



Hybrid Procedures in Vascular Surgery: Bridging Traditional and Endovascular Approaches for Complex Pathology

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DESCRIPTION

The evolution of vascular surgery over the past three decades has been characterized by a progressive shift from open surgical techniques to endovascular approaches for many common pathologies. However, as our field has matured, it has become increasingly apparent that neither approach alone can adequately address all vascular diseases, particularly complex cases involving multiple vascular beds or challenging anatomy. Hybrid procedures-combining open surgical and endovascular techniques within a single planned intervention-have consequently emerged as an important third pathway, offering potential advantages in selected scenarios. This commentary examines the current state of hybrid vascular procedures, their appropriate applications, technical considerations, and future directions.

The concept of hybrid interventions arose from recognition of the complementary strengths and limitations of traditional and endovascular approaches. Open surgery offers durability and definitive reconstruction but carries significant perioperative physiologic stress. Endovascular techniques minimize surgical trauma but may provide less durable results and face anatomic constraints. By strategically combining elements of both approaches, hybrid procedures aim to achieve optimal outcomes while minimizing the drawbacks of either technique alone.

Aortic pathology represents perhaps the most established application of hybrid strategies. The hybrid approach to thoracoabdominal aortic aneurysm repair-combining open visceral debranching with endovascular exclusion of the aneurysm-emerged as an alternative to conventional open repair for high-risk patients. By avoiding thoracotomy, supraceliac cross-clamping, and left heart bypass, this approach reduces physiologic stress while maintaining perfusion to vital organs. Several series have demonstrated lower perioperative mortality compared to traditional open repair, particularly in elderly patients with significant comorbidities.

Similarly, the "frozen elephant trunk" technique for complex aortic arch pathology combines conventional arch replacement with antegrade deployment of a stent graft into the descending thoracic aorta. This approach transforms a two-stage procedure into a single intervention, potentially reducing overall operative risk for patients requiring total arch and descending thoracic aortic repair. The international E-vita registry demonstrated favorable outcomes with this technique, reporting 30-day mortality of 11% and stroke rates of 8% in this high-risk population.

For peripheral arterial disease, hybrid procedures offer solutions for multilevel disease that would otherwise require extensive open reconstruction or multiple staged interventions. The combination of common femoral endarterectomy with endovascular treatment of inflow or outflow disease represents a pragmatic approach that addresses the limitations of endovascular therapy for common femoral disease while minimizing the extent of open surgery. Several series have reported primary patency rates of 60-70% at two years with this approach, comparable to more extensive open reconstruction but with reduced perioperative morbidity.

Carotid pathology presents another opportunity for hybrid solutions, particularly in anatomically challenging cases. Combined carotid endarterectomy with retrograde stenting of the internal carotid origin or proximal common carotid lesions allows complete revascularization in patients with tandem stenoses. For patients with concomitant carotid and coronary disease requiring intervention, various hybrid approaches have been described, though the optimal management strategy remains controversial due to limited comparative data.

Complex venous pathology, particularly involving the ilio caval segment, may also benefit from hybrid approaches. Open femoral vein exposure can facilitate access for extensive ilio caval recanalization in post-thrombotic syndrome, while hybrid venous stenting with open components can address complex iliac compression syndromes involving both intrinsic and extrinsic venous pathology.

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Despite these promising applications, hybrid procedures face several important challenges. The combination of open and endovascular techniques requires dual expertise or effective collaboration between specialists with complementary skills. As vascular training has increasingly emphasized endovascular techniques, some have raised concerns about diminishing open surgical experience among newer graduates. Maintaining proficiency across this broad technical spectrum requires deliberate practice and potentially longer training pathways.

Logistics represent another consideration, particularly regarding appropriate procedural environments. Many hybrid interventions require both advanced imaging capabilities and the resources of a traditional operating room. Purpose-built hybrid operating suites with fixed imaging systems offer optimal conditions but require significant institutional investment. Mobile C-arm fluoroscopy in conventional operating rooms provides greater flexibility but may offer inferior imaging quality for complex endovascular components.

The appropriate staging of hybrid procedures—simultaneous versus sequential—remains debated for certain applications. Simultaneous approaches offer the advantage of single anesthesia exposure and potentially shorter overall hospitalization but may increase procedural complexity and duration. Sequential approaches allow reassessment between

stages but require multiple interventions and may carry higher cumulative risk. The optimal approach likely varies based on specific pathology, institutional resources, and patient factors.

Cost implications of hybrid procedures merit consideration in an increasingly cost-conscious healthcare environment. The combination of open and endovascular techniques often involves expensive devices and extended procedural time. However, potential reductions in complications, length of stay, and reintervention rates may offset these initial costs. Comprehensive cost-effectiveness analyses comparing hybrid approaches to conventional strategies remain limited but are increasingly important for justifying resource allocation. Hybrid procedures represent an important evolution in our approach to complex vascular pathology, offering tailored solutions that capitalize on the strengths of both traditional and endovascular techniques. Their appropriate application requires thoughtful consideration of patient characteristics, anatomic factors, institutional resources, and available expertise. By embracing this "middle path" between conventional approaches, we can continue to expand the boundaries of treatable vascular disease while minimizing procedural risk. The future of vascular surgery likely lies not in the dominance of either traditional or endovascular techniques, but in their judicious integration through increasingly sophisticated hybrid approaches.