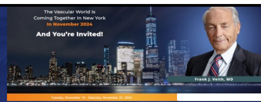

SESSION 4: MORE NEW DEVELOPMENTS IN THE TREATMENT OF TBADS, THORACIC AORTIC DISEASE AND THORACOABDOMINAL ANEURYSMS (TAAAs)

When Should Hybrid Treatment (Endograft Proximal + Open Distal) Be the Preferred Treatment for TAAA Repair: Advantages and Technical Tips

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November 19, 2024

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Original Hybrid Repair for TAAA: Open Debranching then EVAR/TEVAR

Hybrid Repair of Aortic Aneurysms Involving the Visceral and Renal Vessels

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Background: We sought to analyze our experience with hybrid treatment of aortic aneurysms involving the renal and visceral arteries.
Methods: We conducted a retrospective review of 36 consecutive patients who underwent renal/visceral bypasses followed by aortic endografting. Patient demographics, medical history, operations, complications, graft patency, and patient survival were recorded. Observational and comparative analyses were performed.
Results: Mean patient age was 71 years. Mean aneurysm diameter was 6.3 cm (range 4.1-9.4 cm). Crawford aneurysm types included 1 type I, 10 type II, 12 type III, 10 type IV, and 3 pararenal aneurysms. Four patients were symptomatic. One hundred twenty-three bypasses were performed (median of three per patient), including 62 renal, 32 superior mesenteric, and 29 celiac arteries. Retrograde inflow (using the iliac arteries, aorta, or a limb of an aortobifemoral graft) was obtained in 30 patients and antegrade inflow was performed in six (three from the supraceliac aorta and three celiac branch to renal bypasses). In-hospital mortality occurred in 3 patients (8.3%). Patient survival was 80% at a mean follow-up of 6 months. Major morbidity occurred in 17 patients (47%) and included need for dialysis (5), ischemic colitis (3), failure to thrive (5), temporary paraparesis (1), and need for reoperation (7). No patient sustained permanent paraplegia. Mean length of stay was 26 days (range 8-100 days). Primary renovisceral bypass graft patency rate at 8 months was 93%. During follow-up, 14 patients developed at least one endoleak, 2 patients required percutaneous intervention, and the rest remained under observation. At last follow-up, four type 2 endoleaks and one type 3 endoleak with stable or decreasing aneurysm size.
Conclusion: Hybrid repair of aortic aneurysms involving the renal and visceral arteries is feasible with a reasonable mortality and satisfactory short-term visceral graft patency rate. However, the morbidity of the debranching procedures is high. More stringent patient selection may improve these results.

Ann Vasc Surg 2010; 24: 219-224

Thoracoabdominal Aneurysm Repair: Hybrid (Original)

Table VI. Summary of results from previous hybrid TAAA papers

Author	*Patients (n)*	*% unfit for open repair*	*Extent I/II*	*Mortality (30 day)*	*Paraplegia*	*Endoleak*	*Debranching graft patency*
Black[19]	26[a] (completed procedure)	unknown	10%/62%	23%[b] (overall)	0%	42%	98%
Chiesa[20]	13	100%	54%/15%	23%	8% n = 1 (delayed)	0%	100%
Zhou[17c]	31 (15 visceral)	100%	17%/0%	3% (n = 1)	0%	6%	95%
Brockler[18]	28	100%	9%/29%	14%	16%	18%	89% (30 day)
Current series	23	100%	36%/23%	17%	4%	22%	90%

[a]This series reported 29 patients in which hybrid was attempted with 26 patients successfully completing the hybrid and 3 patients having the procedure aborted; [b]Overall mortality included the six rupture patients who died, for elective/urgent repair 30-day mortality was reported as 13%; [c]this series included hybrid arch debranching in addition to hybrid mesenteric debranching.

Patel R, Conrad MF, Paruchuri, V, et al. J Vasc Surg 2009;50:15-22.

TEVAR Followed by Open TAAA (Staged Hybrid)

Staged hybrid approach using proximal thoracic endovascular aneurysm repair and distal open repair for the treatment of extensive thoracoabdominal aortic aneurysms

William F. Johnston, MD,[a] Gilbert R. Upchurch, Jr, MD,[a] Margaret C. Tracci, MD,[a] Kenneth J. Cherry, MD,[a] Gorav Ailawadi, MD,[b] and John A. Kern, MD,[a,b] *Charlottesville, Va*

Objective: Repair of patients with extent I and II thoracoabdominal aortic aneurysms (TAAAs) is associated with significant morbidity and mortality, whereas repair of more distal extent III and IV TAAAs has a lower risk of paraplegia and death. Therefore, we describe an approach using thoracic endovascular aneurysm repair (TEVAR) as the index operation to convert extent I and II TAAAs to extent III and IV TAAAs amenable to subsequent open aortic repair to minimize patient risk.
Methods: Between July 2007 and March 2012, 10 staged hybrid operations were performed to treat one extent I and nine extent II TAAAs. Aortic aneurysm pathology included five chronic type B dissections, three acute type B dissections, and two penetrating aortic ulcers. Initially, the proximal descending thoracic aorta was repaired with TEVAR for coverage of the most proximal fenestration or penetrating ulcer, with seven elective and three emergent repairs. Interval open distal aortic replacement was performed in a short-term planned setting or for progressive dilation of the distal aortic segment. In the open repair, the proximal end of the graft was sewn directly to the distal end of the TEVAR and outer wall of the aorta.
Results: Average patient age was 48 years, and 60% were men. Risk factors included hypertension (80%), current tobacco use (50%), and Marfan syndrome (30%). Complications after TEVAR included type IA (n = 1) and type II (n = 3) endoleaks, pleural effusions (n = 3), and acute kidney injury (n = 1). Three patients required endovascular reinterventions. In patients with dissection, persistent filling of the false lumen was common and associated with distal thoracic aortic dilation. Complications of open repair included acute kidney injury in two patients, but no cardiac, pulmonary, or neurologic morbidity. Median time between TEVAR and open repair was 14 weeks. Most importantly, no deaths or neurologic deficits occurred after either procedure during a median follow-up of 35 weeks.
Conclusions: A staged hybrid approach to extensive TAAAs combining proximal TEVAR, followed by interval open distal TAAA repair, is safe and appears to be an effective alternative to traditional open repair. This approach may decrease the significant morbidity associated with single-stage open extent I and II TAAA repairs and may be applicable to multiple TAAA etiologies. (J Vasc Surg 2012;56:1495-1502.)

Staged hybrid repair of extensive thoracoabdominal aortic aneurysms secondary to chronic aortic dissection

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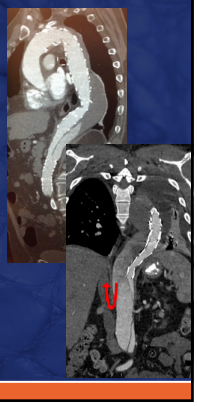
Objective: Many patients with aortic dissection develop Crawford extent I or II thoracoabdominal aortic aneurysms (TAAA). Because open repair is associated with a high morbidity and mortality, hybrid approaches to TAAA repair are emerging. In this study, we evaluated the midterm outcomes and aortic remodeling of a hybrid technique that combines proximal thoracic endovascular aneurysm repair (TEVAR), followed by staged distal open thoracoabdominal repair for patients with Crawford extent I or II TAAAs secondary to chronic aortic dissection.
Methods: We identified 19 patients with Crawford extent I (n = 1) or extent II (n = 18) TAAAs secondary to chronic aortic dissection who underwent a staged hybrid repair from 2007 to 2014 at our institution. Nine patients had previous open ascending aortic surgery for type I aortic dissection. Stage 1 TEVAR was performed via percutaneous (n = 8), femoral cutdown (n = 8), or iliac exposure (n = 3). The left subclavian artery was covered in nine patients and revascularized in eight patients using carotid-subclavian bypass (n = 7) or laser fenestration (n = 1). Stage 2 open repair was performed a median of 18 weeks later with partial cardiopulmonary bypass via left femoral arterial and venous cannulation for visceral and lower body perfusion. The open thoracoabdominal graft was anastomosed proximally in an end to end fashion with the endograft. We then assessed surgical morbidity and mortality, midterm survival, and freedom from reintervention. Aortic remodeling was measured and change in maximum aortic and false lumen diameter at last follow-up (median, 3 years) from baseline was assessed.
Results: There were no deaths, strokes, or chronic renal failure in this cohort. After stage 1 TEVAR, three patients required repeat intervention for endoleak (type IA, n = 1; type IB, n = 1; type II, n = 1) before open repair. After stage 2 open repair, there was a single delayed permanent paralysis 2 weeks after discharge. At a median 3-year follow-up (range, 6 months-6.2 years), there were no deaths, neurologic events, endoleaks, or TAAA reinterventions. Complete false lumen thrombosis occurred in 100% of the patients, with maximum false lumen diameter decreasing from 34.3 ± 15.3 mm to 13.2 ± 12.0 mm ($P < .01$) and total aortic diameter decreasing from 60.2 ± 9.0 mm to 49.4 ± 9.6 mm ($P < .01$).
Conclusions: Staged hybrid TAAA repair, using a combination of proximal TEVAR with open distal repair, can be performed using established endovascular skills and technology coupled with traditional open aortic surgical techniques, with low surgical morbidity and mortality. In the midterm, staged hybrid TAAA repair was associated favorable survival, aortic remodeling, and freedom from reintervention. (J Vasc Surg 2015;■:1-8.)

Treatment Strategy

	Extent II/III	Extent IV
Mortality	13-42%	4-24%
Paraplegia	7.5-32%	1 – 6.5%

1. Repair proximal TAAA with dissection first with TEVAR
2. Followed by interval open distal TAAA
   - Eliminates complex high proximal anastamosis
   - Direct inline flow to visceral, renal, spinal branches
   - Distributes spinal cord ischemia over time

- Left subclavian artery revascularization, if planned coverage
- Endograft from left subclavian to celiac artery level
  - Initially limited coverage
- Distal type 1 B endoleak expected
- Lumbar drain for 24-48 hours standard



Staged Distal Open Repair

- Aorta and endograft are transected
- Dissection septum is divided to allow endograft expansion
- Tapered aortic wall + endograft sewn directly to graft
- Partial cardiopulmonary bypass, perfusion of mesenterics and renals used

CLINICAL RESEARCH STUDIES

From the Society for Clinical Vascular Surgery

Staged hybrid approach using proximal thoracic endovascular aneurysm repair and distal open repair for the treatment of extensive thoracoabdominal aortic aneurysms

William F. Johnston, MD,[a] Gilbert R. Upchurch, Jr, MD,[a] Margaret C. Tracci, MD,[a] Kenneth J. Cherry, MD,[a] Gorav Ailawadi, MD,[b] and John A. Kern, MD,[a,c] Charlottesville, Va

JOURNAL OF VASCULAR SURGERY
December 2012

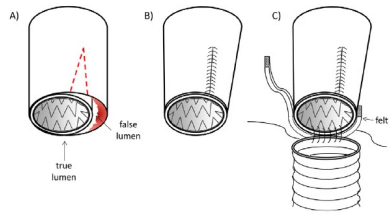
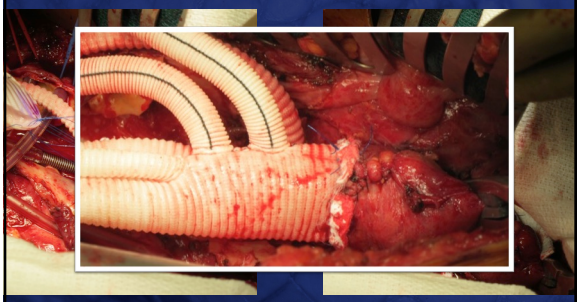
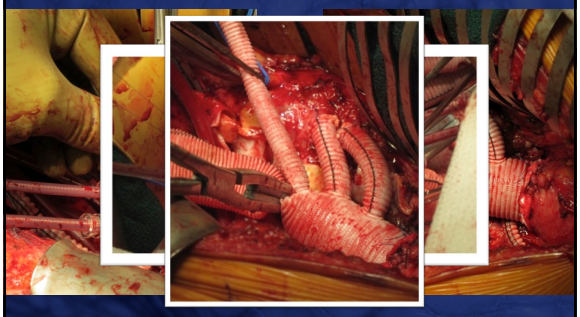


Fig 3. Staged hybrid approach. **A,** Distal thoracic aorta is represented with endograft in the true lumen and thrombus/debris in the false lumen. **B,** The thrombus/debris is removed from the false lumen, dissection septum is divided, and the aortic wall is cut along the *red dashed line* to taper the aortic wall. **C,** The anastomosis is made with an end-to-end attachment of the endograft, tapered aortic wall, and felt reinforcement to the prosthetic graft.

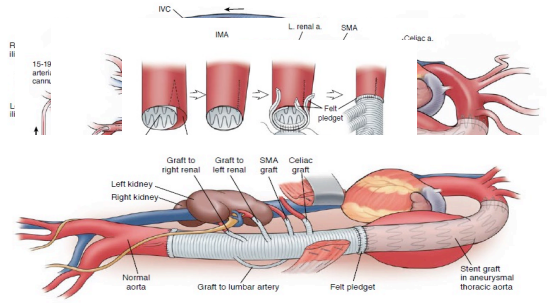
Distal Thoracic Aorta and Endograft Anastomosed to Multi-branch Graft

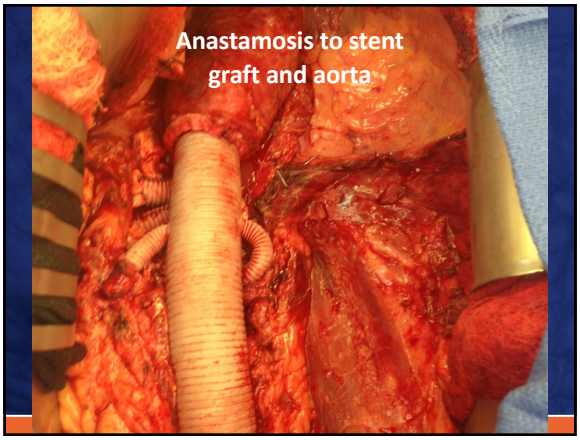


Visceral Anastomosis – Rt Renal → Celiac → SMA → Lt Renal



Sarac & Kashyap Atlas
Gateways in Vascular Surgery



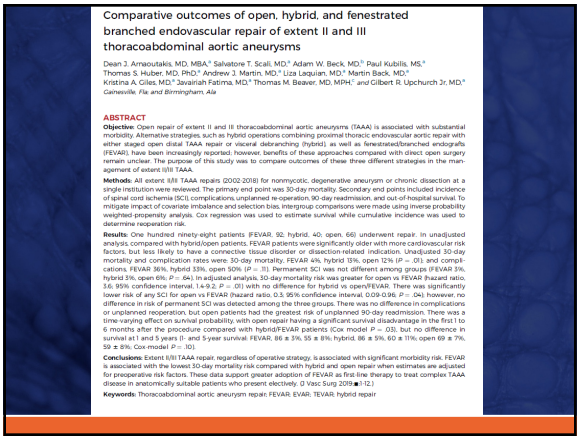


Combined Mid-Term Outcomes – Stages 1 and 2

TEVAR	(N = 19), No. (%)
Death	0 (0)
Stroke/paraplegia	0 (0)
Acute kidney injury	1 (5.2)
Type I endoleak	2 (10.5)
Type II endoleak	1 (5.2)

Open TAAA repair	(N = 19), No. (%)
Death	0 (0)
Stroke/paraplegia	1 (5.2)
Acute kidney injury (Serum creatinine >2 mg/dL)	5 (26.3)
Chronic renal failure	0 (0)

3 patients with baseline renal insufficiency with pre op GFR < 60 returned to their pre op renal functions. All with S Cr < 2mg/dl



Comparative outcomes of open, hybrid, and fenestrated branched endovascular repair of extent II and III thoracoabdominal aortic aneurysms

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Gainesville, Fla; and Birmingham, Ala

ABSTRACT

Objective: Open repair of extent II and III thoracoabdominal aortic aneurysms (TAAA) is associated with substantial morbidity. Alternative strategies, such as hybrid operations combining proximal thoracic endovascular aortic repair with either staged open distal TAAA repair or visceral debranching (hybrid), as well as fenestrated/branched endografts (FEVAR), have been increasingly reported; however, benefits of these approaches compared with direct open surgery remain unclear. The purpose of this study was to compare outcomes of these three different strategies in the management of extent II/III TAAA.

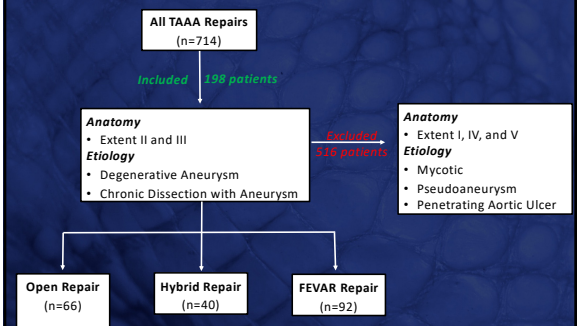
Methods: All extent II/III TAAA repairs (2002-2018) for nonmycotic, degenerative aneurysm or chronic dissection at a single institution were reviewed. The primary end point was 30-day mortality. Secondary end points included incidence of spinal cord ischemia (SCI), complications, unplanned re-operation, 90-day readmission, and out-of-hospital survival. To mitigate impact of covariate imbalance and selection bias, intergroup comparisons were made using inverse probability weighted propensity analysis. Cox regression was used to estimate survival while cumulative incidence was used to determine reoperation risk.

Results: One hundred ninety-eight patients (FEVAR, 92; hybrid, 40; open, 66) underwent repair. In unadjusted analysis, compared with hybrid/open patients, FEVAR patients were significantly older with more cardiovascular risk factors, but less likely to have a connective tissue disorder or dissection-related indication. Unadjusted 30-day mortality and complication rates were: 30-day mortality: FEVAR 4%, hybrid 13%, open 12% ($P = .01$); and complications, FEVAR 36%, hybrid 33%, open 50% ($P = .11$). Permanent SCI was not different among groups (FEVAR 3%, hybrid 3%, open 6%; $P = .64$). In adjusted analysis, 30-day mortality risk was greater for open vs FEVAR (hazard ratio, 3.6; 95% confidence interval, 1.4-9.2; $P = .01$) with no difference for hybrid vs open/FEVAR. There was significantly lower risk of any SCI for open vs FEVAR (hazard ratio, 0.3; 95% confidence interval, 0.09-0.96; $P = .04$); however, no difference in risk of permanent SCI was detected among the three groups. There was no difference in complications or unplanned reoperation, but open patients had the greatest risk of unplanned 90-day readmission. There was a time-varying effect on survival probability, with open repair having a significant survival disadvantage in the first 1 to 6 months after the procedure compared with hybrid/FEVAR patients (Cox model $P = .03$), but no difference in survival at 1 and 5 years (1- and 5-year survival: FEVAR, 86 ± 3%, 55 ± 8%; hybrid, 86 ± 5%, 60 ± 11%; open 69 ± 7%, 59 ± 8%; Cox-model $P = .10$).

Conclusions: Extent II/III TAAA repair, regardless of operative strategy, is associated with significant morbidity risk. FEVAR is associated with the lowest 30-day mortality risk compared with hybrid and open repair when estimates are adjusted for preoperative risk factors. These data support greater adoption of FEVAR as first-line therapy to treat complex TAAA disease in anatomically suitable patients who present electively. (J Vasc Surg 2019;■:1-12.)

Keywords: Thoracoabdominal aortic aneurysm repair; FEVAR; EVAR; TEVAR; hybrid repair

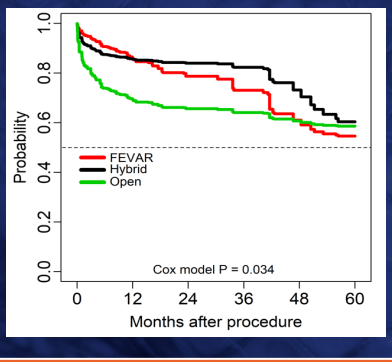
Inclusion & Exclusion Criteria



Risk-adjusted Mortality Outcomes

Outcome	Group	HR	95% CI	P-value
30-day Mortality	Open:FEVAR	3.59	1.41-9.15	0.01
90-day Mortality	Open:FEVAR	2.69	1.24-5.81	0.01
	Open:Hybrid	2.43	1.09-5.44	0.03

Survival: Cox-proportional Hazards Model



1-year
–FEVAR, 86%
–Hybrid, 86%
–Open, 69%

5-year
–FEVAR, 55%
–Hybrid, 60%
–Open, 59%

Summary

- FEVAR and Hybrid vs Open:
  - –Similar or better outcomes compared to Open
    - 1-year survival (86%) *vs* Open (69%)
  - –Survival advantage lost over time
    - 5-year survival highest for hybrid (60%)

Conclusion

- Greater adoption of FEVAR as 1st-line therapy for complex TAAA disease
  - If anatomically suitable

Ultimately, all 3 strategies are complementary and each has a role