Editorial

Should open and endovascular arch repair coexist or compete?

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The treatment of aortic arch disease is on the verge of undergoing a profound transformation. For decades, open surgical repair has represented the gold standard, providing durable and anatomically comprehensive treatment. In contrast, endovascular repair strategies emerged as less invasive alternatives but were initially considered to involve a potential trade-off between reduced perioperative burden and long-term anatomical completeness. This paradigm, however, has evolved substantially over recent years. Advances in patient selection, considering life expectancy, comorbidities, organ function, and underlying aortic pathology, together with improvements in endovascular device technology, graft materials, and cardiopulmonary bypass techniques, have contributed to increasingly comparable outcomes between both treatment strategies. Furthermore, hybrid repair approaches, including the frozen elephant trunk technique with subsequent or adjunctive thoracic endovascular aortic repair (TEVAR), have emerged as integrative concepts aiming to combine the durability and anatomical completeness of open repair with the reduced invasiveness of endovascular treatment. Nevertheless, despite promising results, anatomical limitations remain, and the mid-term durability of endovascular strategies continues to be debated (1). These developments have fueled an ongoing discussion: should open and endovascular arch repair compete, or should they coexist as complementary strategies?

In high-volume centers, elective open total arch replacement is associated with operative mortality rates typically ranging from 4% to 10%, with stroke rates between 3% and 8% (2,3). Major advances in cerebral protection, particularly selective antegrade cerebral perfusion, have contributed significantly to improved neurologic outcomes. Nevertheless, the invasiveness of open arch surgery—requiring cardiopulmonary bypass and deep hypothermic circulatory arrest—is not without substantial perioperative risk, especially in elderly or comorbid patients.

Endovascular and hybrid approaches have emerged as new alternatives for high-risk patient populations in recent years. Hybrid arch repair, by means of supra-aortic debranching followed by TEVAR, has demonstrated early mortality rates in the range of 5% to 12%, with stroke rates of approximately 4% to 10% (4,5). More recently, total endovascular arch repair using inner-branched or fenestrated devices has shown promising early results, with some contemporary series reporting mortality rates below 5% and stroke rates between 3% and 7% in highly selected cohorts (6).

Furthermore, direct comparison between open and endovascular strategies remains challenging due to substantial selection bias. Patients undergoing endovascular repair are frequently older, have a higher burden of comorbidities, and are often considered unsuitable candidates for conventional surgery, whereas open repair cohorts typically include younger patients with different

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anatomical characteristics and pathologies. Moreover, endovascular outcomes are frequently reported from highly specialized high-volume centers, potentially limiting generalizability. Therefore, differences in baseline risk, anatomical complexity, and institutional expertise must be carefully considered when interpreting comparative results.

In a recent meta-analysis of open versus endovascular (hybrid) arch repair, no significant differences in early mortality were found; however, hybrid approaches were associated with a trend toward increased re-intervention rates, while stroke rates remained comparable between both groups (7). Moreover, available registry data suggest that although endovascular strategies may reduce immediate physiological stress and shorten overall hospital stay, they do not consistently outperform open surgery in terms of neurologic outcomes (8). A more recent study assessing outcomes following endovascular arch repair compared with open arch repair in a propensity score-matched retrospective study again showed comparable results for stroke, yet demonstrated some advantages of endovascular repair regarding length of stay and acute kidney injury (1).

In fact, stroke remains a significant risk in both treatment strategies. However, neurological injury after aortic arch repair is multifactorial and cannot be fully captured by clinically apparent stroke rates alone. In open surgery, potential embolization by air and debris, hypoperfusion during circulatory arrest, and intraoperative technical aspects may contribute to neurologic risk. In contrast, endovascular repair carries specific embolic hazards related to catheter manipulation within the arch, passage through supra-aortic vessels, and device deployment. Furthermore, increasing evidence suggests that silent cerebral ischemic lesions may occur after both surgical and endovascular interventions, although their long-term clinical relevance remains incompletely understood. Novel strategies such as cerebral embolic protection systems and refined procedural techniques may help to further reduce neurological complications in endovascular repair. Nevertheless, stroke rates remain a major concern in contemporary series, underscoring that less invasive does not necessarily equate to being neurologically safer. In particular, the presence of complex arch anatomy—with severe kinking, atypical branch vessel configuration, or high atherosclerotic burden—poses challenges irrespective of the chosen technique.

Beyond early outcomes, long-term durability remains a central consideration when selecting the optimal treatment strategy. Elective open arch repair has demonstrated excellent long-term results with durable anatomical reconstruction and low aortic reoperation rates of 13% (9). In contrast, long-term data after total endovascular arch repair remain limited, particularly beyond 5–10 years. Although contemporary branched and fenestrated devices have shown encouraging early and mid-term results, concerns regarding endoleaks, device-related complications, and the need for secondary interventions remain relevant. These aspects are of particular importance in younger patients and individuals with hereditary thoracic aortic diseases (HTAD), in whom the lifetime risk of aortic progression and the need for repeated interventions must be carefully considered. In HTAD, re-intervention rates after hybrid or endovascular arch repair have been reported to be 15–20% at mid-term follow-up (7,10). In these cases, open hybrid strategies—namely the frozen elephant trunk technique with proximalization of the distal anastomosis followed by TEVAR of the descending aortic segment—further exemplify the potential for integration, combining the strengths of both modalities to expand treatment options.

Most recently, the modern concept of an "aortic team" has been recognized as the new standard of care in aortic medicine. Multidisciplinary collaboration within institutions enables high-quality care and individualized decision-making by integrating patient-specific risk factors such as age, comorbidities, anatomical suitability, and life expectancy. Such teams typically include cardiovascular surgeons, vascular surgeons, interventional cardiologists, radiologists, anesthesiologists, intensivists, specialized nursing staff, and other healthcare professionals involved in perioperative management and long-term follow-up. Moreover, ongoing technological advancements are likely to further refine both approaches. In endovascular therapy, improvements in branched and fenestrated endograft design, cerebral embolic protection, and imaging guidance may enhance procedural safety and durability. Meanwhile, open arch surgery has also undergone substantial evolution, incorporating hybrid concepts, refined frozen elephant trunk techniques, distal anastomosis proximalization, branch-first strategies, and advanced cerebral protection methods. Novel approaches aiming to reduce circulatory arrest duration and lower-body ischemic times, including normothermic or mild-hypothermic strategies and endoballoon-assisted reperfusion techniques, have further improved the safety profile of open arch repair. Therefore, rather than converging toward a single dominant or universally superior strategy, the cardiovascular field is

evolving into a spectrum of complementary solutions for patient-tailored treatment of complex aortic arch disease.

The question of whether open and endovascular aortic arch repair should coexist or compete reflects an outdated paradigm. Both techniques may achieve comparable early mortality and similar stroke rates in appropriately selected patients; however, neurological complications remain a relevant concern for both strategies. Despite its invasiveness, open surgery remains indispensable for its durability and reliability, particularly in younger and anatomically complex cases. On the other hand, total and hybrid endovascular approaches provide suitable alternatives for elderly and frail high-risk individuals, offering reduced perioperative burden without compromising early outcomes.

Coexistence is therefore not merely pragmatic: it is essential. The future of aortic arch repair will be shaped by the integration of both strategies, guided by multidisciplinary expertise and patient-centered decision-making. Optimal patient treatment will not be defined by the dominance of one technique over another, but by the ability of true aortic teams to apply the right approach to the right patient at the right time.

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