no standardized definitions with respect to case urgency were used.

This study represents an important contribution to our current understanding of the safety profile of FET and provides new insights in the factors associated with SCI. Perhaps the stage is now set for future randomized controlled trials with long-term follow-up to establish standardized indications and protocols for this potentially transformative procedure.

References

1. Kato M, Ohnishi K, Kaneko M, Ueda T, Kishi D, Mizushima T, et al. New graft implanting method for thoracic aortic aneurysm or dissection with a stented graft. *Circulation*. 1996;94:III188-93.
2. Preventza O, Liao JL, Olive JK, Simpson K, Critsinelis AC, Price MD, et al. Neurologic complications after the frozen elephant trunk procedure: a meta-analysis of more than 3000 patients. *J Thorac Cardiovasc Surg*. 2020;160:20-33.e4.
3. Hanif H, Dubois L, Ouzounian M, Peterson MD, El-Hamamsy I, Dagenais F, et al. Aortic arch reconstructive surgery with conventional techniques vs frozen elephant trunk: a systematic review and meta-analysis. *Can J Cardiol*. 2018;34:262-73.
4. Hagl C, Pichlmaier M, Khaladj N. Elephant trunks in aortic surgery: fresh and frozen. *J Thorac Cardiovasc Surg*. 2013;145:S98-102.
5. Leshnower BG, Chen EP. TEVAR for acute complicated Type B aortic dissection. *Op Tech Thorac Cardiovasc Surg*. 2018;23:21-33.
6. Dinato FJ, Dias RR, Duncan JA, Fernandes F, Ramires FJA, Mady C, et al. The learning curve effect on outcomes with frozen elephant trunk technique for extensive thoracic aorta disease. *J Card Surg*. 2019;34:796-802.

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Commentary: Is it time to thaw the frozen elephant trunk procedure?

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Since its introduction into clinical practice in the late 1990s, the frozen elephant trunk (FET) procedure has become a widely used method of repair for extensive intrathoracic aortic disease that requires replacement of the aortic arch, including acute aortic dissection. In this issue of *The Journal of Thoracic and Cardiovascular Surgery*, Preventza and colleagues¹ present the results of a meta-analysis of more than 3000 patients from 35 studies who had undergone FET procedures, focusing on early mortality and the risks of stroke and spinal cord ischemic injury (SCI). The pooled estimates for operative mortality, stroke, and SCI were 8.8%, 7.6%, and 4.7% respectively, and are comparable to those from 2 previously published meta-analyses.^{2,3} The prevalence of SCI is of particular importance, because the rates reported (4.7% in the current study of Preventza and colleagues,¹ 5.1% in the study of Tian and colleagues,²

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CENTRAL MESSAGE

Extensive analysis continues to indicate that spinal cord ischemic injury is an important complication of the frozen elephant trunk technique for repair of extensive thoracic aortic disease.

and 5.0% in the report of Hanif and colleagues³) are higher than those reported for the classic elephant trunk procedure, for 1-stage procedures performed without a stent graft, and for conventional aortic arch procedures.³⁻⁷

Some important limitations of the current study that were acknowledged by Preventza and colleagues¹ deserve comment. Age of the patients was not analyzed separately. In the 16 studies originating from China, the mean age ranged from 44 to 54 years. Thirteen of these 16 studies reported a rate of SCI of 2.5% or less, and 10 studies reported a rate of 0%. In the 7 series reported from Japan, the mean age ranged from 68 to 74 years, and the rate of SCI ranged

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from 3.3% to 24%. Among the 12 studies from Europe, the United States, and Brazil, the mean age ranged from 56 to 68 years, and the rate of SCI ranged from 0% to 12.9%. Of the 4 series in this subgroup that reported a 0% prevalence of SCI, 3 contained 14 or fewer patients. It is difficult to escape the conclusion that increasing age, and possibly ethnicity, are likely important risk factors for SCI after the FET procedure.

Data regarding the duration of circulatory arrest, the temperature at which circulatory arrest was established, the durations of spinal cord and lower body ischemic periods, and the techniques used for protection of the brain and spinal cord were not analyzed. These are important variables that may also affect the development of SCI. As Preventza and colleagues¹ note, the high mortalities in some of the series may have masked the occurrence of SCI and stroke in additional patients.

Permanent paraplegia and paraparesis are devastating complications after extensive thoracic and thoracoabdominal aortic procedures that adversely affect long-term survival and quality of life.⁸ Preventza and colleagues¹ identified length of the stent graft or extensive coverage of the descending thoracic aorta as important predictors of SCI after the FET procedure. Future studies will hopefully identify additional risk factors for development of SCI, which will result in a more selective application of the procedure and reduce the prevalence of this significant complication. Until this information becomes available, and given that data are not currently available to indicate that patients

managed with the FET procedure have better long-term survival and freedom from distal aortic reinterventions than those treated with other interventions,⁹ it may be prudent to consider use of alternative procedures that are associated with a lower prevalence of SCI for patients with extensive thoracic aortic disease.

References

1. Preventza O, Liao JL, Olive JK, Simpson K, Critsinelis AC, Price MD, et al. Neurologic complications after the frozen elephant trunk procedure: a meta-analysis of more than 3000 patients. *J Thorac Cardiovasc Surg.* 2020;160:20-33.e4.
2. Tian DH, Wan B, DiEusanio M, Black D, Yan TD. A systematic review and meta-analysis on the safety and efficacy of the frozen elephant trunk technique in aortic arch surgery. *Ann Cardiothorac Surg.* 2013;2:581-91.
3. Hanif H, Dubois L, Ouzounian M, Peterson MD, El-Hamamsy I, Dagenais F, et al. Aortic arch reconstructive surgery with conventional techniques vs frozen elephant trunk: a systematic review and meta-analysis. *Can J Cardiol.* 2018;34:262-73.
4. Svensson LG, Rushing GD, Valenzuela ES, Rafael AE, Batizy LH, Blackstone EH, et al. Modifications, classification, and outcomes of elephant-trunk procedures. *Ann Thorac Surg.* 2013;96:548-58.
5. Castrovinci S, Murana G, de Maat GE, Smith T, Schepens MA, Heijmen RH, et al. The classic elephant trunk technique for staged thoracic and thoracoabdominal aortic repair: long-term results. *J Thorac Cardiovasc Surg.* 2015;149:416-22.
6. Kouchoukos NT, Kulik A, Castner CF. Clinical outcomes and rates of aortic growth and reoperation after 1-stage repair of extensive chronic thoracic and aortic dissection. *J Thorac Cardiovasc Surg.* 2018;155:1926-35.
7. Coselli JS, Green SY. Aortic arch repair today: open repair is best for most arch lesions. *J Cardiovasc Surg (Torino).* 2015;56:531-46.
8. Svensson LG, Crawford ES, Hess KR, Coselli JS, Safi HJ. Experience with 1509 patients undergoing thoracoabdominal aortic operations. *J Vasc Surg.* 1993;17:357-68; discussion 368-70.
9. DiBartolomeo R, Pantaleo A, Berretta P, Murana G, Castrovinci S, Cefarelli M, et al. Frozen elephant trunk surgery in acute aortic dissection. *J Thorac Cardiovasc Surg.* 2015;149(2 Suppl):S105-9.