep 22, 2023.
doi: 10.21037/acs-2023-scp-16
View this article at: https://dx.doi.org/10.21037/acs-2023-scp-16

Introduction

New techniques and devices have broadened the spectrum of therapeutic strategies for patients with complex aortic pathologies. Total arch replacement (TAR) using the frozen elephant trunk (FET) technique is one of the latest approaches to surgically treat complex arch and proximal descending aortic pathologies. Although this technique has showed excellent results, it is associated with several complications, such as spinal cord injury (SCI). This is related to the coverage of an extended portion of descending aorta, including the origin of intercostal arteries. The longer the portion of descending aorta covered, the higher the risk of SCI occurrence. Consequently, knowing the anatomy and vascularization of the spinal cord is crucial (1). Even though coverage of the descending aorta beyond T8 (due to coverage of the Adamkiewicz artery) seems to be one of the most important factors associated with higher risk of SCI, there are other elements involved, such as prolonged spinal cord ischemia observed during hypothermic circulatory arrest and air or corpuscular thromboembolism (2).

A higher incidence of this neurological complication after the FET is more often observed in chronic degenerative aneurysms and acute aortic dissections and is less frequently reported in chronic dissections due to the possibility of pre-conditioning of the spinal cord by collateral networks (3,4). Preventive measures can be employed in extended surgical aortic coverage to reduce the occurrence of spinal cord injuries, such as cerebrospinal fluid (CSF) drainage, keeping the mean arterial pressure (MAP) above 90 mmHg, early evaluation of neurological deficits, and the use of moderate hypothermia. CSF drainage allows monitoring of the peridural pressure, as well as the capability of its reduction when it exceeds critical values. However, intrathecal drainage placement can represent a risk and careful examination of the coagulation panel is strongly recommended. In this video article, we present a case of a FET showing how it can be possible in the prevention and management of SCI. A literature review on this subject will describe the incidence and state of the art perspectives on this neurological complication.

Clinical vignette

A 56-year-old female underwent ascending aorta and hemiarch replacement for acute type A aortic dissection. Subsequently, she experienced abrupt abdominal pain, with angiography-computed tomography (angio-CT) demonstrating a residual aortic dissection starting from the distal anastomosis, with true lumen compression at the level of the thoracic portion and occlusion in the abdominal tract with signs of left kidney ischemia and mesenteric malperfusion. After Aortic Team evaluation, the patient underwent an unsuccessful initial attempt of intimal flap fenestration. Consequently, we decided to perform complete arch replacement using the FET technique.

Surgical techniques

Preparation and exposition

The day before surgery, CSF drainage was positioned. Routine intraoperative monitoring included body temperatures (skin, bladder, and nasopharyngeal temperature), three invasive blood pressure detectors (radial arteries bilaterally, left femoral artery), central venous pressure, and transesophageal echocardiography. FET implantation was performed after conventional median sternotomy. The arterial cannulation site of choice was the brachiocephalic trunk (BCT). The innominate vein was suture ligated. Systemic cooling was started to reach moderate hypothermia at 25 ℃ of nasopharyngeal temperature. The aorta was cross-clamped and single-dose crystalloid histidine-tryptophan-ketoglutarate cardioplegia (HTK-Custodiol; Koehler Chemi, Alsbach-Haenlien, Germany) delivered.

Operation

After excision of the patient's aortic arch, the BCT was clamped, and bilateral cerebral perfusion was attained utilizing the Kazui technique. Zone 2 according to Ishimaru's aortic map was elected as the distal anastomosis site and it was reinforced with Teflon. Thoraflex Hybrid graft (Vascutek, Terumo, Inchinnan, Scotland, UK) was implanted with 4/0 polypropylene sutures. Visceral perfusion was restored through the lateral branch of the prosthesis. Systemic heating was initiated, and the subclavian artery reimplanted; with the proximal aortic anastomosis completing the sequence. Finally, the left main carotid artery and BCT were anastomosed to the prosthesis.

Post-operative outcome

The day after surgery the patient experienced lower limb hyposthenia and neurogenic bladder; neurological evaluation was required and a spine magnetic resonance imaging (MRI) showed T6 ischemia. After extensive multidisciplinary and neurological evaluations, the drainage was maintained until the tenth postoperative day. The symptoms gradually regressed and, at discharge, the patient was able to walk. The urinary issue was treated with self-catheterization and rehabilitation therapy.

Comments

SCI after FET is an infrequent but important complication, attributed to the endovascular coverage of a variable length of the descending aorta by the stented graft. It is crucial to properly evaluate the correct size of the device, avoiding excessive stent length, and possibly proximalizing the distal anastomosis site. Several techniques have been developed aiming to reduce the incidence of SCI, which involve intra- and postoperative measures that can be adopted. Many of these techniques are not currently applicable to clinical practice. One of the most appreciated is the use of near-infrared spectroscopy that allows the quantification of regional tissue oxygenation, in monitoring the regional lumbar paraspinal muscle (5).

Clinical results

In our center, CSF drainage is put in place for every elective case; the peridural catheter is inserted the day before surgery and removed 72–96 hours after the operation when monitoring confirms normal, consistent values of CSF tension. To reduce the risk of bleeding, and therefore potential damage to the spinal cord, it is crucial to properly interrupt anticoagulation therapy as recommended. Early evaluation of patients' neurological functions is crucial to obtain the best clinical outcome; hence a neurological assessment is performed 3–4 hours after surgery.

Literature review

Given the interest in this significant topic, a thorough literature search was performed using PubMed databases, selecting publications in English with no time restriction, which yielded 64 articles. Case reports, editorials, expert opinions, and commentaries were excluded, to avoid potential doubling of results. In the end, we examined twenty-four studies focusing on SCI after TAR with the FET technique, with a reported incidence of SCI ranging from 0.8% to 8.9% (details are described in *Video 1*).

Acknowledgments

Funding: None.

Footnote

Conflicts of Interest: The authors have no conflicts of interest to declare.

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Cite this article as: Murana G, Campanini F, Fiaschini C, Barberio G, Folesani G, Pacini D. Spinal cord injury after frozen elephant trunk procedures—prevention and management. Ann Cardiothorac Surg 2023;12(5):500-502. doi: 10.21037/acs-2023-scp-16

