Acute Type A Aortic Dissection: Managing More Than Just the Entry-Tear

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As emergency repair for acute type A aortic dissection is improving, the reintervention rate increases. Over 10% of cases require an aortic reintervention, which should ideally be performed in an early stage to allow for positive aortic remodeling and to prevent limitations by the stiffened aortic flap. These reinterventions remain a surgical challenge and may come with complications. We provide a comprehensive overview of different management strategies and their success in treating aortic adverse remodelling, based on current evidence of the literature. Two meta-analyses and an additional literature search yielded comparable mortality rates between limited repair and extensive repair. Cardiopulmonary bypass time, cross clamping time and cardiac arrest time were significantly shorter in limited repairs. Reintervention rate was generally lower in extensive repair, although not always significant. In conclusion, the early aggressive approach may be useful to lower reintervention rates. However, it has not yet been proven to be more beneficial. It will be imperative to develop a patient-specific early stage prediction model for residual aortic reintervention.

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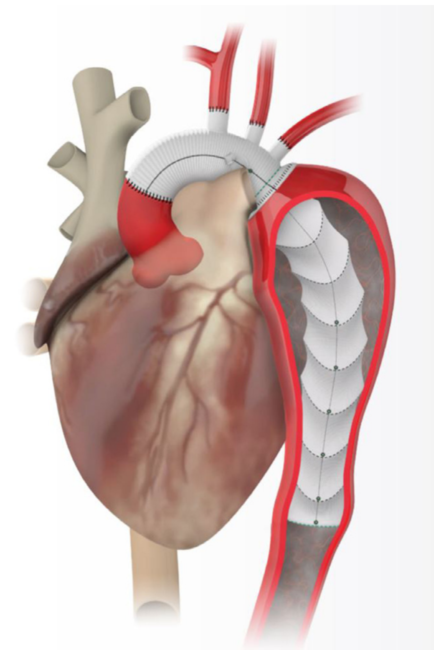

Tetrafurcated frozen elephant trunk for extensive aortic repair. Courtesy of TerumoAortic.

Central Message

Identification of factors predicting distal aortic remodeling after repair of acute type A dissection may facilitate decisions regarding extent and type of the initial repair in the endovascular era.

Perspective Statement

Based on current clinical evidence, extensive initial distal aortic repair does not outweigh the benefits of conventional proximal aortic repair for all patients with acute type A aortic dissection. Finding early predictive factors for adverse aortic remodeling is key in the modern day treatment of acute type A aortic dissection.

INTRODUCTION

Acute type A aortic dissection (ATAAD) is a lethal condition requiring immediate repair.[1] Improved perioperative management has led to more patients surviving the initial hospitalization.[2,3] Indeed, the in-hospital mortality has decreased significantly over the last 20 years from 31% to 17%.[2,3] Since most ATAAD patients have a DeBakey type I configuration, the fate of the residual dissected aorta is becoming increasingly relevant for these survivors. Over 10% of repaired ATAAD cases require one or more additional surgical interventions due to residual distal dissection.[4,5] Distal aortic reintervention remains a surgical challenge particularly if an additional open proximal approach is required for the aortic arch.[6,7] It is for this reason, recent strategies have employed novel use of endovascular technology, including application either during the initial operation or early thereafter. Three options for the approach to a DeBakey type I dissection therefore exist and are reviewed here. First,

Abbreviations: ATAAD, acute type A aortic dissection; CTA, computed tomography angiography; TEVAR, thoracic endovascular aortic repair; FET, frozen elephant trunk; HCA, hypothermic circulatory arrest

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Table 1. The DISSECT Mnemonic Classification Published by Dake et al[9]

DISSECT	Definition	Expressed as
Duration	Duration of dissection as time from onset of symptoms	Acute <2 wk Subacute 2 wk–3 mo Chronic >3 mo
Intimal tear	Primary location intimal tear in the aorta	A = ascending aorta Ar = aortic arch D = descending aorta Ab = abdominal Un = unknown
Size	Size of the aorta based on maximum trans-aortic diameter measured by centre line analysis	Size in mm
Segmental extent	Segmental extent of aortic involvement from proximal to distal boundary	A = ascending aorta exclusively Ar = aortic arch exclusively D = descending aorta exclusively Ab = abdominal exclusively Aar = ascending to arch AD = ascending to descending Aab = ascending to abdomen AI = ascending to iliac ArD = arch to descending ArAb = arch to abdomen ArI = arch to iliac DAb = descending to abdomen DI = descending to iliac
Clinical	Clinical complications related to dissection	Aortic valve involvement Cardiac tamponade Progression + direction aortic involvement Rupture Branch vessel malperfusion
Thrombosis	Thrombosis of aortic false lumen	P = patent aortic false lumen CT = complete thrombosis aortic false lumen PT = partial thrombosis aortic false lumen

ascending aortic replacement with adjunct hemiarch or extended arch replacement (proximal repair) and close postoperative computed tomography angiography follow-up can be performed. Second, hybrid extensive proximal repair with a hemiarch or extended arch resection combined with antegrade descending thoracic endovascular aortic repair (TEVAR) as a frozen elephant trunk (FET) can be performed. Finally, proximal repair, combined with early elective retrograde TEVAR can be utilized. The choice between any of these 3 methods depends to a considerable extent on the surgeon's experience, preference, and specific anatomic considerations. We provide a comprehensive overview of these management strategies and their success in treating aortic adverse remodeling based on current evidence of the literature.

DISTAL AORTIC REMODELING

Several retrospective trials have extensively studied the demographic, clinical and radiographic factors responsible for distal aortic dissection remodeling. The main risk factors, found for future aortic events have included younger age, Marfan syndrome, hypertension at follow-up, perioperative aortic diameter >40 mm, and patent or partially thrombosed false lumen after surgery.[4,5,8] Dake et al described a mnemonic-based classification system to divide patients into subsets according to anatomical involvement, with relevance for endovascular management (Table 1).[9] This classification system aids in understanding the variances in clinical presentation of a challenging disease entity. It simplifies the assessment of the dissection for a clinician. However, it does not guide in predicting surgery outcomes, nor does it dictate the appropriate surgery. For type A dissection patients, some early factors that contribute to distal remodeling are known as mentioned earlier in this paragraph. Somehow, this does not change standard practice sufficiently and there is still a large group of patients where optimal treatment is unclear.

PROCEDURES

The gold standard for the treatment of ATAAD is open surgical repair through median sternotomy.[1] The procedure requires cardiopulmonary bypass with hypothermic circulatory arrest and often times either retrograde or antegrade cerebral perfusion. The primary goal of ATAAD repair is the prevention of a fatal rupture. Secondly, restoration of flow to the compromised branched vessels must be resolved and any aortic valve insufficiency or root pathology must be corrected if possible and deemed necessary. In order to achieve these goals, primary entry-tear location and aortic dimensions in the root, ascending and arch aorta require assessment. There are several technical approaches to manage this and each strategy has its own advantages, disadvantages and risks.

Proximal Aortic Repair Only

In the majority of patients with ATAAD the proximal tear can be fully resected by ascending aorta and hemiarch replacement. If the primary entry-tear cannot be found on imaging or intraoperative, the standard is still this proximal repair. Aortic valve repair is necessary in over 50% of patients and is combined with proximal repair.[10] Aortic valve repair is beyond the scope of this review and will not be further discussed here. Early mortality rates for all proximal aortic repairs have continued to improve with reported rates from 4.4% to 9.9% at experienced sites and overall 1-year survival of more than 82%.[8,11] If the intimal entry-tear or the dissection induced aneurysm extends to Ishimaru zone 0–2, or if the dissection flap extends into the branch vessels, an extended or total arch repair, including repair of the origin of branch vessels may be necessary. In all other cases it is not clear whether ascending aorta with hemiarch repair has better outcomes than extended or total arch repair. Several studies have compared the 2 different approaches over the past 2 decades and no consensus exists identifying improved survival rates for either 1 of the 2 different approaches. (Table 2).[10,12] In addition, when freedom from distal aortic reintervention was evaluated in these studies, extended or total arch aortic repair was not consistently shown to be better than the conventional limited repair group.[8,13,14]

Initial Hybrid Aortic Repair

In the past decade, several investigators have reported success of TEVAR for acute type B aortic dissection.[15,16] In these reports, early false lumen thrombosis led to favorable remodeling of the descending aorta, with the aorta often times demonstrating complete healing along the length of the treated aortic segment and beyond. Recognizing this successful application, TEVAR was then used in a hybrid manner to treat the distal aorta during acute type A dissection.[17] The reported early-mortality rates are similar to those described for a proximal repair strategy alone (Table 2) although hybrid repair may result additional potential complications. These procedures are typically associated with longer cardiopulmonary bypass and circulatory arrest times.[12,17] Second, sizing guidelines for landing zones in dissected aorta are not well understood, and oversizing can easily cause complications, such as infolding of the stent graft or stent graft-induced new entry tears.[18] Both antegrade stenting and retrograde stenting approaches have been described in ATAAD repair, with the antegrade approach used most frequently. The current most commonly used hybrid repair is the FET. This single stage approach uses a stent graft of 10–15 cm deployed just beyond the left subclavian artery and preserves native midarch aorta.[19] A variant on this procedure was described by Roselli et al, where the stent graft is moved to a zone 2 location and a fenestration is created for the left subclavian artery where a branch vessel stent graft is placed.[20] Another 1 stage hybrid variant is Sun's procedure, first described in 2003. In this procedure a tetrafurcated proximal graft providing 3 limbs to the branch arch vessels and a fourth perfusion limb are anastomosed to an antegrade placed stent graft at the level of the distal arch.[11] Sun's procedure was the predecessor to many variants of an FET procedure, currently being introduced by clinicians in cooperation with medical device manufacturers.

Proximal Aortic Repair and Early TEVAR

TEVAR has proven to be a safe and less invasive method to treat the dissected descending aorta and has successfully been used in zone 2 of the distal arch aorta.[21] An alternative described strategy has been to treat the proximal aorta with a hemiarch or extended arch into zone 2, and perform distal TEVAR in a delayed fashion. Advantages of this approach include a potential reduction in cardiopulmonary bypass and circulatory arrest times at the initial procedure. Also, as this procedure is delayed to a time when hemodynamics is more stable, the risk for spinal cord ischemia may be reduced as well. Finally, if the initial operation is a proximal repair into Ishimaru zone 2, the sizing considerations for TEVAR at the proximal landing zone can then be simplified by landing the stent graft into a Dacron aortic graft.[22]

COMPARISON OF CONSERVATIVE VS HYBRID ENDOVASCULAR AORTIC REPAIR

When recognizing that no consensus exists regarding extent of open proximal arch repair in acute type A dissection, the recent addition of hybrid distal procedures has only added to the confusion. No consistent improvement in late aortic or patient survival has been demonstrated with these techniques, and new complications of higher spinal cord ischemic rates and stent graft induced entry-tears have now been introduced for treatment of a procedure typically done for immediate survival benefit.[8,18] Several meta-analyses have not provided any clarification to guide clinical decisions. A 2015 meta-analysis included seven retrospective trials comparing these 2 strategies.[23] A total of 932 patients were included, 503 with ascending and hemiarch repair and 429 with extensive repair, consisting of total arch repairs with different variants of proximal descending thoracic stent grafts. A subanalysis was performed with the 429 distal repair cases existing of 327 antegrade TEVARs, 19 retrograde TEVARs and 83 FETs.

Table 2. Comparison of Ascending and Hemiarch Repair vs Total Arch Repair

Author, Year	Repair	No. of Patients	CPB Time, min	CA Time, min	Mean Follow-Up, Y	Early Mortality, %	Stroke/ Neurologic Deficit, %	Spinal Cord Injury, %	5-Year Distal Aorta Event Free, %	5-Year Survival, %
Ohtsubo, 2002	Asc	41	170	28	3.5	7.3	4.8	N/S	96	87
	HAR	23	190	32	3.5	8.6	17.3	N/S	94	91
	TAR	24	292	48	3.5	33.3	8.3	N/S	100	44
Tan, 2003	Asc	207	N/S	N/S	2.6	21.7	N/S	N/S	N/S	N/S
	HAR	53	N/S	N/S	2.6	16.9	N/S	N/S	N/S	N/S
	TAR	17	N/S	N/S	2.6	23.5	N/S	N/S	N/S	N/S
Shiono, 2006	Asc/HAR	105	N/S	N/S	10	6.7	1.9	N/S	91	77
	TAR	29	N/S	N/S	10	6.9	0	N/S	88	81
Kim, 2011	Asc/HAR	144	233	25	2.7*	9.7	6.3	0.7	93	83
	TAR†	44	314	50	2.7*	13.4	22.7	2.3	88	66
Rylski, 2014	Asc	102	189	25	4.9	9.8	8.8	N/S	89	81
	HAR	37	196	32	4.9	21.6	5.4	N/S	97	64
	TAR	14	274	71	4.9	28.6	7.1	N/S	100	79
DiEusanio, 2015	HAR	187	203	N/S	4.8	24.1	9.1	N/S	85	57
	TAR‡	53	250	N/S	4.8	22.6	7.5	N/S	72	52
Rice, 2015	Asc/HAR	440	160	27	4.1	12.9	10.5	N/S	N/S	76
	TAR	49	173	43	1.3	20.4	8.2	N/S	N/S	70
Omura, 2016	HAR/PAR	109	187	N/S	5.0	14.7	4.6	N/S	84	84
	TAR	88	214	N/S	5.0	10.2	2.3	N/S	95	87
Cabasa, 2016	Asch/Har	149	181	29	7.4	22.4	2	N/S	N/S	N/S
	TAR	21	207	45	7.4	4.8	0	N/S	N/S	N/S

Abbreviations: Asc, ascending aorta repair; HAR, hemiarch repair; PAR, partial arch repair (zone 0 and or zone 1); TAR, total arch repair; FET, frozen elephant trunk; CPB, cardiopulmonary bypass; CA, cardiac arrest.

*excl. 20% lost to follow-up within 6 months.

†11.4% FET.

‡41% (F)ET.

Table 3. Comparison of Arch Repair vs Arch Repair With Extended Distal Repair

Author, Year	Repair	No. of Patients	CPB Time, min	CA Time, min	Mean Follow-Up, Y	Early Mortality, %	Stroke / Neurologic Deficit, %	Spinal Cord Injury, %	5-Year Distal Aorta Event Free, %	5-Year Survival, %
Uchida, 2009	Asc/HAR	55	108	21	5.6	3.6	0.0	0.0	73	69
	TAR + FET	65	163	70	5.6	4.6	0.0	0.0	96	95
Easo, 2013	Asch/HAR	518	308	24	N/S	18.7	13.6	N/S	N/S	N/S
	TAR + FET	140	390	45	N/S	25.7	12.5	N/S	N/S	N/S
Shi, 2014	HAR + FET	71	104	31	3.6	4.2	0.0	0.0	89	N/S
	TAR + FET	84	165	29	3.6	5.9	1.0	0.0	91	N/S
Zhang, 2014	Asc/HAR	74	180	28	4.7	5.4	1.4	N/S	N/S	86*
	TAR + FET	88	182	35	4.7	5.7	2.3	N/S	N/S	95*
Sun, 2014	HAR	65	153	18	4.1	6.2	1.5	N/S	N/S	N/S
	TAR + FET	148	197	24	3.5	4.7	2.7	N/S	N/S	N/S
Vallabhajosyula, 2015	HAR + aTEVAR	30	239	60	3.4	4	7.0	0.0	3.3	73
	TAR	31	313	78	3.7	26	6.0	0.0	3.2	67
Dai, 2015	Asc/HAR	41	150	24	5.0	4.9	4.9	2.4	91	83
	TAR + FET	52	153	26	5.3	3.9	5.8	1.9	100	94

Abbreviations: Asc, ascending aorta repair; HAR, hemiarch repair; TAR, total arch repair; FET, frozen elephant trunk; aTEVAR, antegrade thoracic endovascular aortic repair; CPB, cardiopulmonary bypass; CA, cardiac arrest.
*Excl. in-hospital deaths.

Overall comparison yielded no significant difference in operative mortality ($P = 0.96$), permanent neurologic deficit ($P = 0.95$), and late mortality ($P = 0.59$). However, the operative mortality odds ratio of extensive repair compared to limited repair was lower with 0.73 (0.43−1.24, 95% confidence interval). Additionally, an increase in spinal cord ischemia rate was seen in the adjunct distal repair group (odds ratio 1.34; 0.44−4.04), though this finding was not statistically significant. Extensive repair significantly reduced the risk of distal reintervention compared to proximal repair (odds ratio 0.37; $P = 0.01$), with a reintervention rate of 3.7% and 9.3%, respectively. Subanalysis of the intraoperative extensive repair methods, showed a lower rate of distal reintervention and a higher rate of false lumen thrombosis with FET than with the TEVAR methods
($P = 0.008$ and $P < 0.001$, respectively). Limitations of this study were the small number of included trials and the significant heterogeneity in the additional distal repair data.

A larger meta-analysis was published in 2016, and included 14 studies with 2221 patients.[12] In this meta-analysis, trials comparing ascending and hemiarch repair to extended or total arch repairs with or without the combination of a hybrid distal thoracic repair were included. Again, no significant differences on in-hospital mortality were found between groups and the cardiopulmonary bypass time, cross clamping time and cardiac arrest time were significantly shorter in the limited repairs. Remarkably in this meta-analysis no significant difference was found in reintervention rates, although the rates again favored extensive repair (7.3% vs 3.3%). The authors suggested that treatment bias was substantial, particularly since younger patients and patients with connective tissue disease where distal aortic growth is inevitable, were added to most of study populations. This report concluded that extensive arch repairs are safe, provided that they are carried out in high volume specialized centers. Total arch repair, is however not advocated as a primary approach by all centers and more data is needed to tailor extensive repair for the right patient group.

Finally, we conducted our own literature search to provide a short overview of results of studies comparing ascending and hemiarch repairs to full extensive aortic arch plus proximal descending repairs (Table 3).[12,23] By doing this we were able to briefly assess more homogenous groups of treatment comparisons; limited repair vs total arch repair (Table 2) and limited repair vs full extensive repair (Table 3). The results described in Table 3 are similar to the ones in Table 2, although extensive aortic repair has an overall better outcome on reoperation rates compared to limited or total arch repair.[12,23]

OUR PERSPECTIVE

At the University of Michigan, we employ an entry tear guided approach for acute type A aortic dissection. As this review suggests, we believe this procedure should first be treated as a life-saving one with a high risk for complications even with a conventional limited repair. We agree with the recent comments by Girardi suggesting that there remains selection bias in recent work evaluating different approaches for the arch and descending aorta, and that extrapolations should be carefully done when using this information to guide clinical decisions.[24] However, we do have a low threshold for converting from a hemiarch repair to an extended proximal arch repair, and often do so in the setting of a bovine arch configuration, or when the branch vessels are dissected. The frozen elephant trunk technique has been selectively used in the recent decade, particularly if an entry tear is identified in the distal arch, if the distal arch is ectatic, and finally in the setting of connective tissue disease where distal remodeling is inevitable. Sizing for TEVAR is based upon our personal experience, as well as a recent multicenter report.[25] This work suggests that when the aorta acutely dissects, there is immediate expansion of the total diameter by approximately 10−20% depending upon the location. We therefore use the total aortic diameter at the locations of the landing zones to determine the size of the frozen elephant trunk.

CONCLUSIONS

ATAAD repair outcomes are improving, but distal aortic remodeling remains an issue in a select group of patients. With newly developed technologies the issue of distal aortic remodeling can be addressed early to prevent the need for reintervention. This early aggressive approach may be useful, as reintervention in a chronic dissection patient has proven to be challenging with variable outcomes. However, early aggressive approach comes at a price and has not yet proven to be more beneficial, compared to limited repair and watchful waiting. It will be imperative to develop a patient-specific early stage prediction model for residual aortic reintervention.

SUPPLEMENTARY MATERIAL

The following is the supplementary data to this article:

Video 1. Addressing management strategies for type I deBakey dissection and a case example with succesful use of extensive repair.

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