Eur J Vasc Endovasc Surg (2011) 41, 48–53

Endovascular Treatment of Ruptured Thoracic Aortic Aneurysm in Patients Older than 75 Years

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Submitted 23 June 2010; accepted 20 September 2010
Available online 24 November 2010

KEYWORDS
Aortic aneurysm;
Thoracic;
Rupture;
Endovascular;
Age

Abstract *Objectives:* To investigate the outcomes of thoracic endovascular aortic repair (TEVAR) for ruptured descending thoracic aortic aneurysm (rDTAA) in patients older than 75 years.
Methods: We retrospectively identified all patients treated with TEVAR for rDTAA at seven referral centres between 2002 and 2009. The cohort was stratified according to age $\leq$75 and >75 years, and the outcomes after TEVAR were compared between both groups.
Results: Ninety-two patients were identified of which 73% ($n = 67$) were $\leq$75 years, and 27% ($n = 25$) were older than 75 years. The 30-day mortality was 32.0% in patients older than 75 years, and 13.4% in the remaining patients ($p = 0.041$). Patients older than 75 years suffered more frequently from postoperative stroke (24.0% vs. 1.5%, $p = 0.001$) and pulmonary complications (40.0% vs. 9.0%, $p = 0.001$). The aneurysm-related survival after 2 years was 52.1% for patients >75 years, and 83.9% for patients $\leq$75 years ($p = 0.006$).
Conclusions: Endovascular treatment of rDTAA in patients older than 75 years is associated with an inferior outcome compared with patients younger than 75 years. However, the mortality and morbidity rates in patients above 75 years are still acceptable. These results may indicate that endovascular treatment for patients older than 75 years with rDTAA is worthwhile.

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1078-5884/$36
doi:10.1016/j.ejvs.2010.09.017

Age is a strong risk factor for mortality and morbidity after surgical intervention for acute aortic disease.[1–11] Ruptured descending thoracic aortic aneurysm (rDTAA) is a rare but life-threatening aortic pathology requiring immediate intervention.[11–13] Traditional open thoracic aortic surgery typically involves thoracotomy and aortic cross-clamping, procedures that are poorly tolerated, especially by elderly patients. Because of the extremely high mortality rates,[11] some institutions do not offer open surgical repair to very elderly patients admitted with rDTAA. Thoracic endovascular aortic repair (TEVAR) is a minimally invasive technique, which is increasingly used for the management of acute thoracic aortic pathologies, and endovascular methods are replacing the open surgical approach for the management of rDTAA. As a result of the less-invasive characteristics of TEVAR, increasing age may have a less-significant impact on the results of endovascular management of rDTAA.

We have previously reported about our experience with endovascular management of rDTAA.[14] Because the results were not stratified for age, the exact outcome of elderly patients with rDTAA is unclear, and it remains uncertain if offering TEVAR to rDTAA patients older than 75 years is still worthwhile. The purpose of the present multicentre study is to investigate the outcomes of endovascular treatment for rDTAA in patients above 75 years.

Methods

Study population

For this observational study, we retrospectively identified all patients who were treated with TEVAR for rDTAA between January 2001 and July 2009 at the Yale New Haven Hospital (New Haven, CT, USA), Baylor College of Medicine, (Houston, TX, USA), University of Florida (Gainesville, FL, USA), Policlinico San Donato IRCCS (San Donato Milanese, Italy), St. Antonius Hospital (Nieuwegein, The Netherlands), Erasmus University Medical Center (Rotterdam, The Netherlands) and the University Medical Center Utrecht (Utrecht, The Netherlands). All ruptured aneurysms that were located between the left subclavian artery and the celiac axis and treated with TEVAR were included. Ruptured aneurysm was defined as any disruption of the aneurysmal aortic wall with an extravascular collection of blood. Ruptured dissected aneurysms were included only if the aortic diameter was larger than 50 mm.

Endovascular repair has become the preferred treatment over the years for the management of descending thoracic aortic disease at the participating institutions. All endovascular procedures were performed in the operating room under general anaesthesia by vascular and/or cardiothoracic surgeons. Prophylactic cerebrospinal fluid drainage was only performed if the patient was at increased risk for spinal cord ischaemia, including extensive aortic coverage or TEVAR after previous abdominal aortic intervention. Revascularisation of the left subclavian artery or the use of heparin depended on the surgeon's preference. Current contraindications for TEVAR include no proximal or distal aortic neck, or a neck diameter that is too wide for commercially available thoracic endografts. If the aortic anatomy is unsuitable for an endovascular approach, open surgery is offered or treatment is refused.

The cohort of rDTAA patients was stratified according to age $\leq$75 and >75 years, and presentation, procedural characteristics and outcomes after TEVAR were compared between both groups. The STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) guidelines for observational studies were used for the design of the present study and report.[15] The study was approved by the institutional review committee at all participating institutions.

End points and statistical analysis

The following outcome variables were compared between patients $\leq$75 and >75 years: mortality, major complications including stroke, paraplegia/paraparesis, cardiac complications, pulmonary complications, acute renal failure, bleeding, aortic re-intervention and a composite of these major adverse events. Categorical variables were compared between patients $\leq$75 and >75 years using the chi-square test. Continuous variables with an approximately normal distribution were investigated using the Student's *t*-test; other continuous variables were explored using the Mann–Whitney *U* test. Multivariate logistic regression analysis was used to investigate independent effects of age >75 years and other baseline and operating characteristics on the 30-day mortality. Age >75 years, gender and variables with a *P* value <0.2 in univariate analysis were integrated into the multivariate regression model. Kaplan–Meier survival analysis was used to investigate the aneurysm-related survival and all-cause survival for patients $\leq$75 and >75 years during 2 years of follow-up. Aneurysm-related death was defined as death within 30 days or death after 30 days due to complications related to the aneurysm and/or intervention. Statistical analysis was performed using Statistical Package for Social Sciences (SPSS) 15.0 software; a *P* value < 0.05 was considered statistically significant.

Results

Patient and operating characteristics

Ninety-two patients underwent TEVAR for rDTAA, the mean age of the cohort was 69.4 years and 73% ($n = 67$) were $\leq$75 years and 27% ($n = 25$) were >75 years (Fig. 1). A history of hypertension (83% vs. 46%, $p = 0.002$) and hyperlipidemia (46% vs. 21%, $p = 0.030$) was more common in the elderly cohort (Table 1). Hypovolaemic shock at admission was present in 33% of the patients >75 years, compared with 18% of the patients $\leq$75 years ($p = 0.117$). There were no differences in operating characteristics between both groups (Table 2).

Early outcomes

Overall, 17.4% ($n = 16$) of the cohort expired within the first month. The 30-day mortality was 32.0% in patients older than 75 years, and 13.4% in the remaining patients (odds ratio (OR) 3.0, 95% confidence interval (CI) 1.1–10.6,

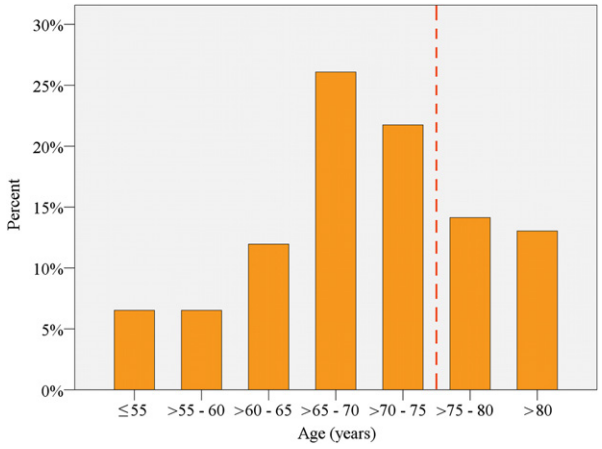

Figure 1 Distribution of age. Overall, 73% ($n = 67$) were ≤75 years, and 27% ($n = 25$) were older than 75 years.

$p = 0.041$). Among the elderly cohort, the 30-day mortality was 41.7% for patients older than 80 years (5 of 12), and 23.1% for patients between 75 and 80 years (3 of 13, $p = 0.319$).

Major postoperative complications (including death) occurred in 72.0% of patients older than 75 years, and in 35.8% of the patients ≤75 years (OR 4.6, 95% CI 1.7—12.6, $p = 0.002$). Patients older than 75 years suffered more frequently from periprocedural stroke (24.0% vs. 1.5%, $p = 0.001$) and pulmonary complications (40.0% vs. 9.0%, $p = 0.001$, Table 3). The median length of stay was 14.0 days for the elderly cohort, compared with 7.0 days for patients ≤75 years ($p = 0.024$).

Multivariate regressions analysis confirmed that age above 75 years was an independent predictor of 30-day mortality after TEVAR (OR 3.7, 95% CI 1.02—13.9, $p = 0.047$). Other independent predictors of 30-day mortality were hypovolaemic shock (OR 5.3, 95% CI 1.41—18.2, $p = 0.013$) and hemothorax at admission (OR 5.0, 95% CI 1.13—22.6, $p = 0.034$, Table 4).

Midterm outcomes

The median length of follow-up of patients who were alive at 30 days was 13.5 months. Five additional patients died during follow-up of complications related to the aneurysm and/or intervention, including an infected endograft and/or sepsis ($n = 3$), aortic rupture ($n = 1$) and a poor general condition ($n = 1$). The aneurysm-related survival after 2 years was 52.1% for patients >75 years, and 83.9% for patients ≤75 years ($p = 0.006$, Fig. 2). Nine additional patients died during follow-up of causes unrelated to the ruptured aneurysms, including myocardial infarction ($n = 5$), stroke ($n = 1$) and unknown ($n = 3$). The all-cause survival after 2 years was 28.9% for patients >75 years, and 71.8% for the younger cohort ($p = 0.001$, Fig. 3).

Overall, thoracic aortic re-interventions were required in 11 patients after TEVAR, of which seven were ≤75 years, and four were >75 years. The median time interval between the initial endovascular procedure was and the re-intervention was 17 days, and 64% ($n = 7$) of the re-interventions were performed during the first month after TEVAR (Table 3).

Discussion

Acute aortic syndromes are generally associated with high mortality and morbidity rates, and risks of surgery for acute aortic disease are dramatically increased in elderly patients.[1—11] The exact outcome of elderly patients with rDTAA undergoing TEVAR has been less well defined

Table 1 Baseline characteristics.

	≤75 years N (%)		>75 years N (%)		*P* value
Demographics					
Mean age (y)	65.4	(±11)	80.5	(±2.6)	<0.001
Male gender	46	(68.7)	16	(64.0)	0.67
Patient History					
Hypertension	29	(46.0)	19	(82.6)	0.003
Diabetes Mellitus	9	(14.5)	2	(9.1)	0.51
Hyperlipidemia	13	(21.3)	10	(45.5)	0.030
CAD	27	(44.3)	11	(50.0)	0.64
COPD	14	(21.5)	8	(34.8)	0.21
CRI	8	(13.1)	5	(23.8)	0.24
Carotid disease	8	(13.1)	5	(22.7)	0.28
Prior aortic intervention	13	(19.4)	5	(20.8)	0.88
Presentation					
Aneurysm diameter (mm)	53.7	(±21)	56.4	(±17)	0.61
Hypovolaemic shock	12	(17.9)	8	(33.3)	0.12
Contained rupture	26	(38.8)	5	(22.7)	0.17
Associated dissection	11	(16.4)	2	(8.3)	0.33

CAD: coronary artery disease, COPD: chronic obstructive pulmonary disease, CRI: chronic renal insufficiency. LSA: left subclavian artery, CSF: cerebrospinal fluid. Hypovolaemic shock was defined as a heart rate ≥120 beats/minute, a respiratory rate ≥30 breaths/minute and a mean arterial pressure <90 mm Hg.

Table 2 Procedural characteristics.

	≤75 years N (%)		>75 years N (%)		*P* value
TEVAR within 24 h	55	(82.1)	22	(91.7)	0.27
Mean graft diameter (mm)	37.6	(±3.6)	37.0	(±4.2)	0.54
Total graft length (mm)	150.6	(±124)	150.7	(±88)	0.99
Coverage LSA	23	(34.3)	8	(33.3)	0.93
CSF drainage	13	(19.4)	4	(16.7)	0.77
TEVAR after 2006	42	(62.7)	17	(68.0)	0.64

LSA: left subclavian artery, CSF: cerebrospinal fluid.

Table 3 Early outcomes.

Variable	≤75 years N (%)		>75 years N (%)		OR	95% CI	*P* value
30-day mortality	8	(11.9)	8	(32.0)	3.5	1.1–10.6	0.024
Major complications	24	(35.8)	18	(72.0)	4.6	1.7–12.6	0.002
Stroke	1	(1.5)	6	(24.0)	20.8	2.4–83.9	0.001
Paraplegia/paraparesis	6	(9.0)	1	(4.0)	0.42	0.05–3.7	0.43
Cardiac complications	3	(4.5)	2	(8.0)	1.9	0.29–11.8	0.51
Pulmonary complications	6	(9.0)	10	(40.0)	6.8	2.1–21.6	0.001
Acute renal failure	5	(7.5)	3	(12.0)	1.7	0.37–7.7	0.49
Bleeding	6	(9.0)	4	(16.0)	1.9	0.50–7.5	0.33
Aortic re-intervention	4	(6.0)	3	(12.0)	2.2	0.45–10.4	0.33
Other re-interventions	19	(28.4)	7	(28.0)	0.98	0.35–2.7	0.97

OR: odds ratio, CI: confidence interval. Major complications included death, stroke, paraplegia/paraparesis, cardiac complications, pulmonary complications, acute renal failure, bleeding, and aortic re-intervention. Other re-interventions included placement of a thorax drain ($n = 22$), esophagostomy ($n = 3$) and a thoracotomy ($n = 1$) for evacuation of a clotted hemothorax and release of trapped lung tissue.

because ruptured aneurysms of the thoracic aorta are less common than rAAA,[12,16] and TEVAR is a relatively novel treatment option. In this evaluation, we observed that the overall outcomes of TEVAR for rDTAA are encouraging. In rDTAA patients older than 75 years, however, the mortality was significantly increased, and a multivariable regression model confirmed that age >75 years was an independent predictor of death. A logical explanation for the high mortality among the elderly cohort may be that such patients typically have a poor general condition, with more cardiovascular risk factors (Table 1), resulting in increased surgical risks. Diagnosed or undiagnosed atherosclerosis of the carotid and cerebral arteries likely was more common in the patients older than 75 years, resulting in a very high incidence of periprocedural stroke, a potentially lethal complication. A higher risk of stroke in elderly patients has been observed as well for other interventions using endovascular devices in the aortic arch, such as carotid artery stenting.[17]

Because of the poor outcomes of the very elderly patients with acute thoracic aortic disease, some institutions do not offer surgical intervention to them. Although we observed substantially increased mortality and morbidity in patients older than 75 years, we believe that the outcomes of TEVAR for rDTAA were still acceptable in our evaluation. Based on these results, endovascular repair with rDTAA appears an appropriate treatment for patients above 75 years, if the procedure is performed by a team with adequate endovascular experience. The mortality rate did differ considerably for the patients between 75 and 80

Table 4 Independent predictors of 30-day mortality.

	OR	95%CI	*P* value
Age >75	3.7	1.02–13.9	0.047
Female gender	0.9	0.21–3.50	0.81
Prior aortic intervention	1.9	0.91–7.74	0.29
Hemothorax	5.0	1.13–22.6	0.034
Hypovolaemic shock	5.3	1.41–18.2	0.013
Aortic dissection	2.2	0.52–11.2	0.25

OR: odds ratio, CI: confidence interval.

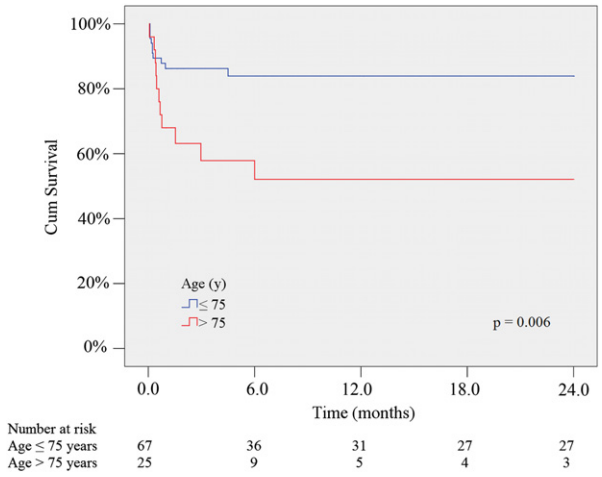

Figure 2 Aneurysm-related survival for patients ≤ and >75 years. The aneurysm-related survival after 2 years was 52.1% for patients >75 years, and 83.9% for patients ≤75 years.

years, and those who were older than 80 years. For the latter, over 40% of patients expired within 30 days. The benefits of an endovascular intervention in the very elderly patients remain therefore more questionable; however, strong conclusions cannot be drawn due to the limited number of patients in this subgroup.

The results of traditional open surgery for elderly rDTAA patients are thought to be inferior compared with patients managed with endovascular repair. Schermerhorn and colleagues found an overall in-hospital mortality rate of 52.4% for rDTAA patients older than 75 years using the National Impatient Sample (NIS) database from 1988 to 2003,[11] which is considerably higher than the early mortality rate here reported. However, the decision to offer open surgery, TEVAR or no treatment to a very elderly patient with rDTAA should be based on individual patient characteristics and the expertise of the operator or institution. Several classifications and scores have been developed, including the Acute Physiology and Chronic Health Evaluation (APACHE) II score, the Glasgow Aneurysm Score (GAS) and the American Society of Anaesthesiologists (ASA) Classification, to estimate the risk of death of admitted patients.[18–21] These parameters may be used as well for assessing the operative risks for an rDTAA patient requiring urgent intervention. In addition, surgical mortality rates are generally lower if the intervention is performed by high-volume surgeons in a high-volume hospital.[22,23] All seven participating hospitals were referral centres that have significant expertise and experience with TEVAR, limiting the applicability of these results to centres that lack such capability.

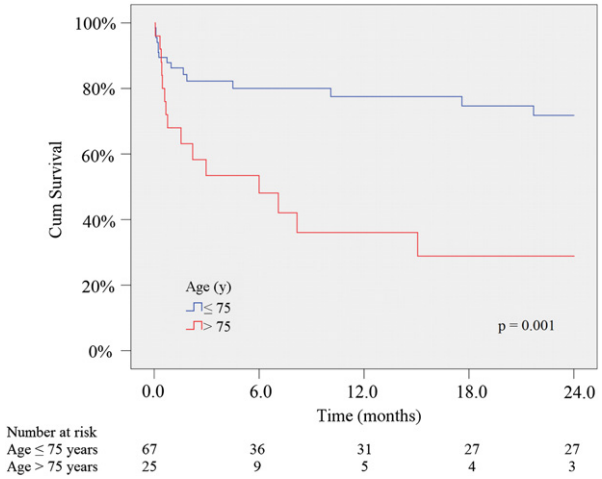

Figure 3 All-cause survival for patients ≤ and >75 years. The all-cause survival after 2 years was only 28.9% for patients >75 years and 71.8% for patients ≤75 years.

This study has several strengths as well as limitations. Because our cohort of rDTAA patients treated with TEVAR is currently the largest available series, it offers a unique opportunity to analyse the outcomes of the subset of patients with an age above 75 years. However, the sample size of this elderly subgroup ($n = 25$) remains relatively small for adequate analysis. Furthermore, data were collected retrospectively, and subject to incomplete or missing reporting of events. Finally, we did not include a control arm of rDTAA patients above 75 years treated with open surgery because TEVAR has emerged as the preferred approach at our institutions.

Conclusion

Age predicts mortality and morbidity in patients affected by rDTAA treated with TEVAR. Endovascular treatment of rDTAA in patients older than 75 years is associated with an inferior outcome compared with patients younger than 75 years. However, the mortality and morbidity rates in patients above 75 years are still acceptable. These results may indicate that endovascular treatment for patients older than 75 years with rDTAA is worthwhile.

Funding Sources

American Geriatrics Society Jahnigen Career Development Grant.

Conflict of Interest

None.

Acknowledgements

We would like to thank Michelle Streukens for the data collection.

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