Comparative effectiveness of the treatments for thoracic aortic transaction

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Objectives: **To synthesize the available evidence regarding the outcomes associated with nonoperative management, open repair, and endovascular repair of thoracic aortic transection.**

Methods: **We searched electronic databases (MEDLINE, EMBASE Cochrane, Web of Science, and Scopus) for studies that enrolled patients with aortic transection and measured the outcomes of interest. Two reviewers determined study eligibility and extracted data. We estimated the event rate associated with the different approaches from case series and the relative risk from comparative studies. Estimates from each study were pooled using the random effects model.**

Results: **We found 139 studies that fulfilled the inclusion criteria, the majority of which were noncomparative surgical case series, retrospective, and none were randomized. Studies included 7768 patients, the majority of which were males. The mortality rate was significantly lower in patients who underwent endovascular repair, followed by open repair and nonoperative management (9%, 19%, and 46%, respectively, $P < .01$). No significant difference in event rate across the three groups was noted for the outcomes of anterior stroke, posterior stroke, or any stroke. The risk of spinal cord ischemia and end-stage renal disease were higher in open repair compared with the other 2 groups (9% vs 3% and 3%, $P = .01$ for spinal cord ischemia and 8% vs 5% and 3%, $P = .01$ for end-stage renal disease). Compared with endovascular repair, open repair was associated with an increased risk of graft infection and systemic infections. Meta-analyses of comparative studies demonstrated that compared with open repair, endovascular repair is associated with reduced mortality and spinal cord ischemia (relative risk, 0.61; 95% confidence interval, 0.46-0.80; and relative risk, 0.34; 95% confidence interval, 0.16-0.74; respectively). Inferences are limited by methodological quality, survival, and publication biases.**

Conclusions: **Very low-quality evidence suggests that, compared with open repair or nonoperative management, endovascular repair of thoracic aortic transection is associated with better survival and decreased risk of spinal cord ischemia, renal injury, and graft and systemic infections. Nonoperative management is associated with the least favorable outcomes.**
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Blunt traumatic thoracic aortic injury remains a highly lethal condition.[1] Of the patients that survive to reach medical care, the majority have significant associated injuries. Due to the mechanics of the injury, the most common location for thoracic aortic tear is at the isthmus. Traditionally, this injury has been repaired through a left thoracotomy, and the segment of injured aorta is replaced with an interposition graft or repaired primarily. This clamp-and-sew technique is associated with a significant incidence of paraplegia reported as high as 19.2%.[2] There have been a variety of surgical adjuncts described to reduce the incidence of paraplegia associated with the clamp-and-sew technique including a Gott shunt, partial left heart bypass, and cardiopulmonary bypass. These techniques have decreased the incidence of paraplegia but typically require partial or full heparinization. In patients with additional severe injuries, adjunctive techniques to repair a thoracic aortic transection are still associated with significant mortality. A contemporary study by the American Association of Trauma in 1997 reported a 14% mortality rate with open surgical repair and an overall paraplegia rate of 8.7%.[3] Medical management of blunt thoracic aortic injury to prioritize and address treatment of other organ injuries is possible in select patients. However, delayed repair of traumatic thoracic aortic injury is still associated with a risk of rupture of up to 6.7%, and mortality remains high in this subset of patients.[4]

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Endovascular stent graft repair of blunt traumatic thoracic aortic injury has emerged as a technique that addresses some of the limitations and morbidity associated with traditional open repair in this complex patient population. Multiple studies have shown a significant decrease in the incidence of paraplegia and mortality compared with open repair. A recent follow-up multicenter study by the American Association of Trauma examining blunt thoracic aortic injury treated with an endovascular stent graft repair found a 0.8% incidence of paraplegia and a mortality rate of 7.2% in patients managed with this modality.[5]

The Society for Vascular Surgery has formed a committee of experts in the treatment of thoracic aortic disease to formulate clinical practice guidelines to guide patients and surgeons in making treatment decisions. This committee commissioned this systematic review and meta-analysis to evaluate the quality of the evidence in the field and inform the formulation of practice recommendations. In this review, we systematically review and summarize the best available evidence regarding the outcomes of patients sustaining blunt traumatic thoracic aortic injury who were treated with endovascular stent graft, traditional open surgical repair, or nonoperative management.

METHODS

The report of this protocol-driven systematic review was approved by the Committee on Thoracic Aortic Disease from the Society for Vascular Surgery and is in adherence with the standards for reporting Meta-analyses of Observational Studies in Epidemiology (MOOSE).[6] The quality of evidence was rated using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) methods.[7]

Eligibility criteria

Eligible studies enrolled patients with thoracic aortic transection who were treated nonoperatively, via endovascular approach or via open repair. Realizing that the literature will likely consist of surgical case series and noncontrolled observational studies, we did not limit the eligibility criteria based on study design.

We included studies that measured the outcomes of interest including death, anterior circulation stroke, posterior circulation stroke, any stroke, spinal cord ischemia, end-stage renal disease, procedural failure (defined as the need for secondary procedure or conversion of endovascular to open repair), and systemic and graft infection. We defined spinal cord ischemia as permanent decrease or loss of lower extremity neurological function in the immediate postoperative period. Studies were included regardless of their language or duration of patient follow up. We excluded nonoriginal references (reviews, letters, etc) and case series with less than 10 patients.

Study identification

An expert reference librarian (PJE) designed and conducted the electronic search strategy with input from study investigators with expertise in conducting systematic reviews. To identify eligible studies, we searched electronic databases (MEDLINE, EMBASE Cochrane, Web of Science, and Scopus) from 1990 through June 2009. We considered studies published before that date to be less relevant considering the advancements in surgical techniques and perioperative care. We also sought references from experts, bibliographies of included trials, and the ISI (Institute for Scientific Information) Science Citation Index for publications that cited included studies. MeSH and EMBASE subject headings were primarily used to describe the aorta with subheadings and text words used to describe the surgical procedures. The outcomes of concern were combined with all terms. Detailed search strategy is available in the Appendix (online only).

Reviewers (AR, RM, JC, AA) working independently and in duplicates screened all titles and abstracts for eligibility. Eligible references were retrieved in full text and reviewed in duplicate. The chance-adjusted inter-reviewer agreement (kappa statistic) about study eligibility ranged from 0.77 to 0.89. Disagreements were resolved by consensus (the two reviewers [AR, MM] discussed the study and reached a consensus). When disagreement persisted, a third reviewer adjudicated the reference.

Data collection

Two reviewers working independently used a standardized online data extraction form to extract data from eligible studies. We extracted descriptive data of included patients (number of patients in each study arm, age, gender, the extent of traumatic injuries, type of surgical procedure, type of graft, percentage of left subclavian coverage, and time between injury and treatment); descriptive data of study characteristics (design, year of publication, and length of follow-up); and outcome data (death, anterior circulation stroke, posterior circulation stroke, any stroke, spinal cord ischemia, end-stage renal disease, procedural failure, and systemic and graft infection).

Statistical analysis

Meta-analysis. For uncontrolled studies, we estimated the event rate and the 95% confidence interval (CI) of the outcomes of interest. For controlled studies (comparative studies [ie, studies in which patients underwent different treatment modalities such as open repair, endovascular repair, or nonoperative management]), we estimated the relative risk (RR) and the 95% CI. Then, estimates from individual studies were pooled using a random-effects model.[8] We chose this model a priori anticipating significant heterogeneity. We used the I^2 statistic, which estimates the percentage of heterogeneity across studies that is due to heterogeneity rather than chance.[9] I^2 values of ≤25%, 50%, and ≥75% represent low, moderate, and high heterogeneity, respectively.

Meta-regression and subgroup analysis. We performed meta-regression using a mixed-effects model to determine whether a linear relationship exists between the a priori established covariates (the independent variables) and the logit event rate of the outcomes of interest (depen-

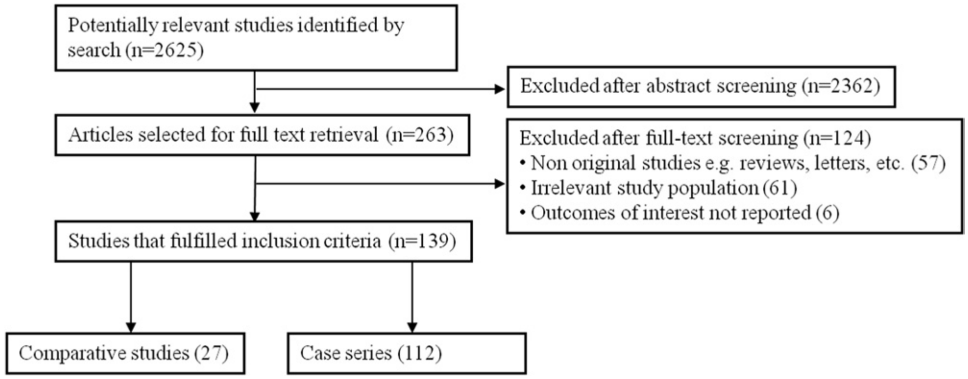


Fig 1. Study selection process.

dent variable).[10] Such associations may have clinical implications and help explain heterogeneity. The covariates and rationale for choosing them were: year of publication (newer studies may have better outcomes due to advancements in medical and surgical care), Injury Severity Score (ISS; patients with worse injuries at presentation are expected to have worse outcomes regardless of procedure), age (older patients may have worse prognosis), lag time between injury and procedure (survival bias), and the percentage of left subclavian artery (LSA) coverage (shown to be associated with increased complications such as arm and vertebrobasilar ischemia).[11] We also compared in subgroup analysis the effect of early versus late repair on mortality. Statistical analysis was conducted using Comprehensive Meta-Analysis, Version 2 (Biostat Inc, 2005, Englewood, NJ).

Publication bias. We visually inspected funnel plots and conducted Egger's regression test to evaluate the impact of publication bias. In this regression model, we use precision (the inverse of the standard error) to predict the effect size; hence, the size of the treatment effect is captured by the slope of the regression line, and bias is captured by the intercept.[10]

RESULTS

Study identification

Fig 1 depicts our search and selection procedures. We found 139 studies that fulfilled the inclusion criteria of this systematic review. Studies consisted of 112 case series (noncomparative) and 27 comparative observational nonrandomized studies. All but eight[3,5,12-17] were retrospective. The characteristics of the included studies are summarized in the supplemental Table (online only).

These studies included 7768 patients, the majority of which (77%) were males. Average age for patients treated nonoperatively, via endovascular approach, and via open repair were 39, 39, and 36 years, respectively. The median study sample size was 15, and median follow-up was 2 years. The median ISS for patients treated nonoperatively, via endovascular approach, and via open repair were 36, 40, and 34, respectively. The lag time between injury and procedure was 16 hours in the open repair group and 19 hours in the endovascular group. The LSA was covered in 30% of patients who received endovascular procedures.

Meta-analysis

The summary of all meta-analyses is presented in the Table and shows the 95% CIs of event rates, associated heterogeneity, and *P* value for test of interaction comparing the three different approaches. The mortality rate was significantly lower in patients who underwent endovascular repair, followed by open repair and nonoperative management (9%, 19%, and 46%, respectively; $P < .01$; supplemental Figs 1-3 in Appendix, online only). No significant difference in event rate across the three groups was noted for the outcomes of anterior stroke, posterior stroke, or any stroke. The risk of spinal cord ischemia and end-stage renal disease were higher in open repair compared with the other two groups (9% vs 3% and 3%; $P = .01$ for SCI and 8% vs 5% and 3%; $P = .01$ for ESRD). Compared with endovascular repair, open repair was associated with increased risk of graft infection and systemic infections, the most common of which was pneumonia.

There was a trend for increased risk of procedural failure (need for a second procedure) in the endovascular repair compared with the open repair group ($P = .07$). This procedural failure occurred in 83 (5.4%) patients, and the most common causes were endoleak (50, 60%), stent graft collapse (9, 11%), intraoperative rupture (2, 2%), iliac artery injury (1, 1%), penetration of metal stent (1, 1%); the remaining 20 (25%) were described as device-related failures that required a secondary intervention. The outcomes of the 50 endoleaks (15 of them were specifically described as type 1, and the rest were nonspecified) were only described in 13 patients. (One was treated with coil embolization, two resolved spontaneously, five required open conversion, and five required placement of additional cuffs.)

Meta-analyses of comparative studies demonstrated that, compared with open repair, endovascular repair is associated with reduced mortality and spinal cord ischemia (RR, 0.61; 95% CI, 0.46-0.80; $I^2 = 0\%$; Fig 2; and RR, 0.34; 95% CI, 0.16-0.74; $I^2 = 0\%$; Fig 3; respectively).

Table. Random effect meta-analyses of outcomes of interest in surgical case series

	Number of studies	*Event rate*	*LL*	*UL*	I^2 *(%)*	P *interaction*
Death						
Nonoperative management	18	0.46	0.31	0.61	75	.01
Endovascular repair	73	0.09	0.07	0.12	48	
Open repair	91	0.19	0.17	0.22	61	
Anterior stroke						
Nonoperative management	4	0.05	0.01	0.18	0	.78
Endovascular repair	34	0.03	0.02	0.05	0	
Open repair	14	0.03	0.02	0.07	0	
Posterior stroke						
Nonoperative management	4	0.05	0.01	0.18	0	.75
Endovascular repair	35	0.03	0.02	0.05	0	
Open repair	14	0.04	0.02	0.07	0	
Any stroke						
Nonoperative management	6	0.02	0.00	0.13	69	.90
Endovascular repair	49	0.03	0.02	0.05	0	
Open repair	24	0.03	0.02	0.05	2	
Spinal cord ischemia						
Nonoperative management	8	0.03	0.01	0.13	63	.01
Endovascular repair	64	0.03	0.02	0.04	0	
Open repair	76	0.09	0.07	0.10	34	
End-stage renal disease						
Nonoperative management	4	0.05	0.01	0.18	0	.01
Endovascular repair	28	0.03	0.02	0.05	0	
Open repair	40	0.08	0.07	0.10	33	
Procedure failure						
Endovascular repair	60	0.10	0.08	0.12	11	.07
Open repair	19	0.06	0.04	0.09	0	
Systemic infection						
Nonoperative management	4	0.05	0.01	0.18	0	.01
Endovascular repair	24	0.05	0.02	0.09	62	
Open repair	40	0.13	0.10	0.17	72	
Graft infection						
Endovascular repair	19	0.03	0.01	0.05	0	.01
Open repair	24	0.11	0.07	0.19	86	

LL, Lower limit of 95% confidence interval; *UL*, upper limit of 95% confidence interval.

There were no statistically significant differences for the other outcomes of interest, for which analyses were severely underpowered.

Meta-regression and subgroup analysis

The lag time between aortic injury and performing the endovascular or open procedures correlated with improved survival, suggesting both ecological and survival biases. That is, patients who survived longer after their injury had better outcomes regardless of procedure (*P* of .04 and .05 for endovascular and open repair, respectively). The severity of injury (ISS) correlated with mortality after open repair but not endovascular repair (*P* of .01 and .68, respectively). There were no other significant linear associations between the event rates of death, stroke, procedural failure, and the other a priori established covariates.

The comparison of urgent versus delayed repair was presented in two studies. The first one by Hemmila et al, in which open repair was used, was unable to detect difference in mortality (early repair 3/33 [9%], delayed repair 9/45 [20%], *P* = NS) but showed increased rate of complications (2.1 vs 1.5 incidents per patient) and longer hospital stay (33.1 vs 20.9 days) with delayed repair. The mean time-to-repair was 10.8 hours vs 17.7 days.[18] Similarly, the second study by Pacini et al, in which endovascular and open repair were used, also failed to show a difference in mortality (early repair 4/21 [19%], delayed repair 2/48 [4.2%], *P* = NS). In this study, the mean time-to-repair was 8 hours vs 3.4 months.[19] Meta-analysis of mortality across the two studies shows no significant difference in mortality (RR for early vs delayed is 2.30; 95% CI, 0.61-4.00).

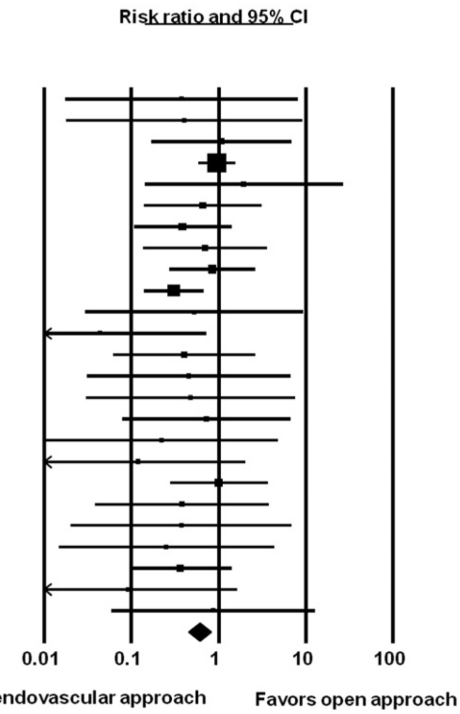
Publication bias

We found evidence of publication bias for the outcome of death, suggesting that case series with higher event rates may have been unpublished (*P* values for Egger's test for endovascular, surgical, and nonoperative management are .01, .01, and .04, respectively).

DISCUSSION

We conducted a systematic review of the literature to compare the effectiveness of the different approaches for treatment of patients with thoracic aortic transection due to blunt trauma. As expected in a disease that is fairly rare and fatal, the available literature consists of small nonrandom-

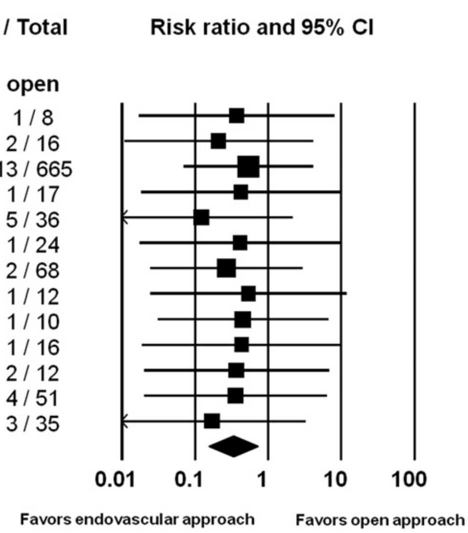
	Risk ratio	Lower limit	Upper limit	Events / Total endov	Events / Total open
Akowuah	0.38	0.02	7.96	0 / 7	1 / 8
Amabile	0.40	0.02	8.78	0 / 9	1 / 11
Andrassy	1.07	0.17	6.64	2 / 15	2 / 16
Arthurs	0.94	0.60	1.49	17 / 95	126 / 665
Baguley	1.93	0.14	25.75	0 / 1	3 / 26
Broux	0.65	0.14	3.04	2 / 13	4 / 17
Buz	0.38	0.11	1.37	3 / 39	7 / 35
Chung	0.69	0.14	3.50	2 / 26	4 / 36
Cook	0.84	0.28	2.56	4 / 19	6 / 24
Demetriades	0.31	0.14	0.66	9 / 125	16 / 68
Doss	0.52	0.03	9.04	0 / 4	2 / 12
Feezor	0.04	0.00	0.71	0 / 22	7 / 14
Kasirajan	0.40	0.06	2.57	1 / 5	5 / 10
Kokotsakis	0.45	0.03	6.56	1 / 22	1 / 10
Kuhne	0.47	0.03	7.38	0 / 5	6 / 36
Lebl	0.71	0.08	6.43	1 / 7	2 / 10
McPhee	0.22	0.01	4.60	0 / 8	1 / 5
Midgley	0.12	0.01	1.96	0 / 12	5 / 16
Moainie	1.00	0.28	3.58	4 / 26	4 / 26
Mohan	0.38	0.04	3.67	1 / 16	2 / 12
Ott	0.37	0.02	6.71	0 / 6	2 / 12
Pacini	0.25	0.01	4.20	0 / 15	6 / 51
Riesenman	0.36	0.10	1.36	2 / 14	19 / 48
Rousseau	0.09	0.01	1.57	0 / 29	6 / 35
Yamane	0.86	0.06	12.28	1 / 14	1 / 12
	0.61	**0.46**	**0.80**		



Meta Analysis

Fig 2. Mortality.

	Risk ratio	Lower limit	Upper limit	Events / Total endov	Events / Total open
Akowuah	0.38	0.02	7.96	0 / 7	1 / 8
Andrassy	0.21	0.01	4.10	0 / 15	2 / 16
Arthurs	0.54	0.07	4.07	1 / 95	13 / 665
Broux	0.43	0.02	9.74	0 / 13	1 / 17
Chung	0.12	0.01	2.16	0 / 26	5 / 36
Cook	0.42	0.02	9.69	0 / 19	1 / 24
Demetriades	0.27	0.03	2.95	1 / 125	2 / 68
Doss	0.54	0.02	11.75	0 / 7	1 / 12
Kokotsakis	0.45	0.03	6.56	1 / 22	1 / 10
Midgley	0.44	0.02	9.85	0 / 12	1 / 16
Ott	0.37	0.02	6.71	0 / 6	2 / 12
Pacini	0.36	0.02	6.35	0 / 15	4 / 51
Rousseau	0.17	0.01	3.19	0 / 29	3 / 35
	0.34	**0.16**	**0.74**		



Meta Analysis

Fig 3. Spinal cord ischemia.

ized case series. Our results demonstrate that the nonoperative approach is associated with the highest mortality rate. Compared with the open approach, the endovascular approach seems to be associated with a lower mortality rate, spinal cord ischemia, end-stage renal disease, and systemic and graft infection. However, the endovascular approach was associated with a trend for an increased need for a secondary procedure.

The main limitation of this systematic review is the very low quality of evidence due to 1) methodological limitations of the included studies that relates to the nonrandomized design of the studies and the obvious survival and publication biases, 2) imprecision caused by the small number of events and small sample size of the combined body of literature, and 3) the inability of the present literature to identify subgroups of patients that may have a differential favorable response to a particular treatment over the other. It is plausible that the underlying aortic pathology or other nonaortic injuries rather than the procedure itself is what is ultimately affecting survival. We did not find a significant difference in mortality between early versus delayed repair, suggesting that, in certain patients, repair can be delayed if other extensive injuries require stabilization before operating on the aortic injury. However, this inference should be considered with extreme caution considering the very small number of events (imprecision), heterogeneity between the two studies (in terms of definition of early vs late repair and the inconsistent point estimates of the studies), and the looming effect of survival bias.

The strengths of this review stem from the comprehensive literature search that spanned across several databases and the bias protection measures undertaken in the conduct of the review, such as selecting studies and extracting data in duplicates.

The clinical implications of this review will be evaluated and presented in the accompanying guideline document prepared by the Committee on Thoracic Aortic Disease from the Society for Vascular Surgery.[20] The committee will consider the comparative effectiveness of these approaches on the outcome of interest reported here, as well as other factors such as cost, patients' values, and preferences and availability of surgical expertise and anatomic/clinical feasibility of the different procedures.

Considering that aortic transsection is fairly uncommon, future studies will be best conducted by collaborations of multiple centers. Such collaboration will lead to a larger number of events and allow stratified analyses according to multiple prognostic factors such as age, injury severity, and aortic pathology. Prospective meta-analysis (preplanned pooling of studies before recruitment) is also strongly recommended in this setting.

CONCLUSION

Very low-quality evidence suggests that, compared with open repair or nonoperative management, endovascular repair of thoracic aortic transection is associated with better survival and decreased risk of spinal cord ischemia, renal injury, and graft and systemic infections. Nonoperative management is associated with the least favorable outcomes. Delayed repair may be appropriate in selected patients.

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AUTHOR CONTRIBUTIONS

Conception and design: MM
Analysis and interpretation: MM, AR, RM, JC, AA, PE, WL, RF
Data collection: MM, AR, RM, JC, AA, PE
Writing the article: MM
Critical revision of the article: MM
Final approval of the article: MM, AR, RM, JC, AA, PE, WL, RF
Statistical analysis: MM
Obtained funding: MM
Overall responsibility: MM
MM and AR contributed equally to this systematic review.

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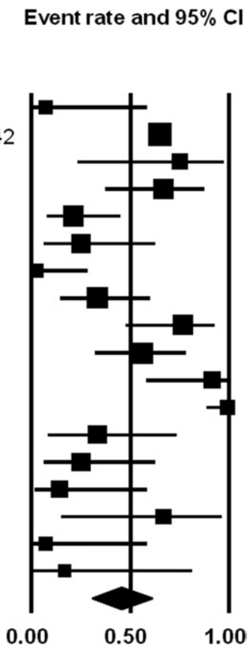
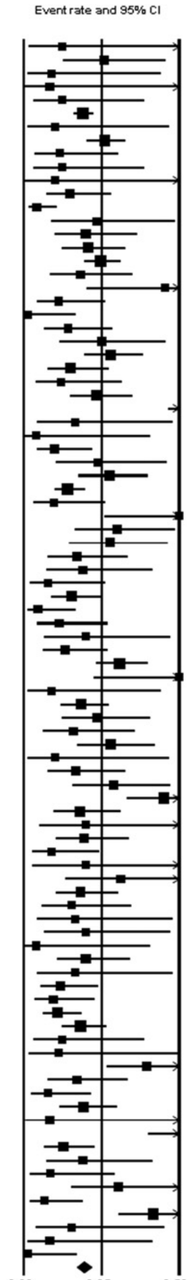
Additional material for this article may be found online at www.jvascsurg.org.

	Event rate	Lower limit	Upper limit	Total
Anderson	0.07	0.00	0.58	1 / 7
Arthurs	0.65	0.63	0.67	1067 / 1642
Benjamin	0.75	0.24	0.97	3 / 4
Camp	0.67	0.38	0.87	8 / 12
Chung	0.21	0.08	0.45	4 / 19
Cook	0.25	0.06	0.62	2 / 8
Galli	0.02	0.00	0.28	1 / 22
Holmes	0.33	0.15	0.59	5 / 15
Jamieson	0.77	0.48	0.92	10 / 13
Karmy-Jones	0.56	0.32	0.78	9 / 16
Kasirajan	0.92	0.59	0.99	11 / 12
Kodali	0.99	0.89	1.00	67 / 67
Kwon	0.33	0.08	0.73	2 / 6
Lebl	0.25	0.06	0.62	2 / 8
Pierangeli	0.14	0.02	0.58	1 / 7
Pate	0.67	0.15	0.96	2 / 3
Rousseau	0.07	0.00	0.58	1 / 7
Stampfl	0.17	0.01	0.81	1 / 3
	0.46	**0.31**	**0.61**	



Supplemental Fig 1, online only. Mortality in transection patients undergoing non operative management.

	Event rate	Lower limit	Upper limit	Total
Akowuah	0.13	0.02	0.54	1 / 8
Albrink	0.26	0.13	0.45	7 / 27
Amabile, 2004	0.09	0.01	0.44	1 / 11
Anderson	0.08	0.01	0.62	1 / 6
Andrassy	0.13	0.03	0.39	2 / 16
Arthurs	0.19	0.16	0.22	126 / 665
Artigues	0.10	0.01	0.47	1 / 10
Attar	0.26	0.20	0.33	50 / 192
Baguley	0.12	0.04	0.30	3 / 26
Benjamin	0.13	0.03	0.39	2 / 16
Botta	0.10	0.01	0.67	1 / 5
Bouchart, 1992	0.15	0.07	0.28	7 / 47
Bouchart, 2001	0.04	0.02	0.10	4 / 97
Broux	0.24	0.09	0.49	4 / 17
Buz	0.20	0.10	0.36	7 / 35
Camp	0.21	0.12	0.32	13 / 63
Cardarelli	0.25	0.19	0.31	54 / 219
Cernaianu	0.18	0.08	0.35	6 / 33
Chittithavorn	0.45	0.20	0.73	5 / 11
Chung	0.11	0.04	0.26	4 / 36
Clark	0.01	0.00	0.16	1 / 42
Contino	0.14	0.07	0.28	6 / 42
Cook	0.25	0.12	0.46	6 / 24
Cowley	0.28	0.20	0.38	25 / 89
Crestanello	0.15	0.08	0.27	8 / 53
DelRossi	0.12	0.04	0.31	3 / 25
Demetriades	0.24	0.15	0.35	16 / 68
Deree	0.62	0.47	0.75	26 / 42
Doss, 2003	0.17	0.04	0.48	2 / 12
Doss, 2005	0.04	0.00	0.40	1 / 13
Downing	0.10	0.04	0.22	5 / 50
Duwayri	0.24	0.10	0.46	5 / 21
Eddy	0.27	0.18	0.40	17 / 62
Fabian	0.14	0.10	0.19	29 / 207
Fasquel	0.10	0.03	0.26	3 / 31
Feezor, 2009	0.50	0.26	0.74	7 / 14
Forbes	0.30	0.16	0.48	9 / 30
Franchello	0.28	0.14	0.46	8 / 29
Frick	0.17	0.08	0.33	6 / 35
Galli	0.19	0.07	0.41	4 / 21
Gammie	0.08	0.02	0.26	2 / 26
Hemmila	0.15	0.09	0.25	12 / 78
Hilgenberg	0.05	0.01	0.16	2 / 44
Hochheiser	0.11	0.04	0.27	4 / 35
Holmes	0.20	0.07	0.47	3 / 15
Jamieson	0.13	0.06	0.27	6 / 45
Karmy-Jones	0.31	0.23	0.40	37 / 120
Kasirajan	0.50	0.22	0.78	5 / 10
Hormuth	0.09	0.01	0.44	1 / 11
Hunt	0.18	0.12	0.27	18 / 98
Kieny	0.24	0.12	0.40	8 / 34
Klima	0.16	0.06	0.36	4 / 25
Kodali	0.28	0.17	0.42	14 / 50
Kokotsakis	0.10	0.01	0.47	1 / 10
Kuhne	0.17	0.08	0.32	6 / 36
Kwon	0.29	0.16	0.47	9 / 31
Lancey	0.45	0.33	0.58	28 / 62
Langanay	0.18	0.10	0.31	9 / 50
Lebl	0.20	0.05	0.54	2 / 10
Lee-s	0.20	0.11	0.34	9 / 46
Maggisano	0.09	0.03	0.24	3 / 34
McPhee	0.20	0.03	0.69	1 / 5
Midgley	0.31	0.14	0.57	5 / 16
Miller-s	0.18	0.10	0.30	11 / 60
Moainie	0.15	0.06	0.35	4 / 26
Mohan	0.17	0.04	0.48	2 / 12
Ndiaye	0.20	0.07	0.47	3 / 15
Nishimoto	0.04	0.00	0.40	1 / 13
Nocolosi	0.20	0.11	0.34	9 / 45
Ott	0.17	0.04	0.48	2 / 12
Pacini	0.12	0.05	0.24	6 / 51
Pierangeli	0.10	0.04	0.23	4 / 42
Pate	0.11	0.06	0.19	11 / 101
Razzouk	0.18	0.12	0.26	21 / 115
Read, 1993	0.13	0.03	0.39	2 / 16
Reed, 2006	0.11	0.02	0.50	1 / 9
Riesenman	0.40	0.27	0.54	19 / 48
Rousseau	0.17	0.08	0.33	6 / 35
Santini	0.08	0.03	0.21	3 / 39
Schmidt	0.19	0.12	0.30	14 / 73
Stampfl	0.08	0.01	0.62	1 / 6
Stulz	0.62	0.40	0.80	13 / 21
Sweeney	0.13	0.07	0.23	9 / 71
Symbas	0.19	0.07	0.41	4 / 21
Tiraboschi	0.09	0.02	0.29	2 / 23
Von Oppell	0.30	0.15	0.52	7 / 23
Wahl	0.07	0.02	0.19	3 / 45
Whitson	0.42	0.31	0.54	28 / 67
Xabregas	0.15	0.04	0.45	2 / 13
Yamane	0.08	0.01	0.41	1 / 12
Zeiger	0.01	0.00	0.17	1 / 41
	0.19	0.17	0.22	



Supplemental Fig 2, online only. Mortality in transection patients undergoing open repair.

	Event rate	Lower limit	Upper limit	Total
Agostinelli	0.14	0.04	0.43	2 / 14
Akowuah	0.06	0.00	0.54	1 / 8
Alsac	0.18	0.08	0.36	5 / 28
Amabile, 2004	0.05	0.00	0.47	1 / 10
Amabile, 2006	0.04	0.00	0.38	1 / 14
Andrassy	0.13	0.03	0.41	2 / 15
Arthurs	0.18	0.11	0.27	17 / 95
Attia, 2007	0.18	0.05	0.51	2 / 11
Attia, 2008	0.14	0.04	0.35	3 / 22
Bent	0.04	0.00	0.38	1 / 14
Bortone	0.02	0.00	0.25	1 / 25
Botta	0.02	0.00	0.23	1 / 28
Broux	0.15	0.04	0.45	2 / 13
Brown	0.05	0.01	0.28	1 / 20
Buz	0.08	0.03	0.21	3 / 39
Canaud	0.04	0.01	0.22	1 / 27
Chung	0.08	0.02	0.26	2 / 26
Cook	0.21	0.08	0.45	4 / 19
Day	0.07	0.02	0.25	2 / 27
Demetriades	0.07	0.04	0.13	9 / 125
Dessl	0.03	0.00	0.37	1 / 15
Doss-a	0.10	0.01	0.67	1 / 5
Doss-b	0.06	0.00	0.54	1 / 8
Dunham	0.06	0.01	0.34	1 / 16
Fattori	0.03	0.00	0.30	1 / 20
Feezor	0.02	0.00	0.27	1 / 23
Go	0.05	0.00	0.45	1 / 11
Hoornweg	0.14	0.05	0.32	4 / 28
Juszkat	0.08	0.01	0.39	1 / 13
Karmy-Jones	0.27	0.09	0.59	3 / 11
Kasirajan	0.20	0.03	0.69	1 / 5
Kaya	0.01	0.00	0.16	1 / 42
Khoynezhad	0.08	0.01	0.41	1 / 12
Kokotsakis	0.05	0.01	0.26	1 / 22
Kuhne	0.08	0.01	0.62	1 / 6
Kurimoto	0.15	0.04	0.45	2 / 13
Lachat	0.08	0.01	0.41	1 / 12
Lebl	0.14	0.02	0.58	1 / 7
Leurs	0.06	0.02	0.17	3 / 50
Marcheix	0.01	0.00	0.20	1 / 34
McPhee	0.06	0.00	0.50	1 / 9
Meites	0.02	0.00	0.26	1 / 24
Melnitchouk	0.07	0.01	0.35	1 / 15
Methodius-Ngwodo	0.02	0.00	0.22	1 / 30
Michelet	0.05	0.00	0.45	1 / 11
Midgley	0.04	0.00	0.40	1 / 13
Moainie	0.15	0.06	0.35	4 / 26
Mohan	0.06	0.01	0.34	1 / 16
Neschis	0.20	0.08	0.43	4 / 20
Neuhauser	0.05	0.00	0.45	1 / 11
Orend, 2007	0.01	0.00	0.19	1 / 35
Orend, 2002	0.09	0.01	0.44	1 / 11
Orend, 2003	0.17	0.04	0.48	2 / 12
Ott	0.07	0.00	0.58	1 / 7
Peterson	0.04	0.00	0.42	1 / 12
Pratesi	0.09	0.01	0.44	1 / 11
Raupach	0.08	0.01	0.39	1 / 13
Reed	0.23	0.08	0.52	3 / 13
Richeux	0.03	0.00	0.34	1 / 17
Riesenman	0.14	0.04	0.43	2 / 14
Rodriguez	0.04	0.00	0.42	1 / 12
Rosenthal	0.06	0.02	0.22	2 / 31
Rousseau	0.02	0.00	0.22	1 / 30
Scharrer-Pamler	0.13	0.03	0.41	2 / 15
Scheinert	0.05	0.00	0.45	1 / 11
Stampfl	0.08	0.01	0.62	1 / 6
Steingruber	0.02	0.00	0.27	1 / 23
Tambyraja	0.59	0.46	0.71	35 / 59
Tehrani	0.07	0.02	0.23	2 / 30
Tespili	0.06	0.01	0.32	1 / 17
Yamane	0.07	0.01	0.37	1 / 14
Zipfel, 2008	0.10	0.01	0.47	1 / 10
Zipfel, 2007	0.03	0.00	0.20	1 / 31
	0.09	**0.07**	**0.12**	

Supplemental Fig 3, online only. Mortality in transection patients undergoing endovascular repair.

Supplemental Table, online only. Description of included studies

Author	*Year*	*Age*	*% Females*	*% Fractures*	*% Head injury*
Agostinelli[12]	2006	42	27	87	40
Akowuah[21]	2007	30	25	100	20
Albrink[22]	1994	37	20	Extremities, 48; pelvic 33; vertebral, 18.5; facial 15	20
Alsac[23]	2008	45	29	Probably 100 (Ribs, 79; Upper extremity, 43; Lower extremity, 39; vertebral body, 43, pelvic, 32)	46
Amabile[24]	2006	33	8	69	23
Amabile[25]	2004	31	15	30	25
Anderson[26]	2008	14	28	91	0
Andrassy[27]	2006	44 endovascular, 38 open	23	71	68
Arthurs[28]	2009	41	28	Nr	31
Artigues[29]	1999	36	10	80	40
Attar[30]	1999	35	23	—	—
Attia[31]	2008	NR	NR	—	—
Attia[32]	2007	37	9	—	—
Baguley[33]	2005	42	17	Nr	NR
Benjamin[34]	2008	44	40	80	30
Bent[13]	2007	43	15	92	38
Bortone[35]	2004	31	NR	—	—
Botta[36]	2008	37	13	63	NR
Bouchart[37]	1992	33	23	50	68
Bouchart[38]	2001	33	NR	67	75
Broux[39]	2006	46 endovascular; 35 open	30	—	90
Brown[40]	2008	NR	NR	—	—
Buz[41]	2008	36	15	—	42
Camp[42]	1994	39	23	5	13
Canaud[43]	2008	40	30	33	37
Cardarelli[44]	2002	42	25	—	—

Supplemental Table, online only. Continued.

Other injuries (%)	*Severity of injury*	*Study design*	*Follow up (d)*	*Choice of procedure**
Lung contusion, 86; liver laceration, 13; spleen injury, 20; spine fracture, 20; atriocaval laceration, 7	5 patients with a Glasgow coma score <8 (unconscious)	Prospective	870	Na
Lung contusion, 26; spleen injury, 26	Mean ISS, 43	Retrospective	—	Based on surgeon's choice (prior to 2004, OR; after 2004, ER)
Cardiac, 15; pulmonary, 18; spleen, 15; liver, 11; pancreas, 4; bladder, 4, diaphragm, 8	—	Retrospective	—	Na
Pulmonary contusion, 71; myocardial contusion, 25, spleen, 21, liver, 28, kidney, 21; mesenteric hematoma, 7	Mean ISS,49, mean RTS, 5.9; mean predicted mortality, 55.6%	Retrospective	720	Na
—	—	Retrospective	399	Na
Spleen, 25; liver, 15; diaphragm, 10; kidney, 15; pulmonary, 20	—	Retrospective	789	Since stent grafts were available it changed the practice.
Small bowel, 36%, chest trauma, 18%; colon, 27%; kidney, 18%, liver, 27%; spleen, 18%	Mean ISS: 24.3 (thoracic pts); 21.2 (abdominal pts)	Retrospective	480	Unclear
Pulmonary, 58, intra-abdominal, 32; spleen, 19; liver, 19, heart, 19; bladder, 10; kidney, 3; bowel perforation, 3	—	Retrospective	Endovascular, 1080; open, 3510	Available stent grafts after 1997 replacing open surgery
Major abdominal injuries, 29% (696); pelvic injuries, 15% (360)	Mean ISS, 40	Retrospective	—	Unclear
Pulmonary, 60; splenic injury, 30; bowel perforation, 20; cardiac contusion, 10	—	Retrospective	—	NA
—	—	Retrospective	—	Based on surgeon's choice
—	—	Retrospective	—	NA
Heart, 7; pulmonary, 7	—	Retrospective	522	NA
—	—	Retrospective	—	Based on surgeon's choice
Pulmonary, 50; abdominal, 65, liver, 45, spleen, 25; deprogram, 5	ISS, 38	Retrospective	—	4 patients treated nonoperatively but with no clear criteria for that
Pulmonary: 46%, Abdominal trauma: 23%	—	Prospective	867	Based on surgeon's choice
—	—	Retrospective	—	Unclear
—	Revised trauma score, 9.3 (endo repair); 9.9 (open repair)	Retrospective	981	Based on surgeon's choice
Abdominal, 11, cardiac, 2; diaphragm, 6; spleen, 13; liver, 13; mesenterium, 2	—	Retrospective	—	NA
Overall thoracic, 37.2; abdominal, 23.5; lung contusion, 37.25; hemopericardium, 11; diaphragmatic rupture, 7.8, cardiac contusion, 2	—	Retrospective	3285	Based on surgeon's choice
Spine injury, 20; ARDS, 60; myocardial contusion, 40; abdominal trauma, 43; pelvic injury, 63; hemorrhagic shock, 60	ISS: 46 (ESG); 36 (open)	Retrospective	930	Unclear
—	—	Retrospective	—	NA
—	Mean ISS: 34 (open repair group); 41 (endovascular group)	Retrospective	2190 (open repair group); 803 (endovascular group)	Unclear
Abdominal, 19; pelvic, 8; spine, 7; thoracic, 44; extremities, 5 (fractures)	ISS, 47.5; RTS, 6.4; TS, 11.5	Retrospective	—	Unclear
Lung contusion, 48%; pneumothorax, 22%; hemothorax, 29%, diaphragmatic rupture, 14%; contusions or rupturing of the spleen, 33%; liver, 37%, kidney, 3%	—	Retrospective	Median, 1200 days	NA
—	—	Retrospective	—	NA

Supplemental Table, online only. Continued.

Author	*Year*	*Age*	*% Females*	*% Fractures*	*% Head injury*
Cernaianu[45]	1992	NR	15	Pelvis, 18; lower extremity, 42	12
Chittithavorn[46]	2004	32	9	Pelvic, 36; lower extremity, 9; rib fracture, 36	27
Chung[47]	2008	37 open, 46 endovascular	27	—	—
Clark[48]	1990	NR	NR	—	—
Contino[49]	1994	33	28	—	—
Cook[14]	2006	41	25	Pelvic fracture, 45; long bone fracture, 51	51
Cowley[50]	1990	31	21	—	—
Crestanello[51]	2006	39	34	Pelvic, 36, lower extremity, 40, upper extremity, 24; spine fracture, 31	49
Day[52]	2008	20	30	—	—
DelRossi[53]	1990	NR	NR	—	—
Demetriades[5]	2008	40	25	—	—
Deree[54]	2007	26	22	—	—
Dessl[55]	2004	NR	NR	—	—
Doss[56]	2003	NR	NR	—	—
Doss[57]	2005	NR	NR	—	—
Downing[58]	2000	43	30	60	16
Dunham[59]	2004	34	31		
Duwayri[60]	2008	41	23	60	50
Eddy[61]	1990	31	19	53	50
Fabian[16]	1997	39	27	93	50
Fasquel[62]	1990	23	10	90	19
Fattori[63]	2002	39	NR	—	—
Feezor[64]	2008	NR	NR	—	—
Feezor[65]	2009	34	32	64	19
Forbes[66]	1994	NR	NR	—	—
Franchello[67]	1997	35	24	62	34.4
Frick[68]	1997	40	39	Upper extremity, 31; lower extremity, 30; pelvic fx, 26; vertebral, 15	39

Supplemental Table, online only. Continued.

Other injuries (%)	*Severity of injury*	*Study design*	*Follow up (d)*	*Choice of procedure**
Liver, 6; mesentery, 9; spleen, 15; cardiac/lung, 9	24	Retrospective	—	NA
Pulmonary, 64; abdominal, 54; liver, 36; spleen, 9; stomach, 9; small bowel, 9; popliteal artery injury, 9	—	Retrospective	—	NA
—	Mean ISS: 37 (open group); 46 (TEVAR group)	Retrospective	1830 (open group); 510 (TEVAR group)	Based on surgeon's choice
—	—	Retrospective	—	Unclear
—	Mean ISS, 37	Retrospective	—	Based on surgeon's choice
Abdominal injury, 45; pulmonary injury, 50; spine injury, 30	—	Prospective	—	Unclear
—	Mean ISS, 18.2	Retrospective	—	NA
Spinal cord injury, 7, intra-abdominal injury, 49; pulmonary contusion, 35	—	Retrospective	—	NA
—	—	Retrospective	—	NA
—	—	Retrospective	—	NA
—	Mean ISS, 39	Prospective	—	Unclear
Inferior vena cava injury, 25	—	Retrospective	—	NA
—	—	Retrospective	—	Unclear
—	—	Retrospective	—	Based on surgeon's choice
—	—	Retrospective	—	Based on surgeon's choice
Abdominal, 62; pulmonary, 24; pelvic, 34	—	Retrospective	—	NA
	ISS, 36.9	Retrospective	321	NA
C spine, 23.3%; lung injury,80%; visceral, 63%	—	Retrospective	—	NA
Cardiac, 29; spine, 14; pulmonary, 52; chest wall, 58; abdominal, 57; pelvic fracture, 24; Extremities fractures, 53	—	Retrospective	—	NA
Overall intra-abdominal injury, 60; overall thoracic injury, 62; multiple ribs, 46; pulmonary contusion, 38; cardiac contusion, 4; diaphragm, 7; spleen, 14; liver, 22; small bowel, 7; other abdominal, 14; spinal cord, 4; pelvis, 31; femur, 24; tibia, 22; upper extremity	42	Prospective	—	NA
Chest wall, 80; maxillofacial, 45; pelvic fracture, 19; liver, 10; spleen, 32; mesenterium, 2	—	Retrospective	1825	NA
—	—	Retrospective	600	NA
—	—	Retrospective	—	NA
Abdominal, 55	Mean ISS, 33	Retrospective	231	Based on surgeon's choice
—	ISS divided into two categories: patients with SCI, 29.5 vs all operative survivors, 35.9. There is no overall ISS.	Retrospective	—	NA
Hemothorax, 48.2; pulmonary, 27.5; rib fx, 44.8; abdominal injuries, 24.1; facial, 24.1; diaphragmatic, 10.3	—	Retrospective	—	NA
Cardiac tamponade, 8; cardiac contusion, 16; skull fracture, 8; cardiac laceration, 8; hemo/pneumothorax, 48, rib fx, 69; pulmonary contusion, 36; spinal cord, 8; diaphragm injury, 6; spleen, 33; liver, 30; pancreas, 8; bowel injury, 11; bladder, 11; IVC, 6; kidney, 6	ISS by groups only: in arrest, 59; in shock, 57; stable no shock, 47	Retrospective	—	NA

Supplemental Table, online only. Continued.

Author	*Year*	*Age*	*% Females*	*% Fractures*	*% Head injury*
Galli[69]	1998	31	24	81	12
Gammie[70]	1998	34	24	—	—
Go[71]	2007	44	50	80	—
Hemmila[19]	2004	40	Early repair, 33; late repair, 18	64	29
Hilgenberg[72]	1992	35	16	Rib fx, 45; sternum fx, 2; clavicle, 9; facial bones fx, 18; upper extremity, 25; lower extremity, 57; pelvis, 29	45
Hochheiser[73]	2002	43	28	—	—
Holmes[4]	2002	44	20	—	—
Hoornweg[74]	2006	41	NR	—	25
Hormuth[75]	1999	15	27	Femur fx, 54; pelvic fx, 36	27
Hunt[76]	1996	42	30	74	37
Jamieson[77]	2002	40	21	—	—
Juszkat[78]	2007	NR	31	Pelvic, 2; lower extremity, 5	—
Karmy-Jones[79]	2003	33	NR	—	91
Karmy-Jones[80]	2001	40	30	Pelvic fx, 22.7; spine fracture, 3.7; clavicular laceration, 2.2; upper extremity, 2.2, sternal fx, 1.7	28.6

Supplemental Table, online only. Continued.

Other injuries (%)	*Severity of injury*	*Study design*	*Follow up (d)*	*Choice of procedure**
Intra-abdominal organs, 26.2% (liver, 12; spleen, 5; diaphragm, 2; gallbladder, 2; bowel, 5; bladder, 2). neurologic complications 14.3% (comma, 12; paraplegia, 2), thoracic lesions 14.3% (pulmonary, 12; myocardial, 2)	—	Retrospective	—	Unclear
—	40	Retrospective	—	Based on surgeon's choice
Liver, 40%; splenic, 20%; pulmonary, 30%; small bowel, 20%	—	Retrospective	600	NA
Liver, 24, spleen, 23; bowel/mesentery, 19; spinal injury, 5%; rib fx, 58; pulmonary contusion, 50; cardiac contusion, 4; diaphragm, 6; pelvic fx, 36; one extremity, 35; more than one extremity, 29; spine fx, 26; renal, 8	ISS: Early Repair group, 38; Delayed Group, 41. No overall mean ISS available.	Retrospective	—	NA
Cardiac contusion, 9; lung contusion, 45; right atrial rupture, 2; tracheal laceration, 2; left diaphragm rupture, 2; liver, 13; spleen, 11; retroperitoneal hematoma, 13; femoral artery injury, 4.5; peripheral nerve, 18	—	Retrospective	—	NA
—	—	Retrospective	—	NA
—	ISS, 34 (overall)	Retrospective	—	Unclear
Abdominal: spleen, 32.1; liver, 17.6; renal, 7.1; diaphragm, 3.6; pancreatic contusion, 3.6; mesenterial hematoma, 3.6; cardiopulmonary: pulmonary contusion, 28.6; hemothorax, 35.7; pneumothorax, 28.6	Mean ISS, 37	Retrospective	780	NA
Spleen, 18; renal, 18; bronchial transaction, 9; liver, 9; splenic, 18; renal, 2	RTS, 10; ISS, 32.4	Retrospective	—	NA
Rib rracture, 34; hemothorax, 25; intra-abdominal, 38; liver, 19; spleen, 15; diaphragm, 5; pulmonary contusion, 26; femur, 24; tibia, 19, radius, 10; facial, 10; sternum, 6; c-spine, 6; flail chest, 7	ISS, 43.5; TR, 11.2; APACHE II, 13.3; mean Glasgow coma score, 10.7	Retrospective	—	NA
98 overall associated injuries (breakdown not provided)	—	Retrospective	—	Unclear
—	—	Retrospective	—	NA
—	—	Retrospective	—	Based on patients associated lesions or comorbidities such as severe pulmonary contusion, cardiac risk factors, coagulopathy, or prior chest surgery/ radiation
Splenic rupture, 15.4; liver laceration, 8; diaphragmatic rupture, 7.3; facial injuries, 5.1; kidney laceration, 2.2; bladder rupture, 0.7	ISS: 29.5, survivor; 37, non-survivor; RTS: 6.7, survivor; 4.4, non-survivor; TRISS: 0.88, Survivor; 0.93, Non survivor	Retrospective	—	Nonoperative: 8 head injuries deemed lethal and 2 severe significant CAD in 2, lung injury and severe respiratory insufficiency in 10, coagulopathy in 5 and >80 years + multiple comorbidities in 2

Supplemental Table, online only. Continued.

Author	*Year*	*Age*	*% Females*	*% Fractures*	*% Head injury*
Kasirajan[81]	2003	Endovascular, 38; surgery, 44; nonoperative, 55	Endovascular, 20; open, 20; nonoperative, 42	48	44
Kaya[82]	2009	NR	NR	—	—
Khoynezhad[17]	2008	NR	NR	—	—
Kieny[83]	1991	Range, 3-70	19	67	61.7
Klima[84]	2004	NR	NR	—	—
Kodali[85]	1991	39	25	Ribs fx, 63	—
Kokotsakis[86]	2007	37	12	—	—
Kuhne[87]	2005	38	NR	—	—
Kurimoto[88]	2009	55	38	—	—
Kwon[89]	2002	NR	41	25	11.5
Lachat[90]	2002	48	40	Extremity, 50; pelvic, 50	58
Lancey[91]	2004	37	22	Lower extremity, 41; upper extremity, 24; facial fx, 16; pelvic fx, 14; vertebral fx, 5	31
Langanay[92]	2002	28	NR	Overall orthopedic injuries, 76; lower limb fracture, 46; upper limb fracture, 28; pelvic fracture, 30; rachis fracture, 6; maxillo-facial fracture, 16; clavicular fracture, 6; skull fracture, 4; sternal fracture, 14; rib fracture, 95	46
Lebl[93]	2006	50	NR	—	—
Lee[94]	1992	NR	NR	—	—
Leurs[18]	2004	46	20	—	—
Maggisano[95]	1995	39	33	Major orthopedic, 72; rib fractures, 52	66
Marcheix[15]	2006	40	12	79	88

Supplemental Table, online only. Continued.

Other injuries (%)	*Severity of injury*	*Study design*	*Follow up (d)*	*Choice of procedure**
Chest, 44; abdominal, 41	Endo ISS, 42; open surgery ISS, 32; non-operative ISS, 47	Retrospective	—	Nonoperative was chosen when predicted mortality due to associated lesions based on ISS approached 100%. Endovascular treatment was chosen when there was inability to ventilate the patient or prohibited risk of anticoagulation
—	—	Retrospective	—	NA
—	—	Prospective	—	NA
Overall abdominal, 51.3; abdominal hollow organs, 12; diaphragm ruptures, 9.6; intra-abdominal parenchymatous lesions, 37; thoracic, 27.4	—	Retrospective	—	NA
—	—	Retrospective	—	NA
Hemothorax, 36	—	Retrospective	—	Patients in the nonoperative did not meet OR criteria due to severe associated injuries
—	Mean ISS, 48	Retrospective	1401 (open group); 309 (stent group)	Based on surgeon's choice
—	Mean ISS, 41	Retrospective	—	Unclear
—	ISS, 17; RTS, 6	Retrospective	600	NA
Abdomen, 20	ISS, 31	Retrospective	Nonoperative follow-up, 690	Reasons for nonoperative management: 2 refusal to have surgery, 1 patient DNR, transfer to another institution, aborted due to technical difficulty and no recovery of cerebral function
Lung contusion, 92; rib fracture, 100; liver, 33; spleen, 33	—	Retrospective	510	NA
Liver, 16; spleen, 16; spinal injury, 10; renal, 6; intestinal, 4; eye, 2, bladder, 1	ISS: alive, 32; dead, 33.6	Retrospective	—	NA
Overall thoracic lesions, 64; flail chest, 22; overall abdominal lesions, 34; ruptured spleen, 18; kidney contusion, 12; liver wound or contusion, 12; ruptured diaphragm, 4	—	Retrospective	—	NA
—	Mean ISS: open group, 35; stent group, 35; medical management group, 30	Retrospective	—	Unclear
—	—	Retrospective	—	NA
—	—	Prospective	—	NA
Overall pulmonary, 75; pneumothorax/hemothorax, 30; spleen, 30; liver, 25; myocardial contusion, 25; diaphragmatic rupture, 14; bladder rupture, 5	—	Retrospective	—	NA
—	Mean ISS, 40	Prospective	985	NA

Supplemental Table, online only. Continued.

Author	*Year*	*Age*	*% Females*	*% Fractures*	*% Head injury*
McPhee[96]	2007	35	31	92	38
Meites[97]	2004	36	NR	—	—
Melnitchouk[98]	2004	45	0	Upper extremity, 33; skull fx, 7, rib fracture, 73; facial fx, 33; pelvic fx, 20; vertebral fx, 13; lower extremity, 27	53
Methodius-Ngwodo[99]	2008	31	45	—	38
Michelet[100]	2005	32	100	Extremity, 30; pelvic fx, 70, spine fx, 10	30
Midgley[101]	2007	43	29	—	—
Miller[102]	2003	NR	NR	14	21
Moainie[103]	2008	Endovascular,39; open, 33	open repair, 27; endovascular, 23	Extremity 54, pelvic 36	23
Mohan[104]	2008	28	17	—	64
Ndiaye[105]	1990	39	13	—	—
Neschis[106]	2007	40	15	—	—
Neuhauser[107]	2004	37	20	Extremity, 30; pelvic, 10	30
Nishimoto[108]	2003	26	25	Pelvic, 33; extremity, 33	16
Nocolosi[109]	1996	34	24	—	—
Novotny[110]	2005	49	10	—	—
Orend[111]	2007	44	32	67	80
Orend[112]	2002	34	18	Extremity, 27; pelvic, 45; rib fx, 36; spinal fx, 18	91
Orend[113]	2003	NR	NR (mixed entities)	—	—
Ott[114]	2004	39	33	Lower extremity, 50; upper extremity, 50; rib fx, 66; pelvic, 39	28
Pacini[20]	2005	35	NR	78.3; lower extremity, 36; upper extremity, 20; rib fx, 51; pelvic, 25, rachis, 3; maxillofacial, 10; sternum, 3	23.2
Pate[115]	1999	33	17	Lower extremity, 50; pelvic, 20	29.8
Peterson[116]	2005	43	36	—	—
Pierangeli[117]	2000	32	22	57	—
Pratesi[118]	2006	48	0	—	—
Raupach[119]	2007	39	15	—	—
Razzouk[120]	2000	35	22	Overall, 75 (head/neck fx, 33)	30
Read[121]	1993	33	6	50	20
Reed[122]	2006	55	31	85	46
Richeux[123]	2004	36		81	50

Supplemental Table, online only. Continued.

Other injuries (%)	*Severity of injury*	*Study design*	*Follow up (d)*	*Choice of procedure**
Pulmonary, 69%; abdominal, 53%	Mean ISS, 43.5	Retrospective	498	Unclear
—	—	Retrospective	—	NA
Hemo/pneumothorax, 80; lung contusion, 67; cardiac contusion, 20; spleen, 13; liver, 40; kidney, 27	—	Retrospective	—	NA
—	ISS range, 29-75	Retrospective	1230	NA
Spleen, 30; liver, 40; hemo/pneumothorax, 20	ISS 53, SAPS II	Retrospective	600	NA
—	Mean ISS TEVAR, 38; mean ISS open repair, 45	Retrospective	Mean f/u for TEVAR only, 450 days	Based on surgeon's choice
Intra-abdominal injury, 38	Mean ISS, 32	Retrospective	—	NA
Liver, 23; splenic, 42; pulmonary, 36	ASCOT, 83%; open repair group, 73.7%; Endovascular. ASCOT Severity Characterization of Trauma (ASCOT) score is a physiologic and anatomic characterization of injury severity that uses Glasgow Coma Scale, Abbreviated Injury Scale, age, systolic blood pressure	Retrospective	—	Focus on endovascular with an open repair group to compare with (case-control study)
—	Mean ISS, 50	Retrospective	—	Based on surgeon's choice
—	—	Retrospective	1080	NA
—	Mean injury severity score, 41; mean revised trauma score, 7.2	Retrospective	162	NA
Spleen,10; liver, 10	—	Retrospective	780	NA
Intrathoracic, 67; pelvic fx, 33; intra-abdominal, 33; spleen, 25; liver, 83; kidney, 8.3	42	Retrospective	—	NA
—	—	Retrospective	—	NA
—	—	Retrospective	—	NA
Intra-abdominal, 73; pelvic, 33	—	Retrospective	1314	NA
Lung contusion, 100; pneumo/hemothorax, 45,overall abdominal trauma, 82; renal, 18; liver, 27; spleen, 27; diaphragm, 19; popliteal artery injury, 9	—	Retrospective	420	NA
—	—	Retrospective	—	NA
Bowel/mesentery, 28; diaphragm, 17; renal, 17; pancreatic, 5.5	ISS endovascular, 46; open repair, 47.5	Retrospective	—	NA
Thoracic, 66.7 (lung contusion, 56; hemopericardium, 1); abdominal, 27.5 (liver, 12; kidney, 7; spleen, 13; diaphragm, 1; bladder, 3; intestinal, 1)	—	Retrospective	—	Unclear
Liver, 9; spleen, 15	—	Retrospective	—	Unclear
—	Mean ISS, 43	Retrospective	630	NA
Liver trauma repair, 7; splenectomy, 7; intestinal resection, 3.5; diaphragmatic rupture, 3.5	—	Retrospective	—	Based on surgeon's choice
—	—	Retrospective	546	NA
—	Mean ISS, 40	Retrospective	651	NA
Thoracic, 52; abdominal, 39; soft tissue/vascular issue, 26	—	Retrospective	—	NA
Liver, 25; pancreas, 12.5; spleen, 6.25; diaphragm, 6.25	ISS, 36.2	Retrospective	—	NA
Intra-abdominal, 53.8; chest trauma, 53.8	Mean ISS, 40	Retrospective	360	Unclear
—	—	Retrospective	—	NA

Supplemental Table, online only. Continued.

Author	*Year*	*Age*	*% Females*	*% Fractures*	*% Head injury*
Riesenman[124]	2007	40	27	—	24
Rodriguez[125]	2007	47	18	—	—
Rosenthal[126]	2008	31	39	Pelvic, 29%; extremity, 61%	68
Rousseau[127]	2005	37	14	—	—
Santini[128]	1999	33	21	Pelvic fracture, 27 (other fx not mentioned)	12
Scharrer-Pamler[129]	2002	34	13	—	—
Scheinert[130]	2004	39	40	Extremity, 40 (lower extremity, 30; upper extremity, 40); pelvic fx, 40; spinal fx, 20; sterna, 10	30
Schmidt[131]	1992	27	21	Head/neck fx, 27.5; skeletal fx, 83.3; extremity, 83.3; ribs/sternum/clavicle, 41; pelvic/hip, 24.3; spine fx, 5	25
Stampfl[132]	2006	Open, 30; endovascular, 47	NR	—	—
Steingruber[133]	2007	39	23	—	—
Stulz[134]	1991	37	24	Extremity fx, 71; pelvic fx, 57; spine fx, 14; rib/sternal fx, 52	43
Sweeney[135]	1997	34	12	Orthopedic, 39; extremities, 38; pelvis/hip, 21; facial fracture, 13; vertebral fracture, 13	24
Symbas[136]	2002	36	21	Extremities, 29; cervical spine fx, 11; ribs, 7; pelvic, 14	11
Tambyraja[137]	2006	36	25	—	—
Tehrani[138]	2006	43	20	77	20
Tespili[139]	2007	Mean acute, 24; mean chronic, 31	11	—	—
Tiraboschi[140]	2000	28	13	—	—
Von Oppell[141]	1996	32	21	Extremity, 64; pelvic, 32; spinal, 14	18
Wahl[142]	1999	38	NR	Extremity, 20; pelvis, 36; spine, 22; rib fx, 44	71
Whitson[143]	2008	41	24	—	—
Xabregas[144]	1991	27	23	Lower extremity, 54; pelvic, 24; facial fx, 24; Rib fx, 38; Sternum fx, 8	69

Supplemental Table, online only. Continued.

Other injuries (%)	*Severity of injury*	*Study design*	*Follow up (d)*	*Choice of procedure**
—	Mean RTS, 6.5; mean ISS, 38; mean NISS, 45 (EV repair group). RTS, 7.024; ISS, 41; NISS, 47 (open repair group)	Retrospective	282	Based on surgeon's choice
—	—	Retrospective	—	NA
Solid organ injury, 16; extremity fracture, 61; pelvic fracture, 29; sternal/clavicular fracture, 19	Mean ISS, 40	Retrospective	1230	NA
—	Mean ISS = 35	Retrospective	1380	Unclear
Abdominal, 15	—	Retrospective	—	NA
—	—	Retrospective	—	NA
Spleen, 20; liver, 10	—	Retrospective	450	NA
Overall thoracic, 41.2; diaphragm, 12.8, lung, 38.5; heart, 10.2; abdominal, 32; spleen, 20; liver, 10; kidney, 8.7; bowel, 10; bladder, 5; pancreas, 6.2	—	Retrospective	—	NA
—	—	Retrospective	1890	Stent-grafts available after > 2001
Mediastinal hematoma, 100; hemothorax, 41; pneumothorax, 22; pulmonary contusion, 45; multiple rib fractures, 59; sternal fracture, 18; pelvic fracture, 27; maxillofacial fracture, 14; multiple extremity fractures, 27; severe spinal trauma, 9% with associated paraplegia		Retrospective	951	NA
Heart contusion, 19; pulmonary/hemo/pneumothorax, 62; overall abdominal trauma, 38; liver, 9.5; diaphragm, 9 .5, splenic, 9.5; small bowel, 9.5	—	Retrospective	3090	NA
Intrathoracic, 49; ribs/clavicle, 31; pulmonary, 24; sternum, 14; cardiac contusion, 11; flail chest, 6; intra-abdominal, 34; spleen, 10; liver, 10; kidneys/bladder, 8; pancreas, 3; diaphragm, 3	—	Retrospective	—	NA
Bladder, 7; pulmonary contusion, 4; urethral, 4; liver, 7; spleen, 14; facial laceration, 4; kidney, 18; hemo/pneumothorax, 18; diaphragm, 7	—	Retrospective	—	Based on surgeon's choice
—	—	Retrospective	—	NA
Pulmonary 37, Spinal injury 17, Intra-abdominal 27	Mean ISS, 42	Retrospective	348	NA
—	—	Retrospective	870	NA
—	—	Retrospective	1460	NA
Abdominal, 71	—	Retrospective	—	Based on surgeon's choice
Liver, 24; spleen, 27; diaphragm, 4; bowel/mesentery, 18; cardiac contusion, 2	ISS, 42.5	Retrospective	—	NA
—	Mean ISS, 40	Retrospective	—	NA
Small bowel, 16; liver, 8; hemo/pneumothorax, 16; liver, 8	—	Retrospective	1170	NA

Supplemental Table, online only. Continued.

Author	*Year*	*Age*	*% Females*	*% Fractures*	*% Head injury*
Yamane[145]	2008	36	23	92	35
Zeiger[146]	1990	28	32	Pelvic fx, 26; long bone, 43; rib fx, 29.6; facial fx, 9.2; spine fx, 7.4	11
Zipfel[147]	2008	32	10	—	—
Zipfel[148]	2007	37	10	—	—

ARDS, Acute respiratory distress syndrome; *APACHE II*, Acute Physiology and Chronic Health Evaluation; *ASCOT*, a severity characterization of trauma; *C spine*, cervical spine; *ER*, endovascular repair; *ESG*, endovascular stent graft; *Fx*, fracture; *ISS*, Injury Severity Score; *IVC*, inferior vena cava; *NA*, nonapplicable; *NISS*, New Injury Severity Score; *NR*, not reported; *OR*, operative repair; *Pt*, patient; *RTS*, revised trauma score; *SCI*, spinal cord ischemia; *TEVAR*, thoracic endovascular aortic repair; *TRISS*, Trauma and Injury Severity Score.

Supplemental Table, online only. Continued.

Other injuries (%)	*Severity of injury*	*Study design*	*Follow up (d)*	*Choice of procedure**
Pulmonary, 54; splenic, 50; liver, 4; pancreas, 4; overall intra-abdominal, 54; spinal injury, 15	Mean ISS endovascular, 33; mean ISS open surgery, 36	Retrospective	—	Unclear
Lung contusion, 11; bowel, 7.4; spleen, 7.4; renal, 3.7; pulmonary artery injury, 1.8	—	Retrospective	—	NA
—	—	Retrospective	—	NA
—	—	Retrospective	—	NA

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SEARCH STRATEGY

Medline

1. aorta, thoracic/in [Injuries] or aorta, abdominal/in
2. aortic rupture/or aortic aneurysm, thoracic/or aortic aneurysm, abdominal/
3. ((aortic or aorta) adj3 (transect* or disrupt* or tear or torn or rupture*)).mp. [mp=title, original title, abstract, name of substance word, subject heading word]
4. (1 or 2) and (thoracic injuries/co, su or abdominal injuries/or wounds, non-penetrating/or blunt*.mp. or decelerat*.mp. or trauma*.mp. or injur*) [mp=title, original title, abstract, name of substance word, subject heading word]
5. 1 or 3 or 4
6. aorta, thoracic/su, th or aortic rupture/su, th or aortic aneurysm, abdominal/su, th
7. vascular surgical procedures/or thoracotomy/or open
8. thoracic surgery, video-assisted/or stents/or surgical procedures, minimally invasive/or blood vessel prosthesis/or blood vessel prosthesis implantation/or angioplasty/or radiography, interventional/
9. (tevar or endovascular* or endograft* or repair* or evar).mp. [mp=title, original title, abstract, name of substance word, subject heading word]
10. 5 and (6 or 7 or 8 or 9)
11. limit 10 to humans
12. comparative study.pt. or exp cohort studies/or meta-analysis.pt. or meta-analysis as topic/or retrospective$.mp. or prospective*.mp. [mp=title, original title, abstract, name of substance word, subject heading word]
13. 11 and 12
14. limit 11 to (clinical trial, all or clinical trial, phase i or clinical trial, phase ii or clinical trial, phase iii or clinical trial, phase iv or clinical trial or comparative study or controlled clinical trial or evaluation studies or guideline or meta analysis or multicenter study or practice guideline or randomized controlled trial)
15. 11 and (longitudinal studies/or follow-up studies/)
16. 13 or 15 or 14
17. monitoring, physiologic/or patient selection/or severity of illness index/or injury severity score/or trauma severity indices/
18. (timing or surviv$).mp. or risk assessment/or time factors/[mp=title, original title, abstract, name of substance word, subject heading word]
19. (conservative* or medical or watch* or wait* or early or late or delay* or postpone* or surveil*).mp. [mp=title, original title, abstract, name of substance word, subject heading word]
20. mo.fs. or mortality/or hospital mortality/or treatment outcomes/or prognosis/or outcome*.mp. or reop-

eration/or length of stay/[mp=title, original title, abstract, name of substance word, subject heading word]
21. 16 and 17
22. 16 and 18
23. 16 and 19
24. 16 and 20
25. 22 or 21 or 24 or 23
26. postoperative complications/ep, mo or respiratory distress syndrome, adult/ep, co, mo or acute lung injury/or respiratory insufficiency/or exp respiration, artificial/
27. exp infections, bacterial/or prosthetic graft infections/or paraplegia/or spinal cord injuries/or exp kidney failure/or exp cerebrovascular disorders/
28. 16 and 26
29. 16 and 27
30. 25 or 28 or 29

Embase

1. aorta, thoracic/in [injuries] or aorta, abdominal/in-[Injuries]
2. aortic rupture/or aortic aneurysm, thoracic/
3. ((aortic or aorta) adj3 (transect* or disrupt* or tear or torn or rupture*)).mp. [mp=title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer name]
4. (1 or 2) and (thoracic injuries/co, su or abdominal injuries/or wounds, non-penetrating/or blunt*.mp. or decelerat*.mp.) [mp=title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer name]
5. 1 or 3 or 4
6. exp aorta/su, th or ex aorta aneurysm/su,th
7. vascular surgical procedures/or thoracotomy/
8. thoracic surgery, video-assisted/or stents/or surgical procedures, minimally invasive/or blood pressure prosthesis/or blood vessel prosthesis implantation/or angioplasty/or radiography, interventional/
9. (tevar or endovascular* or endograft* or repair* or evar).mp. [mp=title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer name]
10. 5 and (6 or 7 or 8 or 9)
11. limit 10 to humans
12. comparative study.pt. or exp cohort studies/or meta-analysis.pt. or meta-analysis as topic/or retrospective$.mp. or prospective*.mp. [mp=title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer name]
13. 11 and 12
14. limit to (clinical trial, all or clinical trial, phase i or clinical trial, phase ii or clinical trial, phase iii or clinical trial, phase iv or clinical trial or comparative study or controlled clinical trial or evaluation studies or guideline or meta analysis or multicenter study or practice guideline or randomized controlled trial)
15. 11 and (longitudinal studies/or follow-up studies/)
16. 13 or 15 or 14
17. monitoring, physiologic/or patient selection/or severity of illness index/or injury severity score/or trauma severity indices/
18. (timing or surviv$).mp. or risk assessment/or time factors/[mp=title, abstract, subject headings, heading

Web of Science/Scopus

Step	*No. citations*	*Terms*
1	2,992	Topic=((aorta or aortic) SAME (transect* or rupture* or disrupt* or tear or torn or injur* or blunt or trauma* or wound* or nonpenetrating or "non-penetrating")) AND Topic=(repair* or surgical or open or thoracotom* or stent* or endovascular or endograft* or tevar)
2	>100,000	TS=(conservative or medical or watch* or timing or early or late or delay* or postpon* or immediate* or severity or planning or outcome* or surviv* or death or mortal* or complicat* or "length of stay" or spinal or paraplegi* or stroke*) *Databases=SCI-EXPANDED Timespan=1993-2009*
3	2,299	#2 AND #1 *Databases=SCI-EXPANDED Timespan=1993-2009*
4	>100,000	TS=(systematic or "meta-analys*" or follow* or comparative or compared or series or cohort* or retrospective* or prospective or guideline* or trial*) *Databases=SCI-EXPANDED Timespan=1993-2009*
5	1,501	#4 AND #3 *Databases=SCI-EXPANDED Timespan=1993-2009*
6	9,839	TI=((aorta or aortic) SAME (transect* or rupture* or disrupt* or tear or torn or injur* or blunt or trauma* or wound* or nonpenetrating or "non-penetrating" or aneurysm*)) *Databases=SCI-EXPANDED Timespan=1993-2009*
7	816	#6 AND #5 *Databases=SCI-EXPANDED Timespan=1993-2009*

word, drug trade name, original title, device manufacturer, drug manufacturer name]
19. (conservative* or medical or watch* or wait* or early or late or delay* or postpone*).mp. [mp=title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer name]
20. mo.fs. or mortality/or hospital mortality/or treatment outcomes/or prognosis/or outcome*.mp. or reoperation/or length of stay/[mp=title, abstract, subject headings, heading word, drug trade name, original title, device manufacturer, drug manufacturer name]
21. 16 and 17
22. 16 and 18
23. 16 and 19
24. 16 and 20
25. 22 or 21 or 24 or 23
26. postoperative complications/ep, mo or respiratory distress syndrome, adult/ep, co, mo or acute lung injury/or respiratory insufficiency/or exp respiration, artificial/
27. exp infections, bacterial/or prosthetic graft infections/or paraplegia/or spinal cord injuries/or exp kidney failure/or exp cerebrovascular disorders/
28. 16 and 26
29. 16 and 27
30. 25 or 28 or 29
31. from 30 keep 1-1283
32. exp comparative study/or exp controlled study/or clinical study/or exp intervention study/or exp longitudinal study/or exp major clinical study/or exp prospective study/or exp retrospective study/or exp case control study/or exp clinical trial/or exp evidence based practice/or exp practice guideline/
33. exp Aorta Dissection/or exp Aorta Rupture/
34. 2 or 3 or 33
35. 34 and (17 or 18 or 19 or 20)
36. (5 or 35) and (6 or 7 or 8 or 9)
37. (5 or 35) and (17 or 18 or 19 or 20 or 26 or 27)
38. 36 or 37
39. 32 and 38
40. limit 39 to human
40. exp *Aorta/
42. exp *aortic aneurysm/or exp *aortic rupture/
43. 42 or 41
44. 44. 40 and 43