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Thoracic endovascular aortic repair: impact of urgency on outcome and quality of life☆

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Abstract

Objectives: Endovascular repair of the descending thoracic aorta is a very promising technique in elective and, particularly, emergency situations. This study assessed the impact of urgency of the procedure on outcome and mid-term quality of life in surviving patients. **Methods:** Post hoc analysis of prospectively collected data of 58 consecutive patients (January 2001—December 2005) with surgical pathologies of the descending thoracic aorta treated by endovascular means. Six patients were excluded due to recent operations on the ascending aorta before thoracic endovascular repair. The remaining patients ($n = 52$) were 69 ± 10 years old, and 43 were men (83%). Twenty-seven had been treated electively, and 25 for emergency indications. Reasons for emergency were acute type B aortic dissections with or without malperfusion syndrome in 14, and aortic ruptures in 11 cases. Follow-up was 29 ± 16 months. Endpoints were perioperative and late morbidity and mortality rates and long-term quality of life as assessed by the short form health survey (SF-36) and Hospital Anxiety and Depression Scale questionnaires. **Results:** Cohorts were comparable regarding age, sex, cardiovascular risk factors, and comorbidities. Perioperative mortality was somewhat higher in emergency cases (12% vs 4%, $p = 0.34$). Paraplegia occurred in one patient in each cohort (4%). Overall quality of life after two and a half years was similar in both treatment cohorts: 72 (58—124) after emergency, and 85 (61—105) after elective endovascular aortic repair ($p = 0.98$). Normal scores range from 85 to 115. Anxiety and depression scores were in the normal range and comparable. **Conclusions:** Thoracic endovascular aortic repair is an excellent and safe treatment option for the diseased descending aorta, particularly in emergency situations. Early morbidity and mortality rates can be kept very low. Mid-term quality of life was not affected by the urgency of the procedure. Similarly, mid-term anxiety and depression scores were not increased after emergency situations.

Keywords: Endovascular repair; Descending aorta; Outcome; Quality of life

1. Introduction

Surgery of the descending thoracic aorta is technically very demanding and associated with substantial mortality and morbidity rates [1,2]. Thoracic endovascular aortic repair (TEVAR) using covered stent grafts represents an attractive alternative to open aortic repair (OAR) because it allows less invasive exclusion of the aortic pathology from the circulation. The advantages of the endovascular approach with its minimised access trauma and remote vascular access might be important. In the perioperative period, endovascular repair has been shown to confer considerable benefit to the patient in treatment of both thoracic and abdominal aortic aneurysms (TAA and AAA, respectively) [2,3]. The thoracic aorta, however, poses several unique technical challenges which may affect long-term results, and which have hampered simple adaptation and transfer of endovascular devices and technology which were originally developed for the abdominal aorta [2,4]. Nonetheless TEVAR has become a valuable alternative to OAR not only in elective, but particularly in emergency situations. Recent studies have shown better outcomes regarding mortality and paraplegia rates than after emergency OAR [5—7]. The specific technical demands of TEVAR, however, may be particularly difficult to meet in emergency situations and therefore unfavourably impact on long-term outcome. Additionally, the traumatic experience of an aortic emergency might lead to increased anxiety or depression levels.

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Health related quality of life (QoL) is increasingly recognised as a pivotal outcome dimension in invasive vascular medicine [8]. Indeed, survivors may subjectively experience QoL as the single most important indicator of treatment success. Long-term QoL after TEVAR has only been assessed in smaller collectives so far [9,10], and it is unknown whether urgency of TEVAR negatively affects QoL during follow-up. The aim of this single centre series therefore was to assess outcome and postoperative QoL in surviving patients after TEVAR and to relate them to an age- and gender-matched standard population after stratification for urgency of initial treatment.

2. Materials and methods

We conducted a post hoc analysis of a prospectively registered consecutive series of 58 patients who were treated by TEVAR for thoracic aortic disease between January 2001 and December 2005. Analysis of data was approved by the local ethics committee, and informed consent was obtained from each patient. Recorded patient details included demographic characteristics, pre-existent comorbidities, cardiovascular risk factors as well as history of previous cardiovascular surgery, clinical presentation, imaging studies, diagnosis, intra-operative details as well as early (i.e. 30 days or in-hospital) morbidity and mortality. Identification of cardiovascular risk factors was based upon previously published definitions [11]. Cut-off value for diagnosis of a TAA was a maximum aortic diameter of at least 3 cm. In order to minimise independent influences on long-term QoL, six patients were excluded from analysis because they had undergone major cardiothoracic surgery for treatment of pathologies of the aortic root, ascending aorta or aortic arch within the previous three years of personal history before being included into this study. The remaining 52 patients were 69 ± 10 years old, and 43 were men (83%).

All patients were followed systematically after intervention in annual intervals within a specialised outpatient clinic. Follow-up data were thereby recorded prospectively. Additional outpatient visits were arranged according to clinical needs.

Cross-sectional assessment of present-day QoL was performed after a mean follow-up of 29 ± 16 months utilising the validated German versions of both the short form health survey (SF-36) and the Hospital Anxiety and Depression Scale (HADS) questionnaires [12–14]. Questionnaires were sent a second time to non-responders before they were contacted by phone. Results were stratified for the urgency of treatment.

2.1. Study endpoints

Perioperative mortality and morbidity included all events within 30 days of treatment or whenever patients were still in hospital. Cumulative mid-term survival was assessed according to the method proposed by Kaplan and Meier [15]. QoL was assessed by means of the self administered SF-36 and the HADS questionnaires. Details of the validated German version of the SF-36 have been published previously [16]. Briefly, the SF-36 consists of 36 short questions reflecting QoL in eight different aspects: bodily pain (2 items); mental health (5 items); vitality (4 items); social functioning (2 items); general health (5 items); physical functioning (10 items); and role functioning, both emotional (3 items) and physical (4 items). Role functioning reflects the impact of emotional and physical disability on work and regular activity (the individual's normal everyday role). Raw points generate a score for each dimension, which add up to a total raw score ranging from 0 to 100, with 100 reflecting best functioning. Raw scores then were adjusted for age and gender of the study population by multiplication with the appropriate factor based on a validated Western European Standard population ($n = 8930$, Sweden) according to the SF-36 manual [13], thereby generating an adjusted score. Normal values for the adjusted score range from 85 to 115. The aspects anxiety and depression were assessed additionally with the HADS. This questionnaire allows to assess psychic restrictions in patients with somatic disorders [14].

2.2. Statistical methods

Normally distributed variables are summarised as mean ($\pm$ 1 SD), and were compared by two-tailed unpaired *t*-test. Asymmetrically distributed variables are represented as median (interquartile range), and were compared by two-sided Mann–Whitney *U* test. Categorical variables are presented as numbers (percentages) and were compared by two-tailed Fisher's exact test. Additionally, odds ratios were calculated including 95% confidence intervals. The SF-36 questionnaire was analysed in accordance with the SF-36 manual, replacing missing values using the described algorithm [12,13]. After arithmetical adjustment for age and gender SF-36 scores were compared by means of Mann–Whitney *U* test. Results were stratified for urgency of intervention. A p value of less than 0.05 was considered to indicate statistical significance. Data were analysed using SPSS for Windows, version 15.0.

3. Results

Fifty-two patients were analysed for the purpose of this study: 27 had been treated electively (52%), and 25 under emergency conditions (48%). Demographic characteristics as well as pre-, intra- and postoperative data of the treatment cohorts are summarised in Tables 1 and 2. Patients were comparable regarding age, sex and cardiovascular risk factors with exception of a higher prevalence of recorded dyslipidaemia in electively treated patients. Similarly, prevalence of assessed comorbidities was comparable in both treatment cohorts (Table 1). Early mortality rates were similar in both cohorts (4% vs 12%, $p = 0.34$ by two-tailed Fisher's exact test). Overall early mortality rate was 8% ($n = 4$).

Characteristics of aortic disease are summarised in Table 1. Prevalence of aneurysmatic disease was similar, whereas aortic ruptures naturally only occurred in the emergency cohort ($p < 0.001$ by two-tailed Fisher's exact test). Other emergency indications for TEVAR were acute type B aortic dissections associated with treatment resistant symptoms ($n = 4$) or visceral malperfusion syndrome ($n = 3$). One patient was operated urgently for a symptomatic aortic pleb in the proximal descending aorta. Patients stayed

Table 1
Demographic characteristics of 58 patients treated for diseased descending aorta by TEVAR

	Elective TEVAR (n = 29)		Emergency TEVAR (n = 29)		OR (95% CI)	p value
Excluded patients, n (%)	2	(7%)	4	(14%)	0.46 (0.09–2.40)	0.67°
Analysed patients, n (%)	27	(93%)	25	(86%)		
Mean age ± SD (years)	71 ± 8		67 ± 12		–	0.15*
Male gender, n (%)	23	(85%)	20	(80%)	1.44 (0.36–5.68)	0.72°
Cardiovascular risk factors						
Diabetes, n (%)	6	(22%)	2	(8%)	3.29 (0.67–15.70)	0.25°
Arterial hypertension	21	(78%)	20	(80%)	0.88 (0.24–3.18)	1.0°
Hyperlipidaemia	16	(59%)	6	(24%)	4.61 (1.42–14.88)	0.013°
Tobacco use	17	(63%)	9	(36%)	3.02 (0.99–9.22)	0.095°
Obesity	4	(15%)	3	(12%)	1.28 (0.28–5.71)	1.0°
Comorbidities						
COPD, n (%)	7	(26%)	4	(16%)	1.84 (0.49–6.82)	0.50°
CHD, n (%)	16	(59%)	2 [a]	(8%)	–	
History of myocardial infarction, n (%)	1	(4%)	0		–	1.0°
Family history of cardiovascular disease, n (%)	5	(19%)	4	(16%)	1.19 (0.30–4.71)	1.0°
Renal insufficiency	8	(30%)	4	(16%)	2.21 (0.60–8.05)	0.33°
History of major thoracic cardiovascular surgery, n (%) [b]	10	(37%)	6	(24%)	1.86 (0.57–6.03)	0.38°
Neoplasia, n (%)	4	(15%)	2	(8%)	2.00 (0.38–10.24)	0.67°
Characterisation and localisation of treated aortic pathology						
Thoracic aneurysm, n (%)	20	(74%)	17	(68%)	1.35 (0.42–4.35)	0.54°
Median aneurysm diameter (mm)	55 (50–73)		40 (39–56)		–	0.021#
Rupture	0		11	(65%)	–	<0.001°
Marfan disease, n (%)	1	(6%)	0		–	1.0°
Type B dissection without aneurysm, n (%)	5	(19%)	4	(16%)	1.19 (0.30–4.71)	1.0°
Other pathologies of thoracic segment of aorta including malperfusion syndrome, n (%)	2	(7%)	4	(16%)	0.42 (0.08–2.20)	0.61°

Demographic characteristics as well as characteristics of local disease of 58 patients undergoing elective or emergency TEVAR of descending aortic disease between January 2001 and December 2005. Results are displayed as absolute figures (percentage), as mean values ± 1 SD, or as median (interquartile range).
COPD: chronic obstructive pulmonary disease; CHD: coronary heart disease; TEVAR: thoracic endovascular aortic repair; OR: odds ratio; CI: confidence interval.
[a] In emergency procedures recent coronary angiographies were often not available.
[b] Only patients with previous thoracic cardiovascular surgery more than three years earlier were included, six patients with more recent thoracic operations were excluded.
° Calculated by two-tailed Fisher's exact test.
* Calculated by two-tailed unpaired t-test.
# Calculated by Mann–Whitney U test.

significantly longer on intermediate care unit (ICU) after emergency TEVAR. However, overall length of hospital stay was not different from elective TEVAR patients (Table 2). Perioperative morbidity as well as incidence of early revisions was similar in both cohorts (Table 2).

3.1. Interventions

Median intervention times were similar in elective (145 min [120–310]) and emergency TEVAR (140 min [100–167]; p = 0.26 by two-sided Mann–Whitney U test). Similarly, the amounts of contrast agent used (230 ml [190–320] vs 250 ml [150–350]; p = 0.75) and of fluoroscopy time (14 min [10–24] vs 15 min [11–35]; p = 0.73), were comparable. Femoral rather than iliac access was chosen more often in emergency TEVAR although not statistically significantly (80% vs 63%, p = 0.23 by two-sided Fisher's exact text). The left subclavian artery was overstented more often in emergency TEVAR (32%) than in elective TEVAR (22%), again without statistical significance (p = 0.54). However, no patient suffered from ischaemic symptoms of the left arm later on nor were neurologic sequelae in the vertebrobasilar region registered. Endovascular fenestrations of dissection membranes were performed in three cases (6%), two of which within emergency procedures (p = 0.60). Intra-operative conversion to OAR was necessary in two patients (4%, one patient in each treatment cohort). In both patients, type 2 endoleaks were the reason for conversion. The overall incidence of endoleaks (n = 11) was higher after elective TEVAR (37% vs 4%, p = 0.005). However, only two of them eventually needed revision procedures (p = 0.49), whereas seven patients were treated conservatively. Another patient of the emergency TEVAR cohort required a reintervention within the first postoperative month, which was related to a proximal extension of an acute type B aortic dissection despite TEVAR. Hence, the resulting type A aortic dissection required open replacement of the ascending aorta and aortic arch. During follow-up, no further reinterventions were needed in this cohort, whereas one late reintervention (18 months) was necessary in the elective TEVAR cohort due to a type 2 endoleak with increasing diameter of the excluded aneurysm.

3.2. Follow-up

Mean length of follow-up was around two and a half years in both treatment cohorts (p = 0.55 by Mann–Whitney U test,

Table 2
Early postoperative course of 52 analysed patients

	Elective TEVAR (n = 27)		Emergency TEVAR (n = 25)		OR (95% CI)	p value
Postoperative (30 days)						
Median length of stay ICU (days)	0 (0–1)		2 (0.75–4.5)		–	0.001[#]
Median length of stay in hospital (days)	8 (5–14)		8.5 (7–15)		–	0.88[#]
Early mortality, n (%)	1	(4%)	3	(12%)	0.28 (0.04–2.16)	0.34[°]
Early morbidity						
Cerebrovascular incident, n (%)	3	(11%)	2	(8%)	1.44 (0.26–7.86)	1.0[°]
Paraparesis or plegia, n (%)	4	(15%)	4	(16%)	0.91 (0.22–3.80)	1.0[°]
New renal insufficiency, n (%)	2	(7%)	3	(12%)	0.59 (0.11–3.26)	0.66[°]
Temporary dialysis, n (%)	0		0		–	1.0[°]
Myocardial infarction, n (%)	0		2	(8%)	–	0.23[°]
Pneumonia, n (%)	2	(7%)	0		–	0.49[°]
Tracheostomy, n (%)	2	(7%)	2	(8%)	0.92 (0.15–5.68)	1.0[°]
Sepsis, n (%)	1	(4%)	0		–	1.0[°]
Early revisions, n (%)	5	(19%)	4	(16%)	1.19 (0.30–4.71)	1.0[°]
Bleeding, n (%)	1	(4%)	2	(8%)	0.44 (0.06–3.66)	0.60[°]
Endoleak or stent-graft extension, n (%)	2	(7%)	2	(8%)	0.92 (0.15–5.68)	1.0[°]
Wound infection, n (%)	1	(4%)	0		–	1.0[°]
Other	1	(4%)	0		–	0.48[°]

Results are displayed as absolute figures (percentage), or as median (interquartile range).
ICU: intermediate care unit; TEVAR: thoracic endovascular aortic repair; OR: odds ratio; CI: confidence interval.
[°] Calculated by two-tailed Fisher's exact test.
[#] Calculated by Mann–Whitney U test.

Table 3). After the perioperative period, 10 patients died during follow-up accounting for cumulative survival rates of 72% (elective TEVAR), and 70% (emergency TEVAR) after three years (p = 0.79 by log rank test, Fig. 1). Therefore, 38 patients were eligible for QoL assessment at cross-sectional follow-up. All patients could be contacted and were sent the SF-36 and HADS questionnaires (no loss of follow-up). Out of these, 27 were returned (71%). The return rates were equal in both treatment cohorts: 70% (elective TEVAR), and 72% (emergency TEVAR, p = 1.0 by two-tailed unpaired Fisher's exact test). Three patients were unable to fill out the questionnaire due to language problems. The remaining eight patients refused to fill out the questionnaires. However, all these patients have been contacted by phone and were alive.

Mid-term overall QoL was assessed by the SF-36, and scores were comparable in both treatment cohorts after adjustment for age and gender: 85 (61–105) after elective, and 72 (58–124) after emergency TEVAR, respectively (p = 0.98 by Mann–Whitney U test). However, both cohorts scored lower than what would be expected from a corresponding standard population which scores between 85 and 115. The eight individual QoL dimensions are

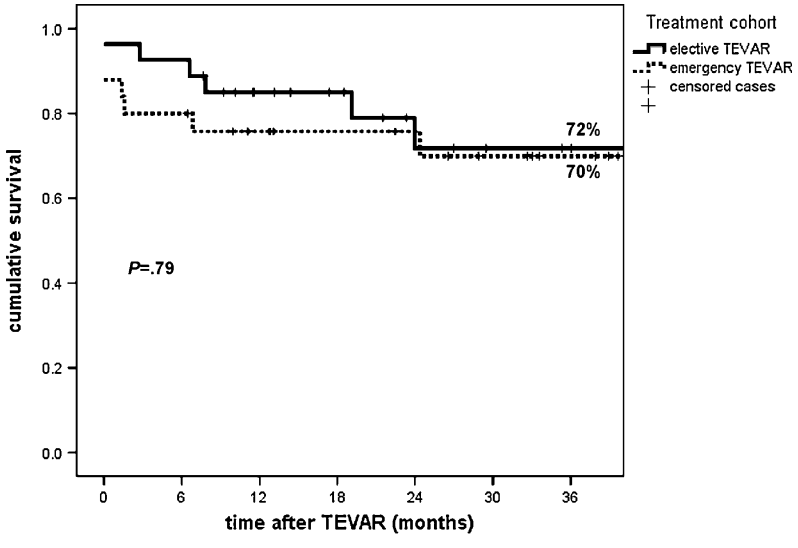

Fig. 1. Kaplan–Meier survival curves for patients undergoing elective (n = 27) and emergency (n = 25) thoracic endovascular aortic repair (TEVAR).

Table 3
Follow-up and long-term quality of life in 38 surviving patients

	Elective TEVAR (n = 27)		Emergency TEVAR (n = 25)		OR (95% CI)	p value
Eligible patients, n (%)	20	(74%)	18	(72%)	1.11 (0.34–3.67)	1.0°
Follow-up completed (QoL), n (%)	14	(70%)	13	(72%)	0.90 (0.23–3.51)	1.0°
Mean follow-up ± SD (months)	27 ± 17		31 ± 16			0.55#
Quality of life (SF-36)						
Median physical function	85 (55–93)		60 (45–104)			0.41#
Median role physical	69 (0–137)		0 (0–126)			0.48#
Median bodily pain	84 (33–135)		102 (66–140)			0.20#
Median general health	89 (58–105)		96 (76–131)			0.74#
Median vitality	81 (34–106)		54 (37–122)			0.92#
Median social function	97 (78–113)		94 (79–114)			0.87#
Median role emotional	111 (56–116)		56 (0–116)			0.51#
Median mental health	97 (78–121)		106 (87–113)			0.60#
Overall physical health	82 (58–114)		70 (61–127)			0.80#
Overall mental health	92 (52–109)		78 (60–119)			0.98#
Overall SF-36	85 (61–105)		72 (58–124)			0.98#
Anxiety and depression (HADS)						
Median anxiety	4.0 (2.0–7.0)		5.0 (3.5–6.0)			0.79#
Median depression	5.0 (3.5–6.0)		5.0 (3.0–8.0)			0.85#

Long-term quality of life as assessed in 27 survivors 30 months after endovascular treatment of descending thoracic aortic disease. Short form 36 health survey data are corrected for age and gender. Values are given as median (interquartile range). Values lower than 85 reflect a significant impairment in quality of life as compared to data obtained in a standard population. Overall physical health includes the physical domains (physical function, physical role, bodily pain, and general health). Overall mental health includes the mental domains (vitality, social function, emotional role, and mental health). Anxiety and depression as assessed by the Hospital Anxiety and Depression Scale questionnaire are displayed as median values (interquartile range), higher values reflecting higher anxiety and/or depression.
TEVAR: thoracic endovascular aortic repair; OR: odds ratio; CI: confidence interval.
° Calculated by two-tailed Fisher's exact test.
Calculated by Mann–Whitney U test.

described in detail in Table 3 and are shown in Fig. 2. No statistically significant differences could be found between the cohorts in any of the assessed dimensions by non-parametric testing. Importantly, both cohorts scored in the key dimension *mental health* in the same and normal range rendering them actually comparable for all other domains of the SF-36. This observation was supported by the results of the specific depression and anxiety subscale in the HADS questionnaire, which showed identical scores in a normal range for both cohorts (Table 3, and Fig. 3).

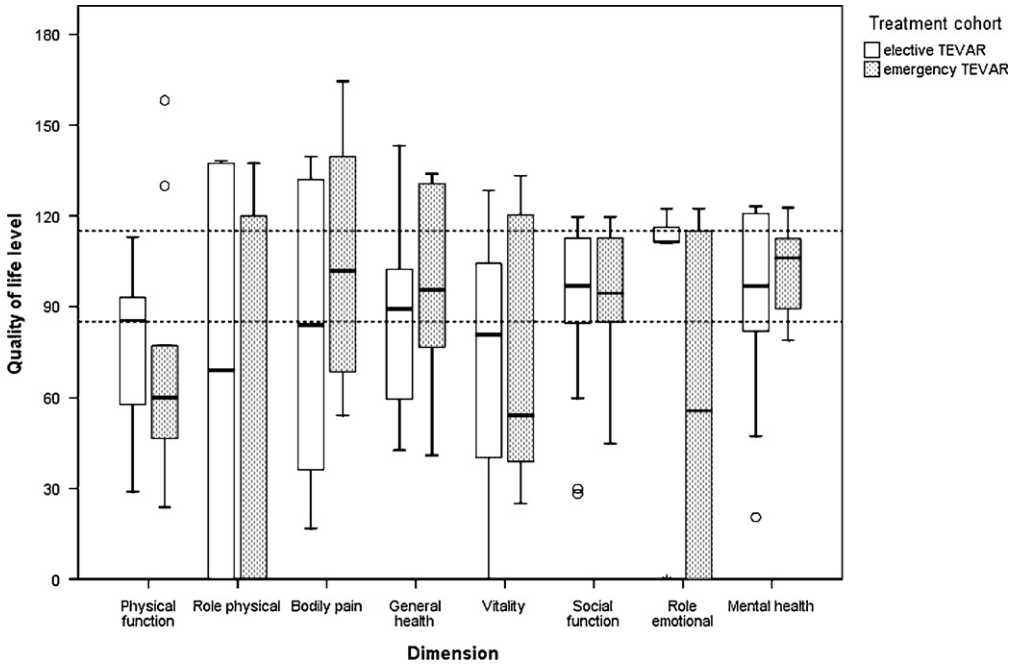

Fig. 2. Long-term quality of life in patients undergoing elective (n = 27) and emergency (n = 25) thoracic endovascular aortic repair (TEVAR). Of 38 surviving patients, 27 were assessed by the short form 36 health questionnaire (71%). Results are displayed as median scores, values are given in Table 3. Age- and gender-adjusted standard populations score between 85 and 115 points (dotted lines).

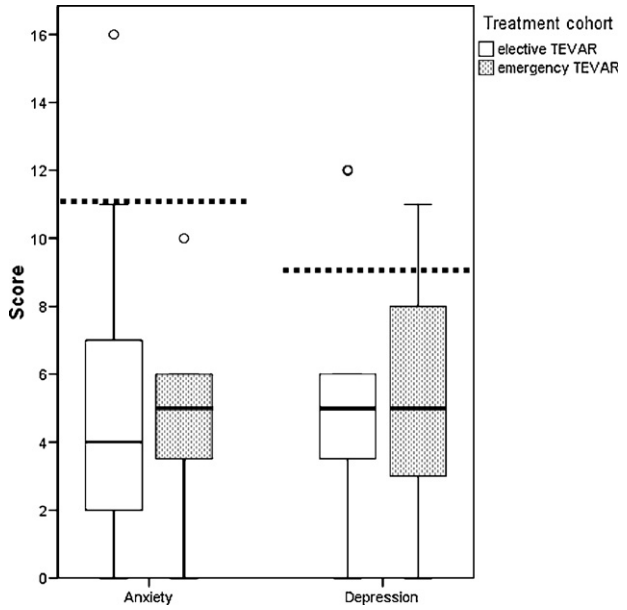

Fig. 3. Hospital anxiety and depression scale (HADS) results in patients undergoing elective ($n = 27$) and emergency ($n = 25$) thoracic endovascular aortic repair (TEVAR). Of 38 surviving patients, 27 were assessed (71%). Results are displayed as median scores; values are given in Table 3. Higher values reflect an increase in anxiety and depression aspects. Normal anxiety levels range below 11, and normal depression levels range below 9 (dotted lines).

4. Discussion

This consecutive single centre series analysed the mid-term results of an unselected collective of 58 TEVAR patients who had undergone thoracic aortic repair for a variety of vascular pathologies between January 2001 and December 2005. Both general outcome and subjective health related QoL were scrutinised after a mean follow-up of two and a half years with stratification for urgency of TEVAR. Key finding was that self-reported QoL, while markedly impaired when compared to an age- and gender-adjusted standard population, was not influenced by urgency of TEVAR despite the fact that requirements for successful TEVAR might be more difficult to meet under emergency conditions.

Open surgical access to the thoracic aorta is technically demanding and may be particularly complication-prone in emergency situations where pressure of time may impede stepwise exposure. Typical complications range from access related morbidity to intra- or postoperative bleeding and cerebral or peripheral embolism to spinal cord ischaemia with consecutive paraplegia or paraparesis [1]. Many of these complications are at least theoretically much less probable with a remote endovascular approach [1]. Indeed, with rising experience in thoracic endovascular interventions and technical improvements of catheters, guide wires, stent material and delivery systems, TEVAR has now become an important alternative to OAR in the thoracic aorta [5—7].

Based on data published in recent years, acceptable perioperative mortality rates for elective TEVAR range from 1.2% to 9.3% [2,17—19], which are very consistent with our findings (early mortality after elective TEVAR 4%). Mortality rates of elective open thoracic aortic repair are usually reported between 5% and 14% [1], and a recent population-based survey found an elective mortality of open repair of 11.3% among patients aged 65—74 years [20]. For emergency TEVAR, however, published mortality rates range from 17.0% to 27.9% [18,21], which is markedly higher than the 12% found in the present series. In contrast, open repair of ruptured thoracic aneurysms was associated with a mortality of 47.1% in an age-matched population [20], which however did not include urgent, non-ruptured cases (35% in our series). Open repair was performed in 78 patients during the same time period in our institution and was associated with an early mortality of 9%. However, patients were younger in average (61 years) and only 10% were treated emergently.

Early revisions were needed in 16% and 19% of patients, respectively, and affected both cohorts equally. Half of the revisions were due to endoleaks and the associated need to extend the stent-graft. Incidence of early endoleaks ranges from 0% to 23% in the literature [6] and learning curve, anatomic complexity of the pathology and reliability of intraoperative imaging have been implicated as important factors [6]. Our series started in 2001 and included the learning curve of the team. However numbers are too small to ascertain a corresponding trend. Although access-related revisions are needed more often after open repair [20] (14% during the corresponding period in our institution), the reason for a revision seems less important from a patient's perspective, which relativises the common belief into the advantages of a minimally invasive access in this respect.

Mid-term survival was assessed up to three years with no differences between the treatment cohorts. Results were consistent with findings in the literature, where 1-year survival rates ranged between 76.2% and 81.6% [2,7,18,22] (Fig. 1). In the elective TEVAR cohort a small early survival benefit during the perioperative period was observed, although it was not statistically significant.

The insufficiency of assessing outcome of dedicated vascular therapies simply by morbidity and mortality rates has only recently been recognised [8]. Health related QoL is an additional yet crucial outcome dimension since it takes into account the most important perspective, the patient's. Indeed, for the individual survivor, health related QoL might subjectively be the single most important determinant of treatment success, since QoL subsumes the relative importance of all intervention-related sequelae. In surgery of the thoracic aorta long-term QoL has mainly been assessed for OAR [9,10], since most TEVAR series were either quite small or did not review sufficient follow-up periods. Systematic comparisons of long-term QoL after TEVAR and thoracic OAR are still lacking, although randomised controlled investigations of QoL after EVAR and OAR of the abdominal aorta have been performed [23,24].

For reasons alluded to above, TEVAR is increasingly performed under emergency conditions with significant benefits for the patients [2]. Hence, the impact of the urgency on long-term QoL after TEVAR is of interest. Obviously patients cannot be randomised to emergency or elective situations. Therefore a randomised controlled investigation of this issue is impossible to conduct. In our series, however, equal numbers of patients were treated by emergency and elective TEVAR by the same surgical staff during the observed study period giving a unique opportunity for such a comparison. Although baseline characteristics of

the treatment cohorts certainly were not completely comparable (Table 1), this probably constitutes the best possible approximation of a controlled investigation so far. The SF-36 questionnaire, as used in this study, is a broadly accepted tool for QoL assessment because of its generic design which renders it widely applicable [8]. It has been used successfully for QoL assessment in vascular patients before [16]. Even more importantly, it has reliably been validated for statistical adjustment for age and gender of the investigated population [12,13]. Thereby, it allows for meaningful *z* testing against a standard Western European control population.

It is common to argue that an unequal distribution of underlying mental disorders might skew the individually experienced QoL unfairly and independently of the assessed influences such as illness or intervention. A comparable score in the domain *mental health* therefore is generally regarded as a precondition for comparability. In our series, both elective and emergency TEVAR patients not only scored in the same range (97 [78—121] vs 106 [87—113], $p = 0.60$, by Mann—Whitney *U* test) but also in the centre of what is perceived as normal in an age- and gender-adjusted standard population (i.e. 85—115, Fig. 2).

Mid-term health related QoL of the total collective of our study was lower than what would be expected in an age- and gender-matched standard population. On integrated physical and emotional QoL scores, no differences were found between treatment cohorts. There was no difference in duration of follow-up between the treatment cohorts, which equalises possible extrinsic influences. However, like in QoL assessments of thoracic OAR patients [9,10], limitations were mainly found in both physical and emotional role functions and were more pronounced after emergency TEVAR. It is important to note that any differences in emotional role function could not be reproduced in the HADS questionnaire, which focuses specifically on aspects of anxiety and depression. Here, the results were comparable in both treatment cohorts. Astonishingly however, emergency TEVAR patients showed a tendency to score better in the aspects bodily pain and general health. This could be related to the fact that patients recovering from a severe and overtaking illness, like a life-threatening emergency, may experience a relatively better convalescence than elective patients that might mainly be reflected in these two dimensions. Further limitations were found in physical functioning and vitality.

4.1. Limitations of study

Some methodological limitations must be cautiously considered when interpreting the data of this series. Although based on prospective data collection, analysis was post hoc and observational. Thus, all limitations of a non-randomised study design are possibly present, and a direct comparison of study cohorts must be judged very cautiously. Although demographic characteristics seemed acceptably similar except for hyperlipidaemia (Table 1), a type II error cannot be ruled out considering the small numbers, and absence of evidence is certainly not evidence of absence. Control of QoL assessment, however, was strived for in various ways and included, as elaborated above, choice of a validated, generic assessment tool, adjustment for age and gender and *z* testing against a standard population rather than direct comparisons. Moreover, the vast overlap of findings between the treatment cohorts (Figs. 2 and 3) supports the interpretation that urgency of TEVAR was not associated with significant impact on mid-term QoL. Another concern is that non-response to questionnaire surveys may introduce bias, mostly because patients with worse outcome might be less likely to respond [25]. Indeed, 8 of 11 non-responders refused to give a reason. This is an intrinsic shortcoming of this study type which has not yet been solved satisfactorily [25]. However, the return rate in our study was 71% which is markedly above average and probably reflects a pronounced emotional involvement of this patient population with their condition [25]. This return can be considered an acceptable representation of surviving patients, and QoL was probably, if anything, overestimated which corroborates the interpretation that mid-term QoL was impaired after TEVAR as compared to the normal population. More importantly, return was identical between the groups (70% vs 72%); therefore any potential bias can be assumed similar between the two groups. A last area of concern is the length of follow-up, which covered two and a half years in the present study. It is an argument whether close surveillance programs after endovascular repair impairs long-term QoL. Indeed, patients were seen in annual follow-up visits, which affected both cohorts equally. EVAR trial 1 found no secondary changes in QoL up to four years after endovascular repair despite a similar follow-up program [23], and the DREAM trial found no association between surveillance intensity and mid-term QoL [24]. Nevertheless, longer follow-up data are needed to answer this question for TEVAR. An important factor towards improved acceptance of follow-up surveillance might be continuous information and guidance of the patients by their general practitioners.

We conclude that TEVAR of the diseased thoracic downstream aorta provides excellent results under both, elective and particularly emergency conditions, even though mid-term QoL may be impaired as compared to an age- and gender-matched standard population. However, urgency of the accomplished procedure does not seem to influence resulting mid-term QoL.

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