THE TEXAS HEART INSTITUTE® JOURNAL

Global Cardiovascular Forum

The Past, Present, and Future of Complex Aortic Intervention

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Keywords: Aorta; aortic aneurysm, thoracoabdominal; aortic aneurysm, abdominal; history of medicine

Albert Einstein once said, "The distinction between the past, present and future is only a stubbornly persistent illusion."

So much of what is done with complex aortic surgical interventions is a direct outgrowth of what has been done, what is being done, and what is intended to be accomplished.

The first successful aortic aneurysm repair was performed by Dr Charles Dubost in 1951; he replaced an infrarenal abdominal aorta aneurysm using a cadaver homograft harvested weeks earlier.[1] This surgery culminated substantial efforts to repair damaged aortas using various techniques, including wiring the aorta with materials to induce thrombosis; proximal ligation of aortic aneurysms using metal tape, sutures, and autogenous tissue; and wrapping the aorta with cellophane and other materials. Dr Dubost's success was made possible by pioneering vascular surgeons, including Dr Alexis Carrel (1873-1944),[2] Dr Rudolph Matas (1860-1957),[3] and Dr Oscar Creech (1916-1967),[4] and contributed to further innovations in the 1950s and 1960s.

When Dr Carrel won the Nobel Prize in 1912, he was the youngest recipient and first surgeon; his awarded work centered on the end-to-end anastomosis of blood vessels.[2] Dr Matas made contributions in the development of endoaneurysmorrhaphy, in which he worked within the aneurysm to effectively restore and preserve the internal contour and surface anatomy of the vessel.[3] Dr Creech[4] revisited this technique, working within the aneurysm to replace the aorta, and leaving the aneurysmal sac in place. Before these techniques were developed, this type of surgery involved complete excision of the aneurysm—which was often difficult, bloody, and hazardous.

Soon after Dr Dubost's successful surgical repair of an abdominal aortic aneurysm,[1] Dr Samuel Etheredge[5] resected a thoracoabdominal aortic aneurysm and replaced it with a homograft. In 1956, Dr Denton Cooley and Dr Michael DeBakey[6] reported the first successful resection of the ascending aorta and homograft replacement, using cardiopulmonary bypass. In 1957, Drs DeBakey, E. Stanley Crawford, and Cooley[7] reported a successful resection of a fusiform aneurysm of the aortic arch replaced with a homograft, which also relied on cardiopulmonary bypass and used an early form of bilateral antegrade perfusion.

In the 1950s, a variety of aortic substitutes were used to replace the aorta. Initially, most physicians used homografts; however, they often calcified and deteriorated over time. As the need for a durable, synthetic replacement became more evident, Voorhees et al[7] used synthetic vinyon-N cloth to repair an abdominal aortic aneurysm. Soon afterward, Dr DeBakey[8] and his team in Houston developed Dacron grafts (Fig. 1) as a more durable alternative, increasing the number of aortic surgeries in Houston, which became a leading clinical center for complex aortic surgery.

As aortic repair continued to evolve, there were several groundbreaking surgeries.

- 1966: Dr Hugh Bentall and Dr Anthony De Bono[8] incorporated the newly developed aortic valve into a composite valve-graft to replace the aortic root.

Citation: Coselli JS. The past, present, and future of complex aortic intervention. *Tex Heart Inst J*. 2023;50(3):e238203. doi:10.14503/THIJ-23-8203
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Fig. 1 Dr Michael E. DeBakey makes a synthetic arterial graft out of Dacron fabric using his wife's sewing machine. Used with permission from Baylor College of Medicine.

- 1975: Dr Randall Griepp[9] described transverse aortic arch replacement using profound hypothermic circulatory arrest (between 12 °C and 18 °C) in 4 patients; 3 of 4 patients survived, which resulted in a paradigm shift for aortic arch repair.
- 1991: Dr Juan C. Parodi[10] reported transfemoral and true luminal graft implantation for infrarenal abdominal aortic aneurysms, thus popularizing endovascular aortic repair, and bringing "stent-grafts" to aortic repair.
- 1992: Drs Tirone David and Christopher Feindel[11] described a technique that spared the aortic valve leaflets but otherwise allowed replacement of the aortic root. This obviated a mechanical prosthetic valve replacement and lifelong warfarin (Coumadin) anticoagulation.

For 40 years after Dr Griepp's report, deep hypothermia with circulatory arrest was standard during total aortic arch replacement.[9] Recently, the resurgence of bilateral antegrade perfusion for brain protection during repair has improved patient outcomes and allowed repair at warmer temperatures—avoiding complications of deep hypothermia, which include coagulopathy issues. Another advance was total arch replacement that combines open repair with endovascular repair using a single device; this "frozen elephant trunk" approach extends repair into the descending thoracic aorta.[12]

Future directions include the use of endovascular stent-grafts to treat the thoracoabdominal aorta. Initially, stent-grafts were used to manage only tubular sections of the aorta. Now, this approach attempts to manage the increased complexity of branches arising from the visceral segment of the aorta. It has been met with significant initial success, although further technologic developments are needed to improve its long-term durability. When it comes to aortic innovation, clearly there are no limits; there are only challenges to overcome.

Published: 20 June 2023

Conflict of Interest Disclosure: Dr Coselli serves as principal investigator for, consults for, and receives royalties and a departmental educational grant from Terumo Aortic; consults and participates in clinical trials for Medtronic, Inc, W. L. Gore & Associates, and Abbott Laboratories; and participates in clinical trials for Cytosorbents, Edwards Lifesciences, and Artivion.

Funding/Support: Dr Coselli's work is supported in part by the Cullen Foundation.

Section Editor: Joseph G. Rogers, MD

Meeting Presentation: Presented at: the Global Cardiovascular Forum: Exploring Innovations Changing Cardiovascular Care; January 28, 2023; Houston, TX.

Acknowledgments: The author thanks Ginger M. Etheridge, BBA, and Susan Y. Green, MPH, of the Michael E. DeBakey Department of Surgery at Baylor College of Medicine for editorial support.

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