REVIEW ARTICLE

TREATMENT STRATEGIES AND OUTCOMES OF THORACIC AORTIC BLUNT INJURIES IN ADULTS: A SYSTEMATIC REVIEW

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Abstract

Introduction: *Blunt thoracic aortic injuries (BTAI) once had mortality rates up to 32%, but the advent of thoracic endovascular aortic repair (TEVAR) has significantly improved outcomes. However, concerns persist regarding long-term device-related complications, device integrity in aging aortas, and the criteria for selecting patients for endovascular repair. We aimed to assess BTAI treatment strategies based on injury grade and their associated outcomes.*

Methods: *A systematic search of MedLine and Scopus databases was conducted to identify original articles published after 2013, which provided information on injury characteristics, outcomes, secondary effects, and reinterventions following BTAI. We classified aortic injuries following the SVS Clinical Practice Guidelines.*

Results: *We included 28 studies involving 1888 BTAI patients, including 5 prospective studies. Most patients were under 45 years old (86.4%), and grade III injuries were the most common (901 patients), followed by grades I and II (307 and 291 patients, respectively). TEVAR was performed in 1458 patients, mainly with grade III and IV injuries (1040 patients). Approximately half of the grade I injuries (153 of 307) were treated with TEVAR. Thirty-day mortality rate was 11.2%, primarily due to associated injuries. Aortic-related deaths were reported in 21 studies, with an overall rate of 2.2%, but none occurred beyond the first 30 days. Partial or complete coverage of the left subclavian artery was performed in 522 patients, with 27.9% requiring immediate or delayed revascularization. Aortic reintervention rates were relatively low (3.9%).*

Conclusion: *TEVAR effectively treats BTAI grades III and IV, with potential benefit for some grade II injuries with more aggressive early intervention. Despite SVS guidelines suggesting conservative management for grade I injuries, there is a substantial rate of intervention with positive outcomes and low mortality. Long-term follow-up data, extending up to almost 20 years, reveal the durability of grafts, aortic remodeling, and minimal reintervention and complications.*

INTRODUCTION

Being the second leading cause of death from blunt trauma after head injuries, with mortality rates up to 32%, blunt thoracic aortic injuries (BTAI) occur, most commonly at the aortic isthmus, just distal to the left subclavian artery (SCA) origin[1-5]. The survival rate of patients who present to hospital with BTAI is 60–70%, often due to multiple organ injuries[6]. The prognosis and management of BTAI is determined by patient haemodynamic status, location and grade of injury, and associated injuries[7, 8]. Grading systems have been developed to help classify the degree of injury and to guide management. The current guidelines from the Society for Vascular Surgery (SVS) mention a grading system that categorizes BTAI based on the extent of injury on the aortic wall: grade 1, an intimal tear; grade 2, intramural hematoma; grade 3, pseudoaneurysm; and grade 4, rupture[9]. These guidelines suggest non-operative management (NOM) with serial imaging for grade 1 injuries and urgent intervention with thoracic endovascular aortic repair (TEVAR) for grades 2 to 4, if anatomically suitable. However, more recently, evidence has shown that minimal aortic injury (SVS grades 1 and 2), can safely receive optimal medical therapy

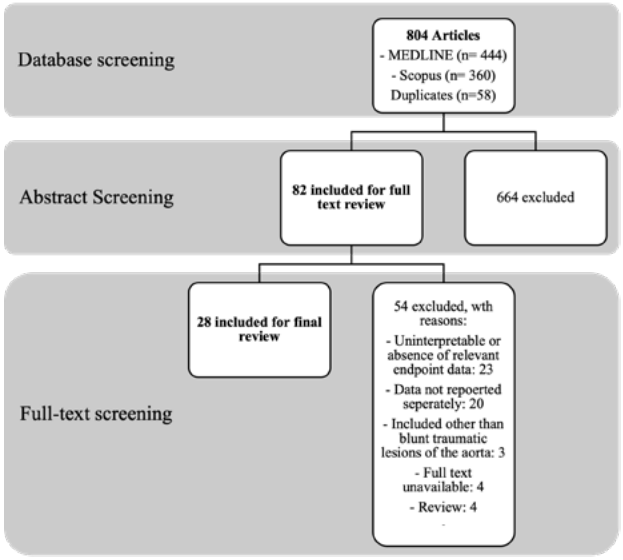

Figure 1 *Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram of the study selection process.*

with a very low risk of disease progression and aortic rupture, as well as low aortic-related mortality[10]. These findings may indicate that the current SVS guidelines for grade 2 injuries may not be optimal for all patients and suggest a possible alternative standard treatment for grade 2 BTAI, with NOM replacing TEVAR for these patients[11, 12]. Although the superiority of TEVAR has been established, controversy still surrounds several aspects, as the optimal timing of the intervention, graft selection, management of the subclavian artery and long-term durability of these repairs[13-15].

METHODS

The systematic review was undertaken in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines.

LITERATURE RESEARCH

A literature search was performed using MEDLINE and the equation ("Aorta, Thoracic/injuries"[Mesh] OR "Aorta, Thoracic/surgery"[Mesh] OR "Aorta, Thoracic/therapy"[Mesh]) AND "Wounds, Nonpenetrating"[Mesh] " and Scopus and a combination of terms "blunt trauma", "thora*" and "aort*." The last date for the search was 26 July 2022.

ELIGIBILITY CRITERIA AND STUDY SELECTION

Search results were imported into Endnote for study selection and duplicate removal. Title and abstract screening were undertaken by two investigators (LF, DS). Any disagreements between reviewers were resolved through discussion with the senior author (AC). The population of interest and intervention was patients older than 18 years old with all types of descending thoracic aortic blunt trauma (type I to IV) who survived initial resuscitating management. It was anticipated that some studies would include TEVAR with intentional left SclA coverage. Nevertheless, data on patients undergoing TEVAR with SclA coverage were also collected, when reported by authors. The primary outcome of interest was aortic mortality according to treatment strategy and lesion classification. Secondary outcomes included need for later intervention (>30 days) in those initially managed conservatively, 30-day hospital mortality, endoleak and re-intervention in those managed with early invasive intervention. All observational English, Portuguese and Spanish language studies published in the last 10 years were eligible for inclusion. Systematic reviews, review articles, case reports, and editorials were excluded.

Data extraction, and study quality assessment

Data were extracted using a pre-defined standardized collection form that included publication information, study design, study demographics (age, sex, comorbidities), type of injury, conservative or interventional management, indication for repair, spinal cord ischemia, 30-day mortality, endoleaks, and re-intervention during follow up. For the assessment of outcome domain, 30-day/in hospital mortality for studies reporting only early outcomes, and at least 1 year of follow up was defined as an acceptable follow up time for studies reporting post-operative outcomes. The quality of the evidence was graded by two reviewers (LF and DS), independently, using the Oxford Centre for Evidence-Based Medicine Levels of Evidence.

RESULTS

Study characteristics

After screening and full text review, 28 studies[1-4, 6, 8, 10, 11, 13-32] were included that were published between January 2013 and July 2022. Over this 9-year period, there was 1 prospective randomized trial, 2 nonrandomized and 2 prospective cohort studied and 24 retrospective cohort studies or case series. The majority (10/28 [36%]) of studies were conducted in the United States; 32% (9/28) were conducted in Europe, 18% (5/28) in Asia, 7% (2/28) in Africa, 3% in South America (1/28) and 3% (1/28) in Australia. Most of the studies that reported age of patients (22 studies), stated a mean age below 45 years (86,4%). By the Oxford Center for Evidence Based Medicine classification, studies were respectively categorized as level 3 and level 4 in 16 and 12 instances. Studies characteristics are summarized in Table 1 and 2.

Aortic injury severity among patients with BTAI managed nonoperatively

Across the 28 studies, 14 studies reported on patients managed nonoperatively, describing a total of 363 patients. There was a median of 18 patients managed nonoperatively per study (interquartile range, 6 – 41.5; mean 28.0±31.95). All studies included reported on aortic injury grade using the SVS

classification or a description compatible with the SVS system. All fourteen studies reported on individual grades of injury, with the majority of patients managed conservatively having grade I injuries (154 patients referring to 50.2% of all grade I injuries), followed by grade II injuries (115/291 patients with grade II injuries [39.5%]). Aortic injuries on patients managed nonoperatively are summarized on Table 2.

Medical management protocols

Only 3 studies included specifics on the blood pressure and heart rate parameters used for patients with BTAI managed nonoperatively. Gaffey (2019)[2] establishes as goal a mean arterial blood pressure of 60-80 mmHg and a heart rate less than 100 beats per minute (bpm), while Sandhu (2018)[27] and Martin (2017)[13] advocate a target systolic blood pressure below 120 mmHg. Sandhu (2018)[27] also sets a goal for the heart rate of 60-90 bpm.

Aortic injury severity among patients with BTAI managed operatively

Across the 28 studies, 25 studies reported on patients managed operatively, describing a total of 1524 patients (1458 with TEVAR [25 studies], 66 with open repair [4 studies]). Per study, there was a median of 40 patients managed with TEVAR (interquartile range, 25 – 55; mean 59.2±86.0) and 12 patients submitted to open repair (interquartile range, 2.8 – 12.0; mean 12.3±10.3). All studies included reported on aortic injury grade using the SVS classification or a description compatible with the SVS system. Regarding TEVAR, 23 studies reported on individual grades of injury, with the majority of patients having grade III injuries (794 patients referring to 88.1% of all grade III injuries), followed by grade IV injuries (206/231 patients with grade IV injuries [89.2%]). The remaining 3 studies (Awadalla, 2022; Prendes, CF, 2021; Chen S., 2015)[3, 19, 21] grouped II and III, III and IV or II, III and IV injuries comprising a total of 129 TEVAR procedures. Aortic injuries on patients managed operatively are summarized on Table 2.

Operative management

TEVAR was performed in 1458 patients, the majority with grade III and IV injuries (1040 patients). About 50% of patients with grade I injury (153 of 307) were submitted to TEVAR. Graft diameter and oversizing, length and manufacturer varied widely on studies that reported it. Further details about stent graft details can be found on Table 4.

FOLLOW-UP

Of the 26 studies reporting a follow-up duration, 14 studies (54%) including 604 patients provided follow-up information beyond 30 days. The length of follow-up, including in-hospital, varied widely from 1 day to 232 months.

CLINICAL OUTCOMES

The overall 30-day mortality was 11.2% (26 studies) mainly due to associated injuries. Twenty-one studies reported aortic-related death, with an overall rate of 2.2% (35 of 1563 patients) at 30 days post index event. Of these 28, 6 studies stratify deaths according to the grade of aortic injury and management: on the TEVAR group, 7 patients had grade III or IV aortic injuries. Mohapatra (2020) reports that 13 patients died after TEVAR for BTAI, and despite not specifying each aortic injury, states that aortic injury grade was not associated with mortality. Prendes (2021)[21] and Awadalla (2022)[19] report one death each due to complications after TEVAR (one graft collapse with aortic occlusion and one with and early endoleak – no further details were given). On the non-operative management group, only one death is reported, which was on a patient with a grade III injury; Al-Thani (2022)[20] also reports 2 other patients but doesn't give any further details. On the open surgery group, 4 patients died, and they had grades III or IV aortic injuries. No aortic related deaths were reported after the first 30 days.

Seventeen studies reported partial or complete coverage of the left subclavian artery (LSA). Reporting on a total of 522 patients, 27.9% of which required immediate or delayed revascularization, due to arm claudication, vertebrobasilar syndrome or previous history of left mammary artery coronary bypass. Further analysis of this outcome was outside the scope of this review.

Injury progression with need of posterior intervention (>30 days) on patients initially managed non-operatively was very uncommon on studies that reported it (5 of 165 patients). More commonly than in grades I and II, late intervention was undertaken in 3 of 41 patients with grade III injuries (versus 1 of 63 and 1 of 54 patients with grade I and II injuries, respectively). Arbabi (2022)[10] reports on 12 (11 TEVAR, 1 OSR) patients needing intervention after failed medical management, 11 of which were grades III and IV injuries (10 and 1 patients, respectively), but doesn't give details about timing of intervention.

Rate of aortic reintervention was 3.9% on studies that reported it (42 out of 1075 patients), mainly due to endoleaks (52%), but also infolding (17%), graft thrombosis (7%), migration (5%) and distal hyperplasia, dissection, malalignment (19% all together). On the studies that reported it, most causes that led to aortic reintervention occurred earlier in experience.

DISCUSSION

This systematic review included 1888 patients with BTAI. Our review found a 30-day all-cause mortality of 11.2% with an aortic-related death at 30 days of 2.2%, and no aortic related mortality after that period. These rates are significantly lower than previously reported and may be attributable to better care, not only by vascular surgeons, but also in the remains areas, and quicker response in such time dependent patients. The current SVS guidelines regarding the management of BTAI suggest nonoperative management only in grade I injury (intimal tear), while types II to IV should be submitted to intervention[9]. Aortic mortality also seems to be lower than previously expected which may be related to the implementation of TEVAR in high grade lesions. Is should be accounted there may be a publication bias, since patients

Table 1 **Assessment of evidence quality**

Title	First author	Publication year	Journal	Oxford CEBM level of evidence
Observational management of Grade II or higher blunt traumatic thoracic aortic injury: 15 years of experience at a single suburban institution	Ye, J.B.	2022	International Journal of Critical Illness and Injury Science	4
Our Experience with Endovascular Repair of Descending Thoracic Aortic Injury after Blunt Trauma	Awadalla, K.M	2022	Egyptian Journal of Hospital Medicine	4
Patterns, management options and outcome of blunt thoracic aortic injuries: a 20-year experience from a Tertiary Care Hospital	Al-Thani, H.	2022	European Journal of Trauma and Emergency Surgery	3
Outcomes after thoracic endovascular aortic repair in patients with traumatic thoracic aortic injuries—a single-centre retrospective review	Chinyepi, N.	2019	Acta Chirurgica Austriaca	4
Outcomes of operative and nonoperative management of blunt thoracic aortic injury.	Madigan MC	2022	Journal of Vascular Surgery	3
Outcomes and practice patterns of medical management of blunt thoracic aortic injury from the Aortic Trauma Foundation global registry	Arbabi CN	2022	Journal of Vascular Surgery	3
Retrospective study of thoracic endovascular aortic repair as a first-line treatment for traumatic blunt thoracic aortic injury	Izumi S	2022	General thoracic and cardiovascular surgery	4
Five-year Outcomes With Conformable GORE TAG Endoprosthesis Used in Traumatic Aortic Transections	Mark A Farber	2022	The Annals of Thoracic Surgery	3
Blunt thoracic aorta injuries, an Australian single centre's perspective	Krystal Dinh	2021	ANZ Journal of Surgery	4
Blunt traumatic thoracic aortic injuries: a retrospective cohort analysis of 2 decades of experience	Carlota Fernandez Prendes	2021	Interactive CardioVascular and Thoracic Surgery	3
Endovascular treatment of traumatic dissection of the thoracic aorta – Series of 16 cases	L. M. Sarquis	2020	Jornal Vascular Brasileiro	4
Five-Year Outcomes From the United States Pivotal Trial of Valiant Captivia Stent Graft for Blunt Aortic Injury	Himanshu J Patel	2020	The Annals of Thoracic Surgery	3
Natural History of Nonoperative Management of Grade II Blunt Thoracic Aortic Injur	Ann C. Gaffey	2020	Annals of Vascular Surgery	3
Risk factors for mortality after endovascular repair for blunt thoracic aortic injury	Abhisekh Mohapatra	2020	Journal of vascular surgery	3
The effect of TEVAR for blunt traumatic thoracic aortic injury on maximal aortic diameter: Mid- and long-term outcome	Hozan Mufty	2019	Vascular, Sage Journals	3
Blunt traumatic injury to the thoracic aorta treated with thoracic endovascular aortic repair: a single-centre 20-year experience	Andrea Agostinellia	2018	Interactive CardioVascular and Thoracic Surgery	4
Determinants and outcomes of nonoperative management for blunt traumatic aortic injuries	Harleen K Sandhu	2018	Journal of Vascular Surgery	3
Experts' Results in Blunt Thoracic Aortic Injury are Reproducible in Lower Volume Tertiary Institutions. Early and Mid-term Results of an Observational Study	Tamer Ghazy	2017	Eur J Vasc Endovasc Surg	3

Title	First author	Publication year	Journal	Oxford CEBM level of evidence
Long-term outcomes of thoracic endovascular aortic repair: A single institution's 11-year experience	Megan Brenner	2017	J Trauma Acute Care Surg	3
Long-term results following emergency stent graft repair for traumatic rupture of the aortic isthmus	Cecile Martin	2017	European Journal of Cardio-Thoracic Surgery	3
Nonoperative management of grade III blunt thoracic aortic injuries	Sagar S Gandhi	2016	Journal of Vascular Surgery	3
Blunt thoracic aortic injury with small pseudoaneurysm may be managed by nonoperative treatment	Shinsuke Tanizaki	2016	Journal of Vascular Surgery	4
Timing of Intervention in Blunt Traumatic Aortic Injury Patients: Open Surgical versus Endovascular Repair	Shao-Wei Chen	2015	Annals of Vascular Surgery	3
Endovascular repair for acute traumatic transection of the descending thoracic aorta: experience of a single centre with a 12-years follow up	Raffaele Serra	2015	Journal of Cardiothoracic Surgery	4
Durability of Endovascular Repair in Blunt Traumatic Thoracic Aortic Injury: Long-Term Outcome from Four Tertiary Referral Centers	J Steuer	2015	Eur J Vasc Endovasc Surg	4
One-year results of thoracic endovascular aortic repair for blunt thoracic aortic injury (RESCUE trial)	Ali Khoynezhad	2015	Journal of Vascular Surgery	3
Outcomes in the emergency endovascular repair of blunt thoracic aortic injuries	Ombretta Martinelli	2013	Journal of Vascular Surgery	4
Outcomes of endovascular repair for blunt thoracic aortic injury	Gabriele Piffaretti	2013	Journal of Vascular Surgery	4

included survived the initial resuscitation which may exclude more severe aortic lesions and falsely lower both all-cause and aortic-related mortality rates.

Despite the variable follow-up rates, our study found low injury progression rates and low need for subsequent intervention (1.6% and 1.9% in grades I and II, respectively), supporting a generally satisfactory natural history with nonoperative management among grade I and II patients with BTAI[2, 5, 10, 27, 33, 34]. This recent body of evidence suggests a shift in the current guidelines towards NOM for grade 2 BTAI. Nevertheless, about 50 and 60% of patients with grade I and II injuries were managed with TEVAR, which raises the question about overtreatment and overexcitement with TEVAR in this pool of patients but also limits assessment of the primary indications for the clinical decision for either NOM or interventional treatment owing to the paucity of data and lack of reporting. It is of major importance to advice about careful interpretation of data.

Almost 90% of patients with grades III and IV aortic injuries were submitted to TEVAR which is in line with the current SVS guidelines[9]. Since the natural history of grade III BTAIs is not completely understood, Gandhi et al. suggest that observation and NOM of grade III BTAI may be a reasonable therapeutic option in selected patients[11], which may include those with small pseudoaneurysms, minimal hematoma or difficult to treat locations[30]. Serial imaging and long-term follow-up are necessary to monitor progression of such pseudoaneurysms.

It is well known that the aortic diameter increases with age.[35] Therefore, TEVAR for the treatment of BTAI in young patient raises the concern that stent grafts sized appropriately at time of implantation, may lose their fixation and sealing over time.[36] Even though follow-up for both nonoperative and operative management of BTAI varied widely, this study included follow-up of up to 20 years and showed good durability of the graft and aortic remodeling and low rate of reintervention and complications.

Most technical failures in TEVAR have occurred early in the experience on those that reported it, a problem that may be mitigated with the upgraded versions of endografts which seem to minimize the risk of long-term complications, including endoleak, migration, bird beaking, and fracture. The development of lower profile, conformable and flexible devices and an increasing experience with endovascular techniques has led to improvements in overall outcomes[10, 37-40]

Table 2 **Baseline characteristics of the included studies**

Author (year)	No. of patients	Patient information	Grade of aortic injury (no. of patients)	Management of aortic injury (grade of injury, no. of patients)
Ye (2022)	12	Male sex: 50% Mean age: 60 ± 16.1 years	II (2) III (10)	NOM (II, 2; III, 5) TEVAR (III)
Awadalla (2022)	58	Male sex: 92% Mean age: 27 ± 13 years	I (9) II or III (49)	NOM (I) TEVAR (II e III)
Al-Thani (2022)	87	Male sex: 81.6% Mean age: 37.3 ± 14.5 years	I (10) II (12) III (36) IV (29)	NOM (I, 10; II, 12; III, 4; IV, 9) TEVAR (III, 10; IV, 9) OSR (III, 22; IV, 11)
Madigan (2022)	176	Male sex: 74.4%	I (36) II (24) III (115) IV (1)	NOM (I 35; II 15; III 14), TEVAR (I 1; II 9; III 101; IV 1)
Arbabi (2022)	114	Male sex: 69.3% Mean age: 38.5 years	I (68) II (27) III (18) IV (1)	NOM
Izumi (2022)	79	Male sex: 69% Mean age: 56.7 ± 20.9 years	I (1) II (21) III (54) IV (3)	NOM (I, 1; II, 20; III, 5; IV, 2) TEVAR (II, 1; III, 46; IV, 1) OSR (III, 3)
Farber (2022)	98	Male sex: 74.3% Mean age: 42.7 ± 19.5 years	I (76) II (9) IV (13)	TEVAR
Dinh (2021)	32	Male sex: 90.6%	I (8) II (10) III (12) IV (2)	NOM (I, 5) TEVAR (I, 3; II, 10; III, 12; IV, 2)
Prendes (2021)	46	Male sex: 71.1% Mean age: 42.2 years	I (3) II (9) III (16) IV (17)	NOM (1) TEVAR (40) OR (5)
Sarquis (2020)	16	Male sex: 87.5% Mean age: 37 years	I (1) II (8) III (6) IV (1)	TEVAR
Patel (2020)	50	Male sex: 76% Mean age: 40.7 ± 17.4 years	I (9) II (6) III (34) IV (1)	TEVAR
Gaffey (2020)	15	Male sex: 60% Mean age: 45 ± 21 years	II (15)	NOM
Mohapatra (2020)	452	Male sex: 73.9% Mean age: 39 years	I (40) II (77) III (254) IV (81)	TEVAR
Chinyepi (2019)	34	Male sex: 91.2% Mean age: 35.1 ± 11.5 years	I (1) II (8) III (22) IV (3)	TEVAR
Mufty (2019)	27	Male sex: 74%	II (3) III (16) IV (8)	TEVAR
Agostinellia (2018)	35	Male sex: 82% Mean age: 42 years	I (9) III (12) IV (14)	TEVAR
Sandhu (2018)	71	Male sex: 70.8% Mean age: 37.5 ± 15.1 years	I (26) II (45)	NOM (I, 26; II, 22) TEVAR (II, 23)

Author (year)	No. of patients	Patient information	Grade of aortic injury (no. of patients)	Management of aortic injury (grade of injury, no. of patients)
Ghazy (2017)	22	Male sex: 89% Mean age: 42 ± 16 years	II (2) IV (20)	NOM (II) TEVAR (IV, 18) OSR (IV, 2)
Brenner (2017)	88	Male sex: 72.7%	II (2) III (79) IV (7)	TEVAR
Martin (2017)	52	Male sex: 80% Mean age: 43 ± 17 years	I (1) III (50) IV (1)	TEVAR
Gandhi (2016)	35	Male sex: 60%	III	NOM (18) TEVAR (17)
Tanizaki (2016)	18	Male sex: 67% Mean age: 58.2 years	III	NOM
Chen (2015)	63	Male sex: 90.3% Mean age: 37.9 ± 17.1 years	III (52) IV (11)	TEVAR (40) OSR (23)
Serra (2015)	11	Male sex: 82% Mean age: 36.9 ± 10.3 years	II (1) III (9) IV (1)	TEVAR
Steuer (2015)	74	Male sex: 84% Mean age: 41 years	I (1) II (10) III (55) IV (8)	TEVAR
Khoynezhad (2015)	50	Male sex: 76% Mean age: 40.7 ± 17.4 years	I (9) II (6) III (34) IV (1)	TEVAR
Martinelli (2013)	27	Male sex: 81%	II (3) III (6) IV (18)	TEVAR
Piffaretti (2013)	46	Male sex: 76.1% Mean age: 39 ± 18 years	I (2) III (26) IV (18)	TEVAR

Table 3 **Classification of treatment strategy per blunt aortic traumatic injury grade**

Aortic injury grade	NOM	TEVAR	OSR	Total
I	154	153	-	307
II	115	176	-	291
III	82	794	25	901
IV	12	206	13	231

NOM: non-operative management; TEVAR: thoracic endovascular aortic repair; OSR: open surgical repair

CONCLUSION

Overall all-cause mortality and aortic mortality seem to be lower than previously described. Although SVS guidelines suggest NOM for grade I injuries and endovascular repair for grade II-IV BAI, grade II injuries can safely be managed using non operative management, even though there might be a pool of patients that might benefit from an earlier, more aggressive treatment strategy. There might be a place for NOM in highly selected patients with grade III aortic injuries. Follow-up times up to almost 20 years are becoming available showing good durability of the graft and aortic remodeling and low rate of reintervention and complications. Newer generation grafts brought better outcomes.

Table 4 **Procedure details of the included studies**

Author (year)	Stent graft (no. of implants)	Oversize	Mean length of aortic coverage, mm
Awadalla (2022)		-	100
Al-Thani (2022)	Medtronic Valiant Captivia (33)	-	
Madigan (2022)	Gore TAG (37) Gore Conformable TAG (56) Cook TX2 (3) Cook Alpha (2) Medtronic Talent (3) Aortic cuffs (11)	-	100
Arbabi (2022)	Gore TAG (9) Gore Conformable TAG (23) GORE® EXCLUDER® cuff (1) Custom-made devices (14)	-	-
Farber (2022)	Gore Conformable TAG (98)	17.93 ± 7.43% with 50% of patients in the 10 – 20% oversizing range	-
Dinh (2021)	CookZenith, Talent and Gore (non specified)	10–20%	-
Prendes (2021)	Cook Zenith TX2 (26) Cook Zenith Alpha (1) Medtronic Valiant (4) Gore TAG (4)	11.5 ± 2%	-
Sarquis (2020)	Medtronic Valiant Captivia® (8) Medtronic Endurant II (4) NANO Endoluminal Apolo Reta Torácica (1) Gore Tag® (1) Cook Zenith® (1) Medtronic Endurant (1)	13-21%	118
Patel (2020)	Medtronic Valliant Captivia (50)	11,5%	-
Mufty (2019)	Medtronic Valiant (17) Medtronic Talent (7) Gore TAG device (3)	Approximately 10%	-
Agostinellia (2018)	Gore Tag (3) Gore C-Tag (7) Medtronic Talent (17) Medtronic Valliant (8)	10-20%	147
Ghazy (2017)	Gore Tag (14) Medtronic Valliant (4)	-	138
Martin (2017)	Gore Excluder (5) Medtronic Talent (17) Medtronic Valliant (38)	10-20%	112 ± 13
Chen (2015)	Cook Zenith (25) Gore Tag (14) Medtronic Talent (1)	18,7%	125,4 ± 28,3
Serra (2015)	Medtronic valliant and Talent (11)	10-20 %	-
Steuer (2015)	Gore TAG (43) Cook Zenith (13) Medronic Talent or Valiant (10) JOTEC E-vita (6)	15-60%	135
Martinelli (2013)	Cook Zenith TX1 or TX2 (4) Gore TAG or C-TAG (5) Medtronic Valiant (9) Medtronic Valiant-Captivia (8) Medtronic Talent (1)	15-20%	150-220 (minimum and maximum)
Piffaretti (2013)	Gore Excluder/TAG/C-TAG Medtronic Talent/Valiant/Captivia Cook TX-1/TX-2	10-20%	-

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