Cost-effectiveness of endovascular versus open repair of acute complicated type B aortic dissections

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Objective: **This study weighed the cost and benefit of thoracic endovascular aortic repair (TEVAR) vs open repair (OR) in the treatment of an acute complicated type B aortic dissection by (TBAD) estimating the cost-effectiveness to determine an optimal treatment strategy based on the best currently available evidence.**

Methods: **A cost-utility analysis from the perspective of the health system payer was performed using a decision analytic model. Within this model, the 1-year survival, quality-adjusted life-years (QALYs), and costs for a hypothetical cohort of patients with an acute complicated TBAD managed with TEVAR or OR were evaluated. Clinical effectiveness data, cost data, and transitional probabilities of different health states were derived from previously published high-quality studies or meta-analyses. Probabilistic sensitivity analyses were performed on uncertain model parameters.**

Results: **The base-case analysis showed, in terms of QALYs, that OR appeared to be more expensive (incremental cost of €17,252.60) and less effective (−0.19 QALYs) compared with TEVAR; hence, in terms of the incremental cost-effectiveness ratio, OR was dominated by TEVAR. As a result, the incremental cost-effectiveness ratio (ie, the cost per life-year saved) was not calculated. The average cost-effectiveness ratio of TEVAR and OR per QALY gained was €56,316.79 and €108,421.91, respectively. In probabilistic sensitivity analyses, TEVAR was economically dominant in 100% of cases. The probability that TEVAR was economically attractive at a willingness-to-pay threshold of €50,000/QALY gained was 100%.**

Conclusions: **The present results suggest that TEVAR yielded more QALYs and was associated with lower 1-year costs compared with OR in patients with an acute complicated TBAD. As a result, from the cost-effectiveness point of view, TEVAR is the dominant therapy over OR for this disease under the predefined conditions. (J Vasc Surg 2014;59:1247-55.)**

Acute aortic dissection is the most common aortic emergency and affects about three to four per 100,000 persons per year.[1] Approximately 30% to 42% of the acute type B aortic dissections (aTBADs) are complicated, and 20% to 30% of patients die before hospital admission.[2,3]

Open repair (OR) using prosthetic graft interposition is the conventional treatment for acute complicated TBADs. Despite remarkably improved operative techniques and improved perioperative care, the results of OR of the aTBADs are reported with contemporary mortality rates of 15% to 30% and even >50% in complicated cases under emergency conditions.[4,5] Another devastating complication of OR is ischemic spinal cord injury, with paraplegia rates up to 30%.[6]

Interventions using thoracic endovascular aortic repair (TEVAR) have added a strong alternative and new dimension to the surgical management of aortic dissection, and recently, the paradigm of treatment of acute complicated distal dissections has shifted in favor of TEVAR over OR. However, the safety, efficacy, and durability of TEVAR have been discussed controversially. The currently available literature is sparse and complicated by heterogeneous clinical definitions and therapeutic treatments, and information on late outcome is scant. To date, we still lack level 1 evidence in support of TEVAR for TBADs because no randomized trials of TEVAR vs OR for aTBADs have been performed with substantial follow-up. Thus, management recommendations for aTBADs are mostly derived from uncontrolled retrospective cohorts, case series, registry data, or expert opinions and are not yet firmly settled.

In a recent meta-analysis, we showed a significant reduction in perioperative mortality and paraplegia rates with TEVAR compared with OR.[7] In TEVAR, however, the reintervention rates and the initial device-associated costs have to be considered. The aim of the present study was to examine the hypothesis that compared with OR, TEVAR may be a more cost-effective therapeutic option for the management of acute complicated TBADs.

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METHODS

The analysis was undertaken from a health care system payer perspective, considering the related total direct medical costs of care for the first year. Loss of productivity (indirect costs) or costs >1 year of follow-up were not included in the present study. Costs and health outcomes in quality-adjusted life-years (QALYs) were assessed and combined into an incremental cost-effectiveness ratio (ICER), which should be interpreted as the cost needed to produce an additional QALY.

Table I. Transitional probabilities based on previous meta-analysis and literature search

	OR		*TEVAR converted to OR*		*TEVAR*		
Final outcome	*Literature path probabilities*	*Plausible range*	*Literature path probabilities*	*Plausible range*	*Literature path probabilities*	*Plausible range*	*References*
30-day mortality[a]	0.299	0.2-0.4	0.026	0.01-0.05	0.115	0.085-0.145	7,9-28
Paraplegia	0.299	0.249-0.349	0.0013	0.001-0.0016	0.049	0.029-0.069	7,10-28
Death	0.0008	…	0.0	…	0.082	0.052-0.112	27-29
Stroke	0.08	0.06-0.1	0.004	0.003-0.005	0.063	0.043-0.083	7,27,28
Death	…	…	…	…	0.082	0.0662-0.102	7,27,28
Renal failure	0.098	0.078-0.118	0.0029	0.0019-0.0039	0.069	0.049-0.089	7,12-15,17-21,23-28
Death	0.0086	…	0.0002	…	0.082	0.062-0.102	30
LOS, days							
ICU	10	…	10	…	6	…	11,19-23,26,31
Ward	9	…	9	…	7	…	19-23,26,31,32
Ventilatory days	7	…	7	…	2	…	14,22,26
Late endoleak	…	…	…	…	0.18	0.15-0.21	7,27,28
Intervention	…	…	…	…	0.113	0.083-0.143	7,27,28
Endoleak	…	…	…	…	0.2319	0.2019-0.2619	7,27,28
Intervention	…	…	…	…	0.2	0.1-0.3	7,27,28

EV, Endovascular repair; *ICU,* intensive care unit; *LOS,* length of stay; *OR,* open repair; *TEVAR,* thoracic endovascular aortic repair.
[a]Defined as nonrespiratory, nonparaplegia, nonrenal deaths.

The direct costs for the initial hospitalization and surgical procedure were obtained from previously published data describing the utilization of health services after TEVAR or OR for TBADs. Costs and health outcomes were discounted at 3% per year, consistent with current guidelines.[8] Costs were based on 2012 prices and, when necessary, were adjusted by means of the consumer price index for health and personal care and converted to euros (€). In all cases, the probability for each outcome was multiplied by the cost associated for each outcome to give the expected cost for OR and TEVAR. Cost associated with intensive care unit length of stay (LOS) and total hospital LOS was then added to each outcome to arrive at the final cost.

The costs and clinical outcomes were modelled by using a Monte Carlo process. A 1-year time horizon was adopted to capture all relevant costs and the benefits.

Data. In the present analysis, we focused on those primary outcomes that were the most serious and those that resulted in the greatest resource utilization, namely: mortality, paraplegia/paraparesis rate, renal failure, stroke, conversion to OR, endoleak rate, intensive care unit LOS, and hospital LOS. We assumed that the remaining outcomes would be similar in both treatment groups. Especially for TEVAR, the additional outcomes of endoleak and conversion to OR were analyzed. These outcome data were mainly extracted from our previously published meta-analysis on TEVAR for acute complicated TBADs.[7] Details of the underlying search criteria, patient selection criteria, statistical analysis, and sensitivity analysis of the meta-analysis are available elsewhere.[7] Because we used the data from only a few studies besides those included in the previously published meta-analysis[7] for the baseline analysis, we took care to ensure that the ranges for the sensitivity analysis included data from other related studies (Table I). In addition, we ensured that the clinically plausible ranges corresponded with the target population and interventions that were modelled. To incorporate the results in the present decision-analytical model, all outcomes were pooled by meta-analytical means, and the weighted data of each outcome were used for the present analysis. The baseline variables and ranges used in sensitivity analysis are summarized in Tables I-III.

A literature review was undertaken to obtain estimates of costs, utilities, and health-related quality of life, respectively (Tables I-III). Utility scores were quoted from the published literature. We used published population-based utilities, representing time trade-off or standard-gamble techniques.

Two studies were identified reporting utilities for post-stroke states.[40,41] Both studies showed that utilities in patients who had a nondisabling stroke were no lower than those in patients who had not had a stroke. Therefore, no decrement in utility was assumed for patients in this state. For patients who had a disabling stroke, the mean utility was 0.5. Because the mean utility of the general population is <1 (full health),[42] this corresponded to a decrement in the quality-adjustment weight of 0.35.

Decision-analytical model. An observational decision-analytical model was constructed for the use of resources and the effectiveness of both treatment strategies on the basis of a previously published model by Tong et al[33] at the London Health Sciences Center. In the present study, the distribution type used for different variables was influenced by the availability of information in the relevant source studies. When the information required to generate an appropriate distribution was not available, we used triangular distribution. The following hypotheses were made in developing the model and conducting the analysis:

1. Patients with acute complicated TBADs undergo TEVAR or OR. Complicated TBADs were characterized by thoracic aortic rupture, shock, malperfusion

Table II. Unit costs (follow-up costs limited to 1 year) based on literature search

	OR		*TEVAR converted to OR*		*TEVAR*		
Resource item	*Unit costs (€)*	*Range (€)*	*Unit costs (€)*	*Range (€)*	*Unit costs (€)*	*Range (€)*	*References*
30-day mortality	18,051	14,051-22,051	26,051	20,051-32,051	20,030	15,030-25,030	33,34
No acute complication/ uneventful recovery	18,177.2	10,177.2-26,177.2	26,177.2	20,177.2-32,177.2	20,156.2	16,156.2-24,156.2	33,34
Paraplegia	142,505.49	12,0505.49-16,4505.49	15,0505.49	110,505.49-190,505.49	…	…	33-35
Stroke	142,505.49	120,505.49-164,505.49	15,0505.49	110,505.49-190,505.49	…	…	33-35
Renal failure	155,132.34	110,132.34-200,132.34	16,3132.34	120,132.34-203,132.34	…	…	33,34
Late endoleak							
Intervention	…	…	…	…	25,566.13	20,566.13-30,566.13	33,34
No intervention	…	…	…	…	20,424.99	16,424.99-24,424.99	33,34
Paraplegia							
Survive + rehabilitation	…	…	…	…	144,484.49	104,484.49-184,484.49	33-35
Death	…	…	…	…	39,884.49	34,884.49-44,884.49	33-35
Early endoleak							
Intervention	…	…	…	…	25,481.13	20,481.13-30,481.13	33,34
No intervention	…	…	…	…	20,339.99	15,339.99-25,339.99	33,34
Stroke							
Survive + recovery	…	…	…	…	39,884.49	32,884.49-46,884.49	33-35
Death	…	…	…	…	39,884.49	32,884.49-46,884.49	33-35
Renal failure							
Survive + recovery	…	…	…	…	157,111.34	117,111.34-197,111.34	33,34
Death	…	…	…	…	52,511.34	45,511.34-60,511.34	33,34

OR, Open repair; *TEVAR,* thoracic endovascular aortic repair.

Table III. Utilities based on literature search

	OR + TEVAR converted to OR		*TEVAR*		
Resource item	*Utility*	*Range*	*Utility*	*Range*	*References*
30-day mortality	0	0	0	0	36-39
No acute complication/uneventful recovery	0.83	0.78-0.88	0.93	0.89-0.97	36-39
Paraplegia	0.6	0.5-0.7	…	…	36-39
Stroke	0.46	0.3-0.65	…	…	10,11
Renal failure	0.68	0.6-0.8	…	…	36-39
Late endoleak					
Intervention	…	…	0.83	0.78-0.88	36-39
No intervention	…	…	0.83	0.78-0.88	36-39
Paraplegia: survive + rehabilitation	…	…	0.6	0.5-0.7	36-39
Early endoleak					
Intervention	…	…	0.83	0.78-0.88	36-39
No intervention	…	…	0.83	0.78-0.88	36-39
Stroke: survive + recovery	…	…	0.46	0.3-0.65	10,11
Renal failure: survive + recovery	…	…	0.68	0.6-0.8	

OR, Open repair; *TEVAR,* thoracic endovascular aortic repair.

(involving the viscera, kidneys, spinal cord, or the lower extremities), intractable hypertension and pain, or rapid expansion in the distal arch or proximal descending aorta with a total aortic diameter of ≥4.5 cm.

2. Analysis was done based on intention to treat (ie, cost associated with conversion to OR counted toward the cost of the TEVAR cohort).
3. Eighty percent of patients with renal failure mortality would also die of respiratory failure.

Table IV. Incremental cost-effectiveness after 1 year in base-case analysis

Strategy	*Cost (€)*	*Incremental cost (€)*	*Effectiveness*	*Incremental effectiveness*	*Cost/effectiveness (€)*	*ICER*
TEVAR	41,288.59		0.73		56,316.79	
OR	58,541.18	17,252.60	0.54	−0.19	108,421.91	(dominated by TEVAR)

ICER, Incremental cost-effectiveness ratio; *OR,* open repair; *TEVAR,* thoracic endovascular aortic repair.

4. Thirty-five percent of early and late endoleak would require intervention.
5. Patients with endoleak would have a 5% mortality rate.
6. In the base-case analysis, TEVAR patients in follow-up would undergo a computed tomography (CT) scan at 1 month and then every 6 months after to ensure that no endoleak had developed and that no endograft migration had taken place.
7. In the base-case analysis, patients in the OR group would not routinely receive postoperative CT imaging.

Cost-effectiveness analysis. The time horizon of the analysis was 1 year. The willingness-to-pay (WTP) threshold was €50,000. As a result, the intervention was considered cost-effective if the ICER was <€50,000 per QALY. End points of this simulation model were the cost-effectiveness ratios, the ICER, and the net health benefit of the two treatment options. The effectiveness of each treatment option was quantified by QALYs. The type of dominance of the comparative probability distribution was analyzed graphically. Cost drivers (variables with the major input to the costs) were identified, and results are presented by means of a tornado diagram. We performed a base-case analysis and varied all variables over a broad range of reasonable hypotheses in multiple one-way and two-way sensitivity analyses to deal with structural uncertainties within the model and patient-related and treatment-related variables. Noncost data were varied systematically in the clinically plausible ranges, and cost data were varied by up to 50% in each direction in the sensitivity analysis.

In the probabilistic analysis, a second-order Monte Carlo simulation with all model parameters >10,000 iterations was used to propagate the uncertainty in single-model inputs through the model so that the uncertainty in the cost-effectiveness results indicated the uncertainty in the decision to implement a treatment strategy rather than the uncertainty surrounding single-model inputs. The results are presented as scatter plots of the ICER. In addition, sensitivity analysis included worst-case and best-case scenario analyses.

The decision analysis model was programmed and analyzed using TreeAge Pro 2009 software (TreeAge Software Inc, Williamstown, Mass).

RESULTS

The rationales for the assumptions in our model are listed in Tables I-III. The relevant costs and adjustment rates for estimates of missing costs are presented in Table II. Each patient's costs were calculated using these assumptions, were compared with actual costs, and were determined to be comparable.

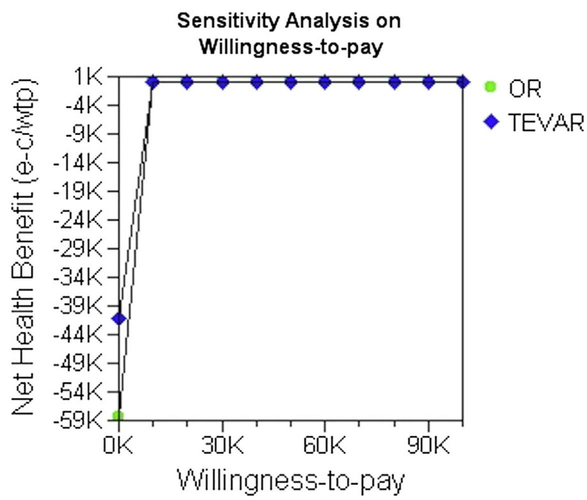

Fig 1. Sensitivity analysis on willingness-to-pay (*WTP*). The preferred treatment in net health benefit is independent of the WYP threshold value of €50,000 for the thoracic endovascular aortic repair (*TEVAR*) option. *OR,* Open repair.

A literature review revealed one study with a detailed analysis of the utilization of health services after spinal cord injury in Alberta and the average costs for the first year.[35] The total 1-year cost for each patient represents the sum of the patient's total hospital cost, the total follow-up cost, and additional costs such as rehabilitation for paraplegic patients or home care nursing visits.

Baseline conditions. In the base-case analysis, in terms of QALYs, OR appeared to be more expensive (incremental cost of €17,252.60) and less effective (−0.19 QALYs) compared with TEVAR; hence, in terms of the ICER, OR was dominated by TEVAR. As a result, we did not calculate the ICER (ie, the cost per life-year saved).

The average cost-effectiveness ratio of TEVAR and OR per QALY gained was €56,316.79 and €108,421.91, respectively (Table IV).

Considering the net health benefit (Fig 1), the preferred treatment was TEVAR compared with OR, independently on the threshold value of WTP (of €50,000).

One-way sensitivity analysis. The outcome of the model remained robust, and TEVAR maintained its cost-effectiveness advantage over OR within broad predefined ranges for different WTP thresholds, costs, and probabilities; namely, uneventful course, paraplegia, stroke, renal

Table V. Dominance report of one-way sensitivity analysis

Therapeutic option	*Parameter*	*ICER*
OR + TEVAR converted to OR	Costs of no acute complication Costs of paraplegia Costs of stroke Costs of renal failure	OR dominated by TEVAR
TEVAR	Costs of no acute complication or uneventful recovery Costs of paraplegia-survive Costs of stroke-survive Costs of renal failure-survive	OR dominated by TEVAR
OR + TEVAR converted to OR + TEVAR	Probability of 30-day death Probability of paraplegia Probability of stroke Probability of renal failure	OR dominated by TEVAR

ICER, Incremental cost-effectiveness ratio; *OR,* open repair; *TEVAR,* thoracic endovascular aortic repair.

failure, and 30-day mortality. No threshold was detected between these variable ranges that could change the superiority of TEVAR in net health benefit (Table V).

Hypothetical worst-case scenario: 30-day mortality of TEVAR. One-way sensitivity analysis, especially on the operative mortality for TEVAR, showed dominance of TEVAR over OR if its mortality rate was up to 37.5%. With a hypothetical high mortality rate of 50%, OR would provide improved effectiveness compared with TEVAR with an ICER of €287,663.05 per QALY (Fig 2).

Two-way sensitivity analysis. The list of variables tested for their joint influence on acute complicated TBADs outcome included the systematically modelled morbidity rates of paraplegia, stroke, and renal failure. The same parameter ranges were used as in the one-way sensitivity analysis. TEVAR repair emerged as the preferred treatment option in net health benefit (Table VI).

TEVAR continued to dominate OR, and the model results were not affected by varying the values of paraplegia, stroke, renal failure, and 30-day mortality rates in the ranges specified.

The tornado diagram displays the seven individual parameters that influence the ICER estimates the most, arranged from top to bottom in order of their importance. As depicted in Fig 3, the tornado diagram demonstrates that results are most sensitive to the probability of renal failure, stroke, or paraplegia after TEVAR, the costs of survival after renal failure, stroke, or paraplegia after TEVAR, and the costs of uneventful recovery after TEVAR.

Monte Carlo simulation. The results of the bootstrapping are depicted in the cost-effectiveness plane (Fig 4). The QALYs gained panel shows that 100% of replicates fall into the right lower quadrant, indicating that we can be 100% certain that TEVAR yields a better outcome in QALYs at 1 year. Because all replicates lie under the *x*-axis, we have 100% certainty that TEVAR is less costly than OR. The oblique line indicates a (rather arbitrary) societal WTP threshold of €50,000 per QALY. All replicates lie under this threshold, indicating that with 100% certainty TEVAR can be considered the preferred strategy at a societal WTP threshold of €50,000 per QALY.

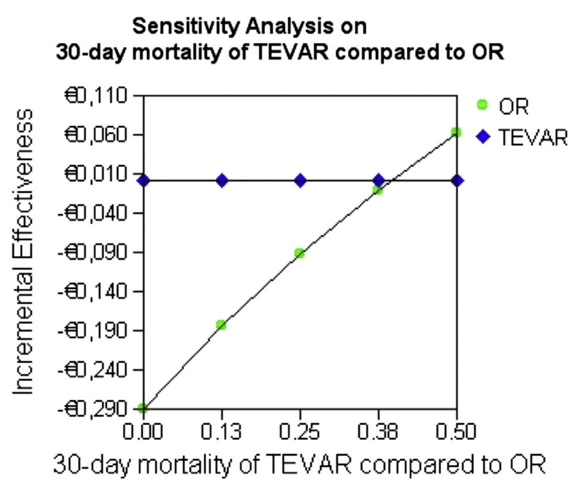

Fig 2. One-way sensitivity analysis for 30-day mortality of thoracic endovascular aortic repair (*TEVAR*), defined as nonrespiratory, nonparaplegia, nonrenal deaths, compared with open repair (*OR*).

Best-case and worst-case scenario. To perform the best-case and worst-case scenario analysis, respectively, we modelled the 10 individual parameters that influenced the ICER estimates most, according to the tornado diagram, to its extremes (intentionally beyond reasonable limits published in the literature; Tables I-III).

In the base-case analysis under this scenario, TEVAR was still the dominant therapeutic option compared with OR. However, under these assumptions in the second-order probabilistic sensitivity analysis, TEVAR dominated OR in only 67.6%, TEVAR was more costly and effective in 9.44%, and its ICER was less than or equal to the WTP, so it was cost-effective. OR was more costly and effective in 8.18%, but its ICER was greater than the WTP, so TEVAR was optimal; TEVAR was more costly and effective in 10.56%, but its ICER was greater than the WTP, so OR was optimal. OR was more costly and effective in 0.74%, and its ICER was less than or equal to the WTP, so it was optimal, and OR dominated TEVAR in 3.39% (Fig 5).

Table VI. Dominance report of two-way sensitivity analysis

Parameter	*ICER*
Probability paraplegia	OR dominated by TEVAR
Probability stroke	OR dominated by TEVAR
Probability renal failure	OR dominated by TEVAR
Probability 30-day mortality	OR dominated by TEVAR

ICER, Incremental cost-effectiveness ratio; *OR,* open repair; *TEVAR,* thoracic endovascular aortic repair.

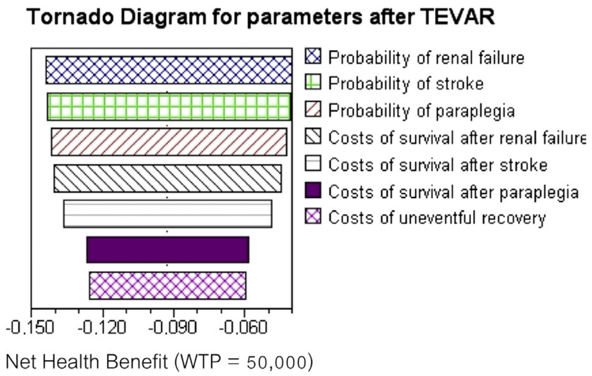

Fig 3. Tornado diagram shows the results of deterministic one-way sensitivity analyses. Each *bar* represents a sensitivity variable, and the width of a *horizontal bar* denotes the effect of each parameter's uncertainty on the base-case value. The net health benefit was calculated with a threshold willingness-to-pay (*WTP*) of €50,000 per quality-adjusted life year (QALY) gained. This tornado diagram shows that the results are most sensitive to the probability of renal failure after thoracic endovascular aortic repair (*TEVAR*).

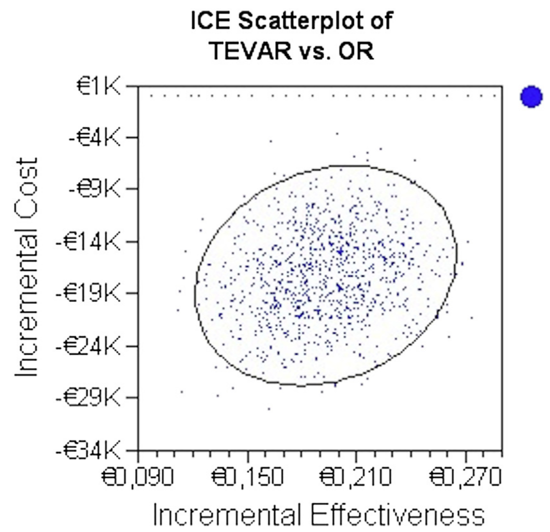

Fig 4. Incremental cost-effectiveness (*ICE*) scatter plot. Bootstrap replications show the difference in costs and quality-adjusted life-years (QALYs) on the cost-effectiveness plane between patients undergoing thoracic endovascular aortic repair (*TEVAR*) or open repair (*OR*) at 1 year of follow-up. Each *dot* represents one iteration in a Monte Carlo simulation (10,000 iterations). The *diagonal line* indicates a maximum willingness-to-pay (WTP) per QALY of €50,000 at 1 year. For clarity, only 1000 of 10,000 simulated data points are shown. The *ellipse* delineates the 95% confidence interval.

DISCUSSION

The present decision analytical model found compelling evidence for the following hypothesis: even when taking into account the cost of the endograft, the cost of conversion to OR, and the cost of reintervention and surveillance, patients treated with TEVAR for acute complicated TBADs dissipate less money in the first postoperative year than patients treated with OR, in addition to improved TEVAR outcomes. This makes TEVAR a dominant treatment option for acute complicated TBADs in the first postoperative year.

The reduction of costs caused by TEVAR in the first postoperative year is significantly higher compared with OR, especially when the treatment costs of patients who develop paraplegia are factored in. It is well documented that paraplegia treatment may produce costs >$100,000 in the first year and costs ~$5400 per year in perpetuity after the fifth year.[35]

However, whether these cost savings of TEVAR compared with OR are durable over time remains to be evidenced, and we did not examine the effect of late interventions after TEVAR or OR beyond the time horizon of 1 year in our model. Probably, the costs of TEVAR will be partly increased by the costs of surveillance and reintervention during subsequent follow-up, but these costs may be equated, at least partially, by the decreased paraplegia rate of TEVAR and the costs associated with paraplegia.[35] However, reintervention rates and costs for OR in the follow-up period are not to be undervalued, especially since as improved technologies and indication-specific endograft design will arise, we assume the benefits of TEVAR compared with OR will increase.

The literature reporting costs and cost-effectiveness of TEVAR vs OR is rather heterogeneous regarding the clinical indication for the procedures, the included cost levels, and follow-up times. Recently, seven studies compared the costs of TEVAR vs OR, but to the best of our knowledge, the present study represents the only cost-effectiveness study based on a meta-analysis that includes total direct 1-year costs for treatment of acute complicated TBADs.

Chung et al[43] analyzed traumatic thoracic aortic injuries and reported comparable procedure costs but higher follow-up cost for TEVAR (US $59,170 for OR vs $61,266 ± $428 per year for TEVAR). Tong et al[33] performed an economic comparison of TEVAR vs OR for the treatment of blunt traumatic thoracic aortic injuries with a time horizon of 1 year. In cost-effectiveness analysis, TEVAR was the dominant therapy over OR for this disease entity. The analysis of the 2005 to 2006 Nationwide Inpatient Sample of thoracic aortic traumas by Mousa et al[44]

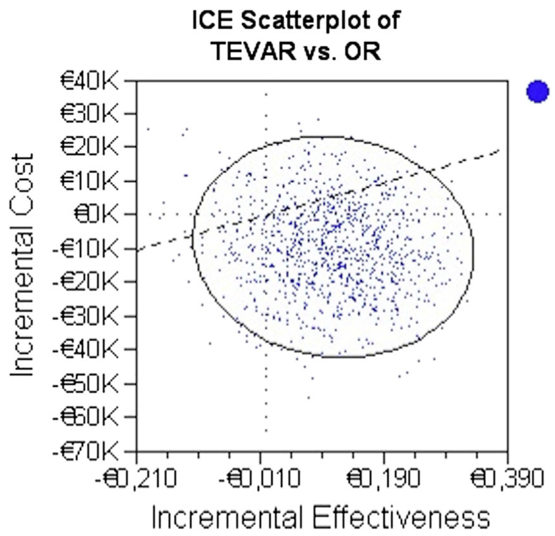

Fig 5. Incremental cost-effectiveness (*ICE*) scatter plot. Bootstrap replications show the difference in costs and quality-adjusted life-years (QALYs) on the cost-effectiveness plane between patients undergoing thoracic endovascular aortic repair (*TEVAR*) or open repair (*OR*) at 1 year of follow-up. Each *dot* represents one iteration in a Monte Carlo simulation (10,000 iterations). The *diagonal line* indicates a maximum willingness-to-pay (WTP) per QALY of €50,000 at 1 year. For clarity, only 1000 of 10,000 simulated data points are shown. The *ellipse* delineates the 95% confidence interval.

demonstrated significantly higher hospital costs of OR compared with TEVAR. Schuster et al[34] compared the hospital costs of TEVAR and OR in patients with thoracic aortic aneurysms. They found that the hospital costs of TEVAR compared favorably with OR, with a difference between total costs of the two procedures of €12,543.14.

Karimi et al[45] conducted a single-institution study comparing hospital and midterm outcomes and costs for elective TEVAR vs OR of descending thoracic aortic aneurysms at 2 years. Ongoing follow-up costs associated with complications incurred during the index surgery were not included (eg, dialysis costs, rehabilitation costs). Karimi et al[45] revealed that mean surveillance imaging costs for TEVAR were $1800.38 higher than for OR at 2 years; however, the cumulative cost analysis still favored TEVAR over OR at 2 years because of the lower initial hospitalization costs.

Narayan et al,[46] in a cost-effectiveness analysis of TEVAR vs OR, showed that TEVAR was associated with reduced morbidity and mortality in the short-term, although no cost benefit was associated with TEVAR in the short-term. In the long-term, due to increased risk of reinterventions, Narayan et al[46] concluded that TEVAR might actually prove to be a more expensive therapeutic option compared with OR.

Finally, Azizzadeh et al[47] performed an outcome analysis of TEVAR vs OR of blunt traumatic aortic injuries. Compared with TEVAR, patients who underwent OR had three times higher odds of a complication or in-hospital death. The mean total hospital cost of TEVAR was not significantly different compared with OR.

These studies largely support the results of the present analysis identifying TEVAR as a more cost-effective therapeutic option than OR in a variety of thoracic aortic pathologies. Only the study by Narayan et al[46] reported seemingly contradictory results. In their cohort, the long-term cost implications of TEVAR were postulated to be significant and to be largely influenced by the risk of reinterventions and costs of follow-up. However, when considering procedures for acute complicated TBADs, based on a current meta-analysis[7] covering only this subgroup, OR has a very high perioperative complication rate regarding paraplegia, stroke, and renal failure compared with TEVAR. These complications have a great impact on future costs during follow-up. As a result, the effect of surveillance imaging would be rather marginal in acute complicated TBADs, and the associated costs would make up only a minute part of the overall costs, which are largely dominated by the long-lasting and cost-driving complications of OR in this disease entity. In the long run, follow-up costs and reintervention costs (which probably will not be higher in the follow-up than already included in our 1-year analysis) might result in an ICER somewhat less favorable for TEVAR.

Despite the minimal invasiveness of TEVAR, studies performed to analyze and compare outcome and quality of life after surgical and endovascular intervention showed that TEVAR patients had no better overall quality of life and that anxiety and depression scores were not reduced by TEVAR compared with OR.[48]

This study has some limitations. A drawback of the present study, and also of other comparative studies on costs of (T)EVAR and OR is that none of them had a randomized design. This may have promoted selection bias.

The technical advances in the endovascular field and best medical treatment during the analyzed time period are further possible confounders to the improved outcomes seen with TEVAR in acute complicated TBADs compared with OR. There is significant literature heterogeneity in the type of devices used, the era of the study, the patient characteristics, and the management approaches.

The preoperative physical condition of the patient is a quantity that has one of the most significant influences of the outcome of any surgical procedure. In patients with TBADs, the preoperative degree of shock has a very important effect on the outcome of OR.[5] Unfortunately, in many of the studies included in the underlaying meta-analysis,[7] the incidence and degree of shock was not defined in detail or mentioned at all. Anyhow, 30% of the patients in the International Registry of Acute Aortic Dissection who underwent OR had signs of shock before surgery.[49]

In general, as with any modelling, the information available is not always complete, and assumptions had to be made when information was not disposable, especially concerning the costs. The transition probabilities in our decision tree analysis were obtained from current meta-analyses[7] and other high-quality studies.[10-26]

Finally, the present analysis adopts a public health system perspective, and indirect costs were not included. The reported costs therefore represent an underestimation of the actual costs associated with both procedures.

The strength of the present analysis is that we included ongoing follow-up costs associated with complications incurred during the index surgery (eg, paraplegia) at 1 year.

According to the Institute for Clinical and Economic Review Integrated Evidence Rating Table,[50] our review corresponds to category Aa (high confidence of the decision analysis results and a high certainty of a moderate-large net health benefit), ranking first on the 18-point evidence rating scale.

CONCLUSIONS

For patients who present with acute complicated TBADs, TEVAR decreases morbidity, mortality, and paraplegia compared with OR. In addition, the 1-year cost is less with TEVAR, making TEVAR the dominant therapy over OR for acute complicated TBADs. However, the long-term durability of the repair is unknown, and long-term follow-up will be required to see if the cost benefit is maintained over time.

AUTHOR CONTRIBUTIONS

Conception and design: TL, JB
Analysis and interpretation: TL, JB
Data collection: TL
Writing the article: TL
Critical revision of the article: TL, JB
Final approval of the article: TL, JB
Statistical analysis: TL
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