



# Frozen elephant trunk—the Bologna experience

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## Introduction

Complex pathologies of the thoracic aorta have always been a challenge in cardiac surgery, since they may require multiple operations with high peri-operative risks and hospital mortality rates. The technique and the devices developed during recent decades, such as the introduction of the Elephant Trunk and branched graft techniques, have improved the possibility of the repair in such patients, simplifying the procedures (1,2). The frozen elephant trunk technique (FET) is the latest evolution in this field (3).

In Bologna University, we started to use this technique in 2007, initially restricting our indication to aneurysms of the distal arch and proximal descending thoracic aorta by using the only device available in Europe: the Jotec E-vita open. Through the years, we extended our indications to chronic aortic dissections (4). With the introduction of the Thoraflex hybrid prosthesis, that we used from 2013, we further extended the indications to acute type A and B aortic dissection (5). This new hybrid prosthesis presented a different shape of stent and a minor length change with a tetrafurcated graft. These features helped determine the choice of prosthesis, as re-operations of the aortic arch, in which the use of a branched graft not provided by the E-vita open, can simplify the procedure both for the re-implantation of the supraaortic vessels, and reperfusion after hypothermic circulatory arrest performed through the side branch. When we previously used the E-vita open prosthesis, we replaced the tubular graft with a further branched graft. Moreover, the same advantages that we found for the reoperations using the new hybrid branched-graft device, were the same also in the case of acute dissections. However, we already compared the two devices

and did not find any differences in terms of in-hospital mortality (6). In addition, we believe that the length of the stent of the Thoraflex (i.e., 100 mm) is enough to stabilize the intimal flap and the downstream aorta.

In recent years, the FET technique has gained consensus with over 30,000 hybrid prostheses implanted worldwide (7). It has been progressively subject to modifications to make the procedure easier and to shorten circulatory arrest time, in order to reduce the rate of a significant complication (e.g., spinal cord injury).

In the United States, due to the unavailability of hybrid prostheses, alternative techniques have been proposed and developed. Pochettino *et al.* (8) described the antegrade delivery of a stent graft during deep hypothermic circulatory arrest (DHCA), followed by partial aortic arch reconstruction. Roselli *et al.* (9) introduced an alternative aortic arch repair technique, including the antegrade deployment of a stent graft, followed by the creation of a scallop on the endoprosthesis to accommodate the supra-aortic trunks. This technique was recently modified, with the introduction of a fenestration in the stent graft for the left subclavian artery (LSA), associated with a direct placement of a covered stent. These improvements introduced a new concept: the proximalization of the FET technique to reduce the surgical complexity by virtue of a more proximal anastomosis, and to deploy the stent higher in the descending aorta, reducing the risk of spinal cord injury.

Until 2014, our institution had always performed the distal anastomosis beyond the LSA (arch ZONE 3). Subsequently, we changed our practice moving our target to the arch ZONE 2, between the left carotid artery and the LSA, allowing both the reimplantation of the latter

and a higher deployment of the stent graft (6). We used the Thoraflex hybrid prosthesis in arch ZONE 2 more frequently, especially in cases of acute aortic dissections. This was for the reasons mentioned above, but additionally, because it is known that a large intimal tear is often located in proximity to the LSA and it can be easily excluded. The use of a shorter endograft length is also another key factor in the reduction of spinal cord injury rate.

On the other hand, in degenerative aneurysm and chronic aortic dissections, we have increasingly used the arch ZONE 3, along with a higher rate of E-vita open prosthesis. In order to achieve a single-stage treatment, in such cases, the use of a Thoraflex hybrid prosthesis is not always possible, since the distance from ZONE 2 and the distal end of the aneurysm did not allow a perfect sealing of the stent. Therefore, it can be necessary either to perform the distal anastomosis in ZONE 3 or to use a longer stent as for the E-vita open prosthesis (130–160 mm). Given management of the LSA was one of the technique's main drawbacks, extra-anatomic bypasses and others forms of LSA revascularization have been proposed. In our hospital, for patients whose LSA is hard to reach, we re-implant it by using the GORE hybrid vascular graft (W.L. Gore & Associates, Newark, Del), to perform a sutureless endoluminal anastomosis.

We also typically treat acute type B aortic dissections with the FET technique. The treatment of choice for this pathology is thoracic endovascular aortic repair (TEVAR). However, when primary endovascular repair is not feasible, or in case of a high risk of retrograde type A aortic dissection, as occurs during concomitant dilatation of the aortic arch and ascending aorta or when no landing zone is present, the FET may represent an alternative solution, especially in young patients.

## Conclusions

In experienced aortic surgery centers, the FET technique has become an almost standard treatment; however, we only use this technique in carefully selected cases. Indeed, it is important to focus attention on two main aspects: firstly, we are still using the classical total/partial arch replacement or the elephant trunk according to the indications; secondly, we should not forget that we are treating complex and extensive pathologies of the thoraco-abdominal aorta, and even if we are using a hybrid arch prosthesis, these patients may require further endovascular extension.

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None.

## Footnote

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

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