Harky *et al. Vessel Plus* 2018;2:8
DOI: 10.20517/2574-1209.2018.12

Vessel Plus

Review

Open Access

Ruptured isolated descending thoracic aortic aneurysm: open or endovascular repair?

Amer Harky[1,2], Nichola Manu[1], Rafal Al Nasiri[3], Dilan Sanli[4], Ciaran Grafton-Clarke[5], Jeffrey Shi Kai Chan[6], Chris Ho Ming Wong[6]

[1]Department of Vascular Surgery, Countess of Chester Hospital, Chester CH2 1UL, UK.
[2]School of Medicine, Cardiff University, Cardiff CF14 4XN, UK.
[3]Department of General Surgery, Countess of Chester Hospital, Chester CH2 1UL, UK.
[4]Faculty of Medicine, Bulent Ecevit University, Zonguldak 67100, Turkey.
[5]School of Medicine, University of Liverpool, Liverpool L69 3GE, UK.
[6]Faculty of Medicine, The Chinese University of Hong Kong, Hong Kong, China.

Correspondence to: Dr. Amer Harky, Department of Vascular Surgery, Countess of Chester Hospital, Chester CH2 1UL, UK. E-mail: aaharky@gmail.com

How to cite this article: Harky A, Manu N, Al Nasiri R, Sanli D, Grafton-Clarke C, Chan JSK, Wong CHM. Ruptured isolated descending thoracic aortic aneurysm: open or endovascular repair? *Vessel Plus* 2018;2:8. http://dx.doi.org/10.20517/2574-1209.2018.12

Received: 18 Mar 2018 **First Decision**: 9 Apr 2018 **Revised**: 27 Apr 2018 **Accepted**: 3 May 2018 **Published**: 7 May 2018

Science Editor: Nikolaos Patelis, Mario F. L. Gaudino **Copy Editor**: Jun-Yao Li **Production Editor**: Huan-Liang Wu

Abstract

Descending thoracic aortic aneurysm management has gained momentum and became a topic of many debates at international levels since the evolution of endovascular repair. Ruptured descending thoracic aortic aneurysm is a clinical emergency which is associated with high mortality and morbidity rates if not managed properly. Prior to thoracic endovascular aortic repair (TEVAR), open repair (OR) was the gold standard management, however since the evolution of TEVAR, this has changed. Several centers have reported many of their experiences and published that TEVAR can provide equal or even better perioperative outcomes when compared to OR, although the evidences can be of only short term and could be biased at different levels at the time of publication. This review article is aimed to examine current literature evidences behind the use of TEVAR *vs.* OR and the reported comparative clinical outcomes.

Keywords: Open repair, aorta, endovascular repair, ruptured aorta, descending thoracic aorta

INTRODUCTION

Descending thoracic aortic aneurysm (DTAA) is a clinical entity that gained a lot of international attention in the current era. Currently, the presence of such aneurysms is mandated for elective repair to prevent

rupture or dissection, however the clinical emergency occurs when such aneurysms rupture. Although it is a rare pathology, ruptured descending thoracic aortic aneurysm (rDTAA) carries high mortality and morbidity rates with the majority of patients dying prior to arrival to hospital[1]. The incidence of rupture is estimated to be 5 in 100,000 of population.

Just over a decade ago, the gold standard management of rDTAA was open repair (OR) requiring thoracotomy, aortic cross-clamping, aneurysm resection and replacement with an interposition of a prosthetic graft and cardiopulmonary bypass[2-4]. However, ORs were associated with high perioperative mortality and neurological adverse events[5]; nevertheless with advancement in clinical practice and evolving minimal access surgical interventions, the role of endovascular repair in such emergencies has been explored. Thoracic endovascular aortic repair (TEVAR) has appealing qualities including a minimally invasive procedure with rapid deployment with decreased operative time and decreased blood loss[3]. However, this approach is subject to anatomical and logistical limitations, including anatomical requirements and variations, the quality of the landing zones, ease of iliac access, availability of the wide range of stent graft sizes in an emergency setting and available expertise on site[4]. The major benefits of endovascular repair reported are lower mortality and morbidity rates associated with such a complex procedure[5]. The advantage of TEVAR was not only limited to such perioperative outcomes but TEVAR was also used in patients who were not surgical candidates, which has resulted in an alternate management option as opposed to conservative management in those patients with almost 100% mortality rates[5].

Despite TEVAR being an attractive alternative option for OR, it still remains a high-risk procedure. The current literature has many limitations in that the majority of evidence comes from case series and there is a lack of appropriate randomized controlled trials or long term comparative data that confirms the accuracy of the data and thus globalization of the results[6-8]. Therefore, the aim of this paper is to review current literature and the evidence behind using TEVAR in the emergency setting of rDTAA and comparing the clinical outcomes with OR in such cohort of patients.

EVIDENCES BEHIND TEVAR IN rDTAA

The use of endovascular repair goes back to as early as 1991, when first performed on an abdominal aortic aneurysm[9]. Since then, the technology has evolved with advancement in using endovascular repair for aortic aneurysms repair. Most of the patients who experience rDTAA do not survive to present to hospital. Hence why of those that do, open repair remains a strong choice for managing such patients. Yet, open repair is associated with significantly higher rates of mortality (ranging 14%-45% in specialized centers) and morbidity peri- and post-operatively[10-13].

Currently, TEVAR is the standard management plan for elective cases of DTAA[14], however the evidences behind using TEVAR in the emergency setting are scarce and limited[7]. There are however several published reports from international centers about the clinical outcomes for the use of TEVAR in emergency situations for rDTAA[2,6-8,15], but most of these are limited to a relatively small number of cases and are observational studies. These studies have been summarized in Table 1.

A study by Jonker *et al*.[7] analysed 87 patients that underwent emergency TEVAR for rDTAA between 2002 and 2009. The majority of the cases (> 90%) were in critical condition and immediate intervention was required. Forty percent of the patients were haemodynamically unstable and 22% were in shock. In their study, they have noted a 30-day mortality rate of 18.4%, whilst the rate of stroke and neurological complications were 8% in both. Eighteen percent of the patients were diagnosed with an endoleak within 30 days of the procedure. It is important to note that the presence of shock and haemothorax at the time of admission were the two contributing factors for increased mortality rates in these groups of patients. The same group[16] published their data of 161 patients, of which 92 patients were treated with OR and 69 with

Table 1. Findings of large-scale comparative studies on open versus endovascular repair of rDTAA

Study	Type	Population	Sample size	Age (years)		Male		30-day mortality		Long term survival		Re-intervention rate[a]	
				Open	TEVAR	Open	TEVAR	Open	TEVAR	Open	TEVAR	Open	TEVAR
Jonker *et al.*[18], 2010	Meta-analysis	United States	Open: 81 TEVAR: 143 Total: 244	70.2	70	66.7%	70.8%	33.3%	18.9% (*P* = 0.016)	3 years 82%	70.6%	30 days 2.3%	9.1% (*P* = 0.169)
Jonker *et al.*[16], 2011	Retrospective cohort	United States	Open: 69 TEVAR: 92 Total: 161	64.8	69.4	51%	62%	24.6%	17.4% (*P* = 0.26)	4 years 64.3%	75.2% (*P* = 0.191)	30 days 2.9%	7.6%[b]
Jonker *et al.*[7], 2010	Retrospective cohort	United States	Open: n/a TEVAR: 87 Total: 87	n/a	69.8	n/a	69%	n/a	18.4% (*P* = 0.014)	4 years n/a	74.6%	30 days n/a	18.4%[b]
Piffaretti *et al.*[17], 2015	Retrospective analysis		Open: n/a TEVAR: 56 Total: 56	n/a	62	n/a	71.2%	n/a	12.5%	2 years n/a	81%	30 days n/a	0%
Kilic *et al.*[15], 2014	Retrospective analysis	United States	Total: 2788 1998-2004: 1596 2005-2008: 1192	68.6		60%		36.6%	21.5%	n/a		n/a	
Minami *et al.*[8], 2015	Retrospective analysis	Japan	Open: 14 TEVAR: 23 Conservative: 13 Total: 50	n/a	76.8	n/a	62.5%	7.7%	4.3%	2 years n/a	57.8%	30 days n/a	17.4%[b]

[a]Includes re-exploration for bleeding, open repair and additional TEVAR; [b]rate of Endoleak within 30 days. TEVAR: thoracic endovascular aortic repair; rDTAA: ruptured descending thoracic aortic aneurysm; n/a: not available

TEVAR. The outcomes were different, however in favour of TEVAR. There was a 30-day mortality of 25% in the OR group *vs.* 17% following TEVAR, although this was not deemed to be statistically significant. On the other hand, the 4-year survival rate was 75% in TEVAR *vs.* 64% in OR group; moreover the postoperative neurological complications were much less in TEVAR than the OR group. In a further study by Piffaretti *et al.*[17], who studied 56 patients that underwent TEVAR for rDTAA found that early evacuation of a haemothorax reduced postoperative mortality significantly in patients with cardiorespiratory compromise at the time of presentation.

All these findings were supported by a larger study from Kilic *et al.*[15], who analysed 2788 patients that had rDTAA and underwent either open or endovascular repair in an emergency setting. They identified an operative mortality reduction from 52.6% to 23.4% primarily related to the use of an endovascular repair approach in the majority of patients. Whilst their study is reflective of a large database, they have only demonstrated the short-term outcome with operative mortality rather any mid or long term outcomes.

In a further study by Minami *et al.*[8] in 2015, 23 patients that underwent emergency TEVAR for rDTAA showed that the mortality rate is much lower when benchmarked with OR at an international center. They reported operative mortality of 26% whilst the rate of neurological complications postoperatively was 26%.

Lastly, a meta-analysis of 224 patients that had rDTAA by Jonker *et al.*[18], of which 143 patients underwent TEVAR and 81 patients underwent OR have concluded that TEVAR is a safe and effective alternate option to OR in selected patients. The 30-day mortality was 19% *vs.* 33% in TEVAR and OR group of patients respectively. Although the rate of postoperative neurological complications was higher in OR than TEVAR, this again was not statistically significant.

The overall current published literature shows that TEVAR is a feasible option in managing patients with rDTAA and the results are promising in the short term when compared to open repair.

IS EVERYONE A CANDIDATE FOR TEVAR?

Although TEVAR seems an attractive option for managing patients with rDTAA, it cannot be used as a standard management in every patient at the time of presentation due to many factors[3]. Initially the gold standard method for managing such patients was OR[19], however this method has been challenged by the evolution of TEVAR and the favourable short-term outcomes[16,20,21]. One of the key factors in choosing TEVAR over OR, is the anatomic variations and suitability for TEVAR. To assess such anatomical variation, thorough imaging studies are required such as computerized tomography and magnetic resonance imaging to assess such anatomical suitability[3]. Cross-sectional imaging of the aorta is essential, alongside detailed aortic pathology assessment using computerized tomography aortogram. Although obtaining such imaging can be time consuming and may delay the immediate management, they are crucial to determine the location and extent of the pathology so that appropriate interference can be implicated[19]. It is not only important to obtain knowledge about the pathology itself, but rather the assessment of the neck vessels, vertebral arteries and access point vessels are of paramount to evaluate for suitable of endovascular repair, which provides a sufficient amount of information for a rapid decision about whether to perform TEVAR or OR.

An important factor considering TEVAR for rDTAA is the quality of the landing zones. The application for traditional TEVAR requires a proximal and distal landing zone of at least 2 cm. However, patients who present with thoracic aortic pathology can have disease extending to the aortic arch, resulting in an unsuitable proximal landing zone distal to the left subclavian artery. In order to optimize outcome and reduce complications following the graft placement in zones 0, 1 or 2 of the aortic arch, planning for revascularization of the aortic vessels is essential to prevent neurovascular compromise and risk of stroke. Therefore, when TEVAR is extended into zone 2 further procedures such as left carotid-subclavian artery bypass or left carotid-subclavian artery transposition is warranted. When TEVAR is extended into zone 1 of the aortic arch, the left common carotid artery requires revascularization via carotid-carotid crossover bypass[22].

Traditionally, patients with calcified vessels, difficult anatomy and an inability to identify suitable access points, as well as patients with connective tissue disorders, are offered open repair over TEVAR[7,16,23].

OPEN OR ENDOVASCULAR REPAIR FOR rDTAA?

The choice of OR or TEVAR in patients presenting with rDTAA remains debatable at present. In many centers internationally TEVAR is offered as the first line treatment for these patients unless contraindicated, such as patients with connective tissue disorders, except as a temporizing solution until definitive surgery can be performed[24]. The choice of TEVAR also depends largely on the available expertise and the anatomic limitations of the DTA, as discussed above.

TEVAR itself offers a minimal access procedure and thus saving major operating time and reducing perioperative complications associated with OR. Stabilization of the patient through aggressive resuscitation is a key step in preparing the patient for either OR or TEVAR. This includes potentially controlling of the source of bleeding through either application of a clamp at the proximal aorta in OR or balloon inflation in the case of TEVAR; however the later seems to be less efficient technically in providing adequate control of the bleeding[3]. An advantage of TEVAR is the selection of anaesthetic technique. It is possible to perform TEVAR under either local, regional or general anaesthesia, in contrary to OR where it can be performed only under general anaesthesia. Therefore, patients with advanced cardiopulmonary comorbidities and those who are unfit for OR may potentially be a suitable candidate for TEVAR and thus a life saving procedure can be performed[25].

Neuroprotection in patients undergoing repair of rDTAA is a key step for a favourable outcome. This includes stabilization of spinal cord perfusion pressure through placement of a lumbar drain to avoid the

effect of fluctuated blood pressure during repair[26,27]. The current paraplegia rate following TEVAR is around 2%-6%[28] in contrary to OR that has a 8.7% rate[16]. This rate in TEVAR can go as high as 15% depending on the presence of many cofounding factors such as hypotension, concomitant repair of abdominal aortic aneurysm, long standing aortic disease and renal failure[25,27,28].

Although the current trend in managing patients with rDTAA is shifting towards TEVAR, the experience is limited to case series and based on centers of excellence and the presence of experienced operators. Nevertheless, the studies are confined to short-term outcomes. There is a lack of data related to long-term outcomes, on the contrary to OR, where the evidence behind its success and long-term outcomes has been well reported in literature. The surge in using TEVAR is pushed forward by the satisfactory short-term outcomes in TEVAR itself, providing lower morbidity and mortality rates when compared with OR[7,16,23].

In a meta-analysis by Jonker *et al.*[18], they have identified that the mortality rate is much lower in TEVAR group than OR, 18.9% *vs.* 33.3% respectively ($P = 0.16$), whilst the stroke rate is reported to be higher in OR than TEVAR (10.2% *vs.* 4.1% respectively), however this is not statistically significant ($P = 0.11$). Similarly, the paraplegia rate was higher in OR than TEVAR (5.5% *vs.* 3.1%), yet this is also not statistically significant ($P = 0.40$). Whilst vascular complications were higher in the TEVAR group than OR (9.1% *vs.* 2.3%, $P = 0.17$), interestingly, the survival rate from aneurysm related complications was 70.6% in TEVAR patients compared with 100% in the OR patients.

Despite the success of TEVAR, it carries many limitations. A key consideration in patients undergoing TEVAR is the rate of re-intervention. A study by Desai *et al.*[29] has reported a survival rate of TEVAR equivalent to OR in patients with rDTAA at 8-10 years of follow up. In a later study by Botsios *et al.*[21], the rate of re-intervention is thought to be between 4.5%-16% at 1.5-44 months follow up time. Interestingly this rate reported to be as high as 45.5% after rDTAA in some other studies[6,18]. Such re-interventions can be very drastic and require further major intervention and hence affect the long-term outcomes overall. Another limitation of TEVAR is the rate of graft infection, although rare, it is associated with a high mortality rate of up to 50% and often requires surgical intervention for definitive management[30].

Moreover, current vascular surgery practice guidelines suggest considering several factors prior to TEVAR in patients presenting with rDTAA. These factors include anatomical consideration, surgical urgency and the presence of surgical expertise to perform the procedure[18].

At this current stage, there is no randomized controlled trial found to provide comparative clinical outcomes and cost effectiveness comparison between OR and TEVAR in patients presenting with rDTAA. Therefore, the choice of procedure in these patients is based on the experience of the center and the operator[3].

CONCLUSION

TEVAR serves a feasible and attractive option for patients presenting with rDTAA. It is being used in many centers as the first line management of such acutely unwell patients, primarily due to its promising short-term outcomes. However, the published data behind this recommendation is limited and is composed of only case series with retrospective observational studies and lacks any randomized data trials. Regular follow up of patients that undergo a TEVAR is required for early identification and management of TEVAR-related complications such as endoleaks.

DECLARATIONS

Authors' contributions

Design: Harky A, Chan JSK, Wong CHM

Draft: Harky A, Al Nasiri R, Sanli D, Chan JSK, Wong CHM
Proofreading: Manu N, Grafton-Clarke C
Revising: Harky A, Manu N, Grafton-Clarke C
Approved the final manuscript: all authors

Financial support and sponsorship

None.

Conflicts of interest

There are no conflicts of interest.

Patient consent

Not applicable.

Ethics approval

Not applicable.

REFERENCES

1. Johansson G, Swedenborg J. Ruptured abdominal aortic aneurysms: a study of incidence and mortality. *Br J Surg* 1986;73:101-3.
2. Gaudino M, Lau C, Munjal M, Girardi LN. Open repair of ruptured descending thoracic and thoracoabdominal aortic aneurysms. *J Thorac Cardiovasc Surg* 2015;150:814-23.
3. Farlough CL, Eskandari MK. Thoracic endovascular aneurysm repair (TEVAR) for ruptured thoracic aortic aneurysms. *J Vasc Endovasc Surg* 2017;2:14.
4. Gabriel SA, Rinaldi E, Leopardi M, Melissano G, Chiesa R. TEVAR for ruptured descending thoracic arotic aneurysm: case report. *J Vasc Surg* 2016;15:322-7.
5. Keulen JWV, Jonker FHW, Indes J, Muhs BE. Endovascular repair of ruptured descending thoracic aneurysms. *Endovasc Today* 2010;9:64-6.
6. Choi JS, Oh SJ, Sung YW, Moon HJ, Lee JS. Early experiences with the endovascular repair of ruptured descending thoracic aortic aneurysm. *Korean J Thorac Cardiovasc Surg* 2016;49:73-9.
7. Jonker FH, Verhagen HJ, Lin PH, Heijmen RH, Trimarchi S, Lee WA, Moll FL, Athamneh H, Muhs BE. Outcomes of endovascular repair of ruptured descending thoracic aortic aneurysms. *Circulation* 2010;121:2718-23.
8. Minami T, Imoto K, Uchida K, Karube N, Yasuda S, Choh T, Suzuki S, Masuda M. Thoracic endovascular aortic repair for ruptured descending thoracic aortic aneurysm. *J Card Surg* 2015;30:163-9.
9. Parodi JC, Palmaz JC, Barone HD. Transfemoral intraluminal graft implantation for abdominal aortic aneurysms. *Ann Vasc Surg* 1991;5:491-9.
10. Minatoya K, Ogino H, Matsuda H, Sasaki H, Yagihara T, Kitamura S. Replacement of the descending aorta: recent outcomes of open surgery performed with partial cardiopulmonary bypass. *J Thorac Cardiovasc Surg* 2008;136:431-5.
11. Barbato JE, Kim JY, Zenati M, Abu-Hamad G, Rhee RY, Makaroun MS, Cho JS. Contemporary results of open repair of ruptured descending thoracic and thoracoabdominal aortic aneurysms. *J Vasc Surg* 2007;45:667-76.
12. Girardi LN, Krieger KH, Altorki NK, Mack CA, Lee LY, Isom OW. Ruptured descending and thoracoabdominal aortic aneurysms. *The Ann Thorac Surg* 2002;74:1066-70.
13. Schermerhorn ML, Giles KA, Hamdan AD, Dalhberg SE, Hagberg R, Pomposelli F. Population-based outcomes of open descending thoracic aortic aneurysm repair. *J Vasc Surg* 2008;48:821-7.
14. Walsh SR, Tang TY, Sadat U, Naik J, Gaunt ME, Boyle JR, Hayes PD, Varty K. Endovascular stenting versus open surgery for thoracic aortic disease: systematic review and meta-analysis of perioperative results. *J Vasc Surg* 2008;47:1094-8.
15. Kilic A, Shah AS, Black JH, Whitman GJR, Yuh DD, Cameron DE, Conte JV. Trends in repair of intact and ruptured descending thoracic aortic aneurysms in the United States: a population-based analysis. *J Thorac Cardiovasc Surg* 2014;147:1855-60.
16. Jonker FH, Verhagen HJ, Lin PH, Heijmen RH, Trimarchi S, Lee WA, Moll FL, Atamneh H, Rampoldi V, Muhs BE. Open surgery versus endovascular repair of ruptured thoracic aortic aneurysms. *J Vasc Surg* 2011;53:1210-6.
17. Piffaretti G, Menegolo M, Kahlberg A, Mariscalco G, Rinaldi E, Castelli P, Grego F, Chiesa R, Antonello M. Hemothorax management after endovascular treatment for thoracic aortic rupture. *Eur J Vasc Endovasc Surg* 2015;50:608-13.

18. Jonker FH, Trimarchi S, Verhagen HJ, Moll FL, Sumpio BE, Muhs BE. Meta-analysis of open versus endovascular repair for ruptured descending thoracic aortic aneurysm. *J Vasc Surg* 2010;51:1026-32.
19. Coselli JS, Gopaldas RR. Ruptured thoracic aneurysms: to stent or not to stent? *Circulation* 2010;121:2705-7.
20. Goldstein LJ, Ramaiah VG, McKinsey JF. TEVAR for the ruptured thoracic aorta. *Endovasc Today* 2007;6:74-8.
21. Botsios S, Fromke J, Walterbusch G, Schuermann K, Reinstadler J. Endovascular treatment for non-traumatic rupture of the descending thoracic aorta: long-term results. *J Card Surg* 2014;29:353-8.
22. Han DK, Jokisch C, McKinsey J. Expanding the landing zone for TEVAR. *Endovasc Today* 2016;15:85-90.
23. Cambria RP, Crawford RS, Cho JS, Bavaria J, Farber M. A multicenter clinical trial of endovascular stent graft repair of acute catastrophes of the descending thoracic aorta. *J Vasc Surg* 2009;50:1255-64.
24. Shah A, Khoynezhad A. Thoracic repair for acute type A aortic dissection: operative teachnique. *Ann Cardiothorac Surg* 2016;5:389-96.
25. Hogendoorn W, Schlosser FJ, Muhs BE, Popescu WM. Surgical and anesthetic considerations for the endovascular treatment of ruptured descending thoracic aortic aneurysms. *Curr Opin Anaesthesiol* 2014;27:12-20.
26. Lam CH, Vatakencherry G. Spinal cord protection with a cerebrospinal fluid drain in a patient undergoing thoracic endovascular aortic repair. *J Vasc Interv Radiol* 2010;21:1343-6.
27. Scali ST, Wang SK, Feezor RJ, Huber TS, Martin TD. Preoperative prediction of spinal cord ischemia after thoracic endovascular repair. *J Vasc Surg* 2014;60:1481-90.
28. Eskandari MK, Daly CM. Management of Late TEVAR Failures. In: Eskandari MK, Pearce WH, Yao JST, editors. Current Vascular Surgery, 2012. Shelton, CT: PMPH-USA; 2012. p. 393-406.
29. Desai ND, Burtch K, Moser W, Moeller P, Szeto WY. Long-term comparison of thoracic endovascular aortic repair (TEVAR) to open surgery for the treatment of thoracic aortic aneurysms. *J Thorac Cardiovasc Surg* 2012;144:604-9.
30. Cernohorsky P, Reijnen MM, Tielliu IF, van Sterkenburg SM, van den Dungen JJ. The relevance of aortic endograft prosthetic infection. *J Vasc Surg* 2011;54:327-33.