Blunt Aortic Traumatic Injury Management: An Observational Study in 10 French Trauma Centers.

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Research

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Abstract

Background: Blunt aortic trauma injury (BTAI) in severe trauma patients is rare but lethal and is the second leading cause of death after brain damage. Development in automotive technology have reduced mortality at the scene of the accident and increased hospital admissions for patients with aortic injury. The aim of this work was to proceed with an epidemiologic analysis of BTAI on a French cohort.

Methods: This is a multicentric retrospective study including patients admitted between 2013 and 2018 in 10 French trauma centers and participating in the Traumabase® registry. Demographic, diagnostic and therapeutic data were collected. Severity of aortic injuries was classified according to the Vancouver grades.

Results: 209 patients were included, mean age was 43 years (19) and 168 (80%) were men. They had a Red Flag of 2[1-3], an injury severity score of 39 (18.3) and several associated lesions: 4[3-5]. The calculated prevalence of BTAI was 1%.

Mechanisms associated with BTAI were high kinetic accidents, with severe thoracic injury. Patients presented with high clinical suspicion for severe hemorrhage. The time to diagnosis increased with the severity of aortic injury (grade 1: 94[74-143] minutes, grade 2: 129[106-143] minutes, grade 3: 117[100-170] minutes, grade 4: 154[112-202] minutes, p=0.02).

Overall mortality was 20% and increased with the severity of aortic injury (grades 1: 6%, grades 2: 12%, grades 3: 22% et grades 4: 65%, p<0.001). The delay before death was 1,5[1-4.7] days (grade 1: 2[1.5-3] days, grade 2: 12[1-42.7] days, grade 3: 2[1-6.2] days, grade 4: 1[1-1.5] days, p=0.003).

Among deceased patients, 16 (38%) had hemorrhagic shock, 13 (31%) had post-hemorrhagic multiple organ failure, 5 (12%) had cerebral cause, and 8 (19%) had septic shock.

Conclusions: Patients with BTAI presented severe trauma with multiple associated injuries, were victims of a high kinetic accident and had an overall 20% mortality with a 65% mortality rate for grade 4 patients. They died of hemorrhagic shock in more than 2/3 of the cases and received endovascular treatment in 2/3 of the case.

Trial registration: Advisory Committee for Information Processing in Health Research (CCTIRS, 11.305 bis). National Commission on Informatics and Liberties Data protection agency (CNIL, 911461 and 2211878). National institutional review board requirements (Comité de Protection des Personnes Paris VI, Paris, France).

Background

Blunt traumatic aortic injury (BTAI) is associated with an increased mortality in severe trauma patients and is frequently due to deceleration mechanisms found in high-speed motor vehicle accident or high-level falls (1). BTAIs are mostly localized at the aortic isthmus as it is a connecting area between a mobile

aortic arch and a relatively fixed descending thoracic aorta (2). While it remains a rare consequence of blunt trauma (0.3 to 1%) (3), autopsy series describe that 80 to 90% of all BTAIs are immediately fatal (4,5). Patients arriving alive at hospital still have an overall mortality greater than 40%. The more severe the aortic injuries, the greater the morbidity and mortality (4,6). Patients with BTAIs often have associated injuries such as traumatic brain injuries (TBI), thoracic or abdominal injuries.

An early suspicion of BTAI is paramount for adequate care and appropriate triage. Commanding a rapid swift diagnosis and treatment for patients presenting BTAI is an ultimate objective as they mostly die of hemorrhage. In the last decade, the use of computerized tomography (CT scan) for trauma patients injuries assessment and the development of endovascular repair have improved both diagnosis and treatment of these injuries (7).

The literature on BTAI is not abundant and most have been performed in the United States of America (USA). It seemed appropriate to deepen knowledge on BTAI with more recent epidemiological data from a European setting.

The aims of our study were to analyze a large cohort of BTAI patients, to determine BTAI prevalence, their characteristics and outcomes and to explore management modalities.

Methods

Study design and setting

This is a multicenter (n = 10) retrospective study using prospectively collected data from the French national trauma registry (TraumaBase®) and National Uniform Hospital Discharge Database (Program of medicalization of information systems - PMSI). Sociodemographic, clinical, biological, therapeutic and scoring data (from the prehospital phase to discharge from the intensive care unit (ICU)) are systematically collected for all trauma patients. The structure of the TraumaBase® integrates algorithms for consistency and coherence. Data monitoring is performed by a central administrator. The TraumaBase® obtained approval from the Advisory Committee for Information Processing in Health Research (CCTIRS, 11.305 bis) and from the National Commission on Informatics and Liberties Data protection agency (CNIL, 911461 and 2211878), and meets the national institutional review board requirements (Comité de Protection des Personnes Paris VI, Paris, France).

Patients

Every trauma patient with a diagnosis of BTAI (Traumabase® cross-checked with PMSI as detailed in **Supp Data 1 [see Additional file]**) admitted between January 2013 and December 2018 to one of the ten participating trauma centers was included. Participating facilities were all specialized trauma centers distributed in multiple French regions. A detailed description of the emergency medical system (EMS) management and trauma system has been provided elsewhere (8). Diagnosis of aortic injury was confirmed by imaging (CT scan or transesophageal echocardiography (TEE)) and grades were defined

using the Vancouver classification of BTAI (9). Patients were not included if they died before admission, if the diagnosis of BTAI remained uncertain or was caused by penetrating trauma. Patients were excluded if missing data exceeded 30% of all variable fields, or if data regarding resuscitation were missing.

Management was left to the discretion of the physicians in charge according to National and European guidelines with clear clinical and biological targets adapted to associated injuries and timing (10). Treatment of the aortic injury consisted of non-operative management (observation), endovascular treatment or open repair surgery, according to the surgeon in charge.

Data

In addition to the Traumabase® dataset, we collected injury specific characteristics, including grade and location of aortic injury, diagnostic timing and method, treatment related details including technique, timing and duration of the procedure. The collected and computed outcomes were mortality, ICU length of stay (LOS), hospital LOS and treatment related specific complications. Predictive scores were calculated during prehospital management and resuscitation room: Shock index, Red Flag shock activation code, ISS (Injury Severity Score), SAPS2 (Simplified Acute Severity Score II). Predicted mortality was assessed using Trauma Injury Severity Score (TRISS). Acute kidney injury was defined according Kidney Disease Improving Global Outcome (KDIGO) criteria using admission creatinine concentration as baseline.

The Vancouver classification for BTAI was based on CT scan analysis to define 4 grades : grade 1 (intimal tear or intramural hematoma < 10 mm), grade 2 (intimal tear or intramural hematoma > 10 mm), grade 3 (pseudo-aneurysm) and grade 4 (aortic rupture) (11). Patients were classified as “Severe BTAI” when presenting with a grade 3 or 4 and as “Not Severe BTAI” for a grade 1 or 2 (12).

Endpoints

The primary outcome measure was the prevalence and distribution of the severity of BTAI using the Vancouver classification. The secondary outcomes were the mortality rate, ICU and hospital LOS, characteristics of associated injuries, trauma mechanisms, diagnosis and treatment modalities, clinical and biological characteristics of patients with a BTAI.

Statistical analysis

The report follows the Strobe guideline (13). Continuous data were described as mean (standard deviation) or median [1st – 3rd quartile] according to their distribution, and categorical variables as count (percentages). Bivariate analyses were performed using Chi^2 test and Student t tests (or Mann-Whitney test) depending on variable type. Kruskal Wallis test was used for multiple group comparison.

A binomial logistic regression was performed to assess the association between severity and clinical presentation, associated OR (odds ratio) and CI_{95} (Confidence interval at 95%) were calculated. A p-value < 0.05 was considered significant. All data were analyzed with R software 3.5.6 (The R Foundation for Statistical Computing, Vienna, Austria).

Results

Population characteristics

Between January 2013 and December 2018, 280 patients presented with suspected BTAI, 227 patients met inclusion criterion and 18 patients were excluded because medical records were unavailable **(Flow chart presented in Fig. 1)**. 209 patients were analyzed. The screening period for Traumabase® depended on the date when the centres started participating in the registry (as detailed in **Supp Data 2 [see Additional file])**.

Table 1
Demographics and injuries mechanisms characteristics

	Total (n = 209)	**Grade 1 (n = 49, 23%)**	**Grade 2 (n = 64, 31%)**	**Grade 3 (n = 73, 35%)**	**Grade 4 (n = 23, 11%)**	**P-value**
Characteristics						
Age, Years (SD)	43.4 (18.9)	46.7 (18)	44.7 (17.6)	38.5 (17.9)	48.17 (24.6)	0.04
Sex (male), n (%)	168 (80%)	40 (82%)	49 (67%)	60 (82%)	19 (83%)	0.83
Mechanisms						
Fall (> 6 m), n (%)	62 (30%)	12 (24%)	19 (30%)	23 (32%)	8 (35%)	0.79
Car accident, n (%)	61 (29%)	14 (29%)	22 (34%)	22 (30%)	3 (13%)	0.29
Pedestrian accident, n (%)	17 (8%)	3 (6%)	5 (8%)	4 (5%)	5 (22%)	0.08
Motorcycle accident, n (%)	62 (30%)	19 (39%)	16 (25%)	20 (27%)	7 (30%)	0.42
Other, n (%)	4 (2%)	1 (2%)	2 (3%)	1 (1%)	0 (0%)	0.78
Skiing, n (%)	1 (0%)	0 (0%)	0 (0%)	1 (1%)	0 (0%)	0.6
Bike accident, n (%)	2 (1%)	0 (0%)	0 (0%)	2 (3%)	0 (0%)	0.29
Severity scores						
ISS, median [IQR]	34 [25–48]	29 [21–34]	34 [28.2–45]	38 [29–50]	43 [37–75]	< 0.001
SAPS2, median [IQR]	37 [21–60]	24 [18–42]	37 [23.8–55.5]	38 [21–60]	71 [49–85]	< 0.001

ISS = Injury Severity Score, SAPS2 = Simplified Acute Physiology Score 2

For the period allowing the monitoring of all severe trauma patients admission with the Traumabase®, 15094 blunt trauma were admitted and 162 patients (1%) had BTAI. The distribution of patients' origin, the period considered and the associated prevalence of BTAI are detailed in **Supp Data 2 [see Additional file]**.

Demographics and injury mechanisms are described in Table 1.

There was no missing data concerning patients or injuries characteristics.

Observed patient pathway

Figure 2 Illustrates the observed characteristics and management of patients with a BTAI.

Prehospital management

Patients profile stratified according to the aortic grade are described in **Supp Data 3 [see Additional file]**.

Patients with a severe BTAI presented with characteristics predictive of hemorrhagic shock: prehospital shock index > 1 and clinical Red flag > 2 and was significantly higher according to the grade of the aortic lesion. There was no significant difference for initial capillary hemoglobin measurement according to BTAI grade with a mean capillary hemoglobin concentration of 12.9 (2.3) g/dL **(Supp Data 3 [see Additional file])**.

Median EMS transportation time was 82 [56–124] minutes (arrival on scene to hospital admission) and there was no significant difference according to the injury grade (p = 0.31) even though patients with a grade 4 aortic injury needed more frequently prehospital orotracheal intubation and were more frequently in cardiac arrest (n = 6, 26%).

Resuscitation room (RR)

Patients' characteristics in RR are described in **Supp Data 4 [see Additional file]**.

On arrival in the RR, patients with a severe BTAI were more frequently in shock as indicated by a more frequent need for vasopressor support, mean (MAP) and systolic arterial pressure (SAP) lower and increased blood lactate concentration. The underlying mechanism of shock was hemorrhage with a significantly decreased plasmatic hemoglobin concentration in RR (-1.4 (2.6) g/dL) compared to patient without shock.

During hospital resuscitation, more patients were in shock with an increase in patients receiving norepinephrine infusion (+ 33 patients (+ 16%)) during RR medical care.

BTAI diagnosis and treatment

Data on the diagnosis and treatment of BTAI are presented in Table 2.

The diagnosis of aortic injury was always confirmed with a CT scan, with one exception the diagnosis being performed in the operating theater by transesophageal echocardiography. The time to diagnosis was 124 [94–171] minutes except for 27 patients (13%) who underwent a CT scan prior to their admission in the trauma center (Table 2). The grade of BTAI seemed associated to a longer time to diagnosis: grade 1: 94 [74–143] minutes, grade 2: 129 [106–143] minutes, grade 3: 117 [100–170] minutes, grade 4: 154 [112–202] minutes ($p = 0.02$).

Chest X-ray was not carried out systematically and was performed on 114 patients (55%): X-ray was described as normal in 54 (47%) patients, wide mediastinum in 19 (17%) and hemothorax in 18 (16%). No left apical cap was described. Focused assessment with sonography for trauma (FAST) imaging was realized in 78% of cases and described a hemothorax in 25 patients (15%) and pericardial effusion in 1 (1%) patient. Characteristics of the chest X-ray or FAST imaging are described in **Supp Data 5 [see Additional file]**.

The aortic injury was localized at the aortic isthmus for 156 patients (75%), the abdominal aorta for 25 patients (12%), the thoracic descending aorta for 15 patients (7%). Few patients had a BTAI localized at the aortic arch (4 patients (2%)) or the thoracic ascending aorta (2 patients (1%)). 7 patients (3%) had multiple aortic injury.

Table 2
Aortic trauma management

	Total (n = 209)	Grade 1 (n = 49, 23%)	Grade 2 (n = 64, 31%)	Grade 3 (n = 73, 35%)	Grade 4 (n = 23, 11%)	P-value
Diagnosis						
Diagnosis before admission, n (%)	27 (13%)	7 (14%)	10 (16%)	9 (12%)	1 (4%)	0.621
Time from admission to diagnosis, median, minutes [IQR]	124 [94 – 17]	94 [74–143]	129 [106–172]	117 [100–170]	154 [112–202]	0.021
TEE diagnosis, n (%)	2 (0.5%)	0 (0%)	2 (3%)	0 (0%)	0 (0%)	0.206
CT scan diagnosis, n (%)	208 (99.5%)	49 (100%)	64 (100%)	73 (100%)	22 (96%)	0.043
First therapeutic managment						
Within first 24 hours, n (%)	167 (80%)	26 (53%)	55 (86%)	69 (95%)	17 (74%)	< 0.001
Aortic injury first, n (%)	124 (59%)	8 (16%)	44 (69%)	60 (82%)	12 (52%)	< 0.001
Embolization first n (%)	36 (17%)	1 (2%)	13 (20%)	17 (23%)	5 (22%)	0.113
Non-aortic surgery first n (%)	60 (29%)	13 (27%)	24 (38%)	20 (27%)	3 (13%)	0.056
Time before treatment, median, minutes, [IQR]	311 [240–560]	1005[340–3399]	291 [240–537]	309 [240–491]	260 [189–330]	0.016
Aortic treatment type						
Endovascular graft, n (%)	130 (62%)	13 (27%)	49 (77%)	57 (78%)	11 (48%)	< 0.001
Open surgery, n (%)	14 (7%)	0 (0%)	2 (3%)	9 (12%)	3 (13%)	0.018
Non operative management, n (%)	67 (32%)	36 (73%)	13 (20%)	8 (11%)	10 (43%)	< 0.001
Died within 24 h hours, n (%)	13 (19%)	1 (2%)	3 (4.7%)	2 (2.7%)	7 (30%)	-
Died in-ICU	22 (33%)	3 (6.1%)	3 (4.7%)	6 (8.2%)	10 (43.4%)	-

	Total (n = 209)	Grade 1 (n = 49, 23%)	Grade 2 (n = 64, 31%)	Grade 3 (n = 73, 35%)	Grade 4 (n = 23, 11%)	P-value
WLS (%)	7 (10.4%)	2 (4.1%)	0 (0%)	1 (1.5%)	4 (17.4%)	-
Timing of aortic treatment						
Early (< 24 h), n (%)	123 (59%)	9 (18%)	45 (70%)	58 (79%)	11 (48%)	0.07
Delayed (> 24 h), n (%)	15 (7%)	4 (8%)	5 (8%)	6 (8%)	0 (0%)	-

TEE = transesophageal echocardiography, CT = Computerized tomography, ICU = Intensive care unit, WLST = Withdraw life support

One hundred and thirty patients (62%) had endovascular grafting, 14 (7%) had a surgical repair and 67 (32%) were managed non-operatively. Among operated patients, most patients with a grade 2 or 3 lesion underwent endovascular grafting (75%): 35% for grade 2, 40% for grade 3, 6.2% for grade 1 and 7.8% for grade 4 (p < 0.001). Surgical treatment detailed was not collected, neither described. 80% of the procedures were performed during the first 24 hours and aortic treatment was assessed in priority for 76% of patients, 24% had non-aortic surgery first. Among the 67 patients managed non-operatively: 36 patients (54%) had grade 1 injury, 13 (19%) grade 2, 8 (12%) grade 3, and 10 (15%) grade 4. Among the 67 patients managed non-operatively, 47 (70%) patients were not operated because it wasn't recommended according to the surgeon, 7 (10%) patients were too severe and had withdrawal of life support (WLS), and 13 (19%) didn't have time to be operated as they died quickly of hemorrhagic shock.

The median number of associated injuries was 4 [3–5] and was not significantly different according to the grade of BTAI (p = 0.15). The most common associated injuries were thoracic injuries such as rib fractures (57% of patients, n = 120), hemothorax (52% of patients, n = 108), pneumothorax (38% of patients, n = 80). Abdominal and pelvic injuries were frequent in respectively 60% and 47% of patients. One third of patients presented with an associated TBI. Finally, 56% of patients had associated limb injuries **(Supp Data 6 [see Additional file])**.

Morbidity and mortality for BTAI

Forty-two patients (20%) died in ICU, none died in hospital after ICU discharge. Mortality was significantly associated to the grade of BTAI with a 6% mortality rate for grade 1, 12% for grade 2, 22% for grade 3 and 65% for grade 4 (p < 0.001). Among the 42 deceased patients, 16 (38%) died of hemorrhagic shock, 13 (31%) of post-hemorrhagic multi-organ failure, 8 (19%) of septic shock and 5 (12%) of severe TBI. Median time to death was 1.5 [1-4.7] days with a shorter time for severe BTAI (p = 0.03).

33 (79%) patients died prematurely within the first 5 days, 25 (75%) of them from hemorrhage, 4 (12%) from severe TBI, 4 (12%) from early septic shock. Amongst these patients, WLS was performed in 9 case (27%). The remainder 9 patients (21.4%) died after 5 days, 2 (22%) of them due to the consequences of hemorrhagic shock, 6 (66%) had septic shock, 1 (11%) had severe TBI.

There was no significant difference between aortic injury localization and mortality nor between single or multiple localizations and mortality.

TBI and pelvic injuries were not associated with BTAI severity but were associated with a higher mortality: OR = 2.23 CI_{95} [1.02–5.06], $p < 0.001$ and OR = 3.9 CI_{95} [1.9–8.3], $p < 0.001$ respectively **(Supp Data 7 [see Additional file])**.

The median ICU LOS was 6 [2–16] days (8 [4-17.5] days for survivors) and the median hospital LOS was 18 [8–35] days (24 [12-39.5] for survivors). The in-hospital complications are detailed in Table 3.

For the complications specific to endovascular treatment, 12 patients (9%) had a stroke, 2 (1.5%) patients became paraplegic after treatment whereas they had no spinal injury on admission. Two patients (2%) presented with a graft infection, 9 (7%) patients had a graft migration, 1 patient (0.7%) had an arteriovenous fistula and 4 (3%) a false aneurysm. There was no significant difference in treatment-related complications according to the severity of the aortic lesion with a median follow-up of 13 months : 399 [56–844] days (**Supp Data 8 [see Additional file]**).

Table 3
Morbidity and mortality for blunt traumatic aortic injuries

Morbidity and mortality	**Total (n = 209)**	**Grade 1 (n = 49, 23%)**	**Grade 2 (n = 64, 31%)**	**Grade 3 (n = 73, 35%)**	**Grade 4 (n = 23, 11%)**	**P-Value**
Outcomes						
Mortality, n (%)	42 (20%)	3 (6%)	8 (12%)	16 (22%)	15 (65%)	< 0.001
Predicted mortality by TRISS, (%)	28,8%	15.5%	26.5%	32.2%	58.8%	NA
ICU LOS, median [IQR]	6 [2–16]	4 [2–8]	9 [4–18]	8 [3–28]	2 [1–7]	< 0.001
Hospital LOS, median [IQR]	18 [8–35]	15 [8-26.75]	26 [11–40]	19 [10–39]	2 [1–20]	0.001
Time before death, median [IQR]	1.5 [1-4.7]	2 [1.5-3]	12 [1-42.75]	2 [1-6.25]	1 [1-1.5]	0.03

TRISS = Trauma Injury Severity Score, ICU = Intensive care unit, LOS = length of stay

Discussion

In this multicenter cohort study, BTAI prevalence in trauma patients alive on admission was 1%, and mortality was 20% (predicted 28%). The most frequent and early cause of death was hemorrhage within the first 36 hours, which highlight the need for a quick diagnosis and treatment. The most frequently used treatment modality was endovascular repair (62% vs 7% for open repair).

Observed patient pathway

Prehospital management

As usual in trauma population, BTAI affects mostly young males (14). Few studies focus on prehospital management of BTAI as many patients die on scene. In our study, BTAI are essentially secondary to falls, car crashes and motorcycle accidents, mechanisms consistent with high velocity with sudden deceleration.

Patients with severe BTAI had *severe hemorrhage* predictive indicators (shock index, red flag). Despite patient's high risk of hemorrhage, the prehospital capillary hemoglobin was not decreased in accordance to the aortic grade whereas it has been described to be lower in patients with severe hemorrhage (15,16), this highlight that intensive bleeding might occur secondarily.

Delay before diagnosis

Time to diagnosis and time to treatment are important notions in damage control : as shown in Gauss et *al*. study, the odds of death after adjustment increased by 4% for each 10-minute increase in prehospital time (14). Resuscitation time in the RR was 35 [20–50] minutes but the "Time to diagnosis" (120 [94–171] minutes) and more importantly the "Time to treatment" (311 [240–560] minutes) were extended while diagnosis and treatment remain essential for the survival of patients with hemorrhage. Nevertheless, the association of in-hospital resuscitation time and trauma mortality has been rarely explored.

Diagnosis of aortic injury and associated lesions

Injuries of the aortic isthmus represented 3 out of 4 aortic injuries, as found in the work of Teixeira et *al*., with 66% of aortic isthmus injury (5). We reported only 3% of multiple aortic injuries while Teixeira et *al.* reported 18%. However, Teixeira *et al.* also included autopsic series where multiple aortic injuries were associated with poor prognosis. For the same reasons, no localization of aortic trauma was significantly associated with mortality in our study, as trauma of ascending aorta or aortic arch are associated with a higher mortality rate (5,17).

Compared to Teixeira et *al*., our study found a similar rate of associated abdominal lesions (74% in Teixeira et *al*. versus 60% in our study), but with a lower incidence of associated brain injuries (52% in Teixeira et *al.* versus 33% in our study) (5).

Treatment and mortality

The emergence of endovascular treatment since its first description in 1991 by Parodi et *al.* for treatment of aortic aneurysms has completely changed the management of BTAI and the associated morbidity and mortality (2,18). Endovascular repair is a minimally invasive procedure with no need for bypass (meaning no high dose heparin and consequent high-risk of associated injuries bleeding). In our study, endovascular repair was the treatment of choice in 91.6% (130 patients) of treated patients while only 10% (14 patients) of treated patients had an open repair. This partition is found in studies such as Demetriades et *al.* for the American Association for the Surgery of Trauma (AAST) which included 193 patients and in which 65% of patients benefitted from endovascular repair when the first AAST study from Fabian et *al*. for blunt aortic traumas reported nearly exclusively open repairs (19,20). Surgical treatment detailed were not collected in this work and covering left subclavian artery or not maintaining systolic arterial pressure over 90 mmHg during surgery could lead to paraplegia or neurological poor outcome.

In our study, 67 patients (32%) were managed non operatively including 10 patients (15%) with a grade 4 injury. Nevertheless, none of these 10 patients survived and they did not have time or were too severe to receive treatment (5 of TBI, among them 4 had withdrawal of life support and 4 died before access to treatment from hemorrhage). These patients were too severe to be treated, the key of survival among them is to limit aortic injury extension from lower grade to grade 4. These results are similar to other studies such as Mosquera et *al*. study in which 32.4% of patients in the non-operative group presented with a head AIS of more than 3 or Estrera et *al*. study in which 80% of patients that did not undergo aortic repair died in the first 24 hours after admission (21,22).

The overall mortality rate is consistent with the literature with mortality rates around 18 to 19.5% as in Mosquera or Bade-Boon's recent reviews (23,24). Although there is a better understanding of the factors associated with aggravation or mortality, there are still difficulties in improving the management of these patients.

Strengths and limitations

This original work has several strenghts. First, this is the largest french cohort of BTAI to be analyzed. Second, the patient journey is precisely analyzed from EMS management to hospital discharge and surgical follow-up to allow a reflection on the clinical care proposed to the patient in our physician-based system. Last, very few data are missing and the Traumabase® registry is conceived to guarantee data quality and exhaustivity.

This study presents limitations inherent to its observational design. First, it precluded the measurement of important clinical factors such as provider experience, timing and appropriateness of care. Second, medical treatment and use of blood pressure medications were not detailed in our work. For endovascular grafting, we could not gather enough data concerning the coverage of the left subclavian artery, which is a concern for the left superior limb circulation. However, no case of arterial ischemia was reported. Finally, endovascular grafting has become the first line treatment in those BTAI patients even if we don't have a

lot of hindsight on this technique. In our cohort, long-term follow-up including surgical consultation was highly inconsistent or not reported.

Conclusion

Patients of this large cohort of BTAI presented severe trauma with multiple associated injuries, were victims of a high kinetic accident, and had an overall 20% mortality. They died of hemorrhagic shock in more than 2/3 of the cases and received endovascular treatment in 2/3 of the case.

According to these observations, a key point for survival could be to properly integrate the suspicion of BTAI in order to propose an early and adequate treatment and limit the bleeding and extension of injuries.

Prospective research projects would be useful to assess the impact of potential improvements suggested by the different analyses of this cohort comparing specific medical pathway for patients with suspected aortic injury with a long-term follow-up.

Abbreviations

AAST: American Association of the Surgery of Trauma

BTAI: Blunt Traumatic Aortic Injury

CCTIRS: « Comité Consultatif sur le Traitement de l'Information en matière de Recherche Scientifique »

CNIL: « Commission Nationale de l'Informatique et des Libertés »

CT: Computerized Tomography

EMS: Emergency Medical Service

FAST: Focused Assessment with Sonography for Trauma

ICU: Intensive Care Unit

ISS: Injury Severity Score

KDIGO: Kidney Disease: Improving Global Outcomes

LOS: Length Of Stay

MAP: Mean Arterial Pressure

PMSI: Program of Medicalisation of Information Systems

RR: Resuscitation Room

SAP: Systolic Arterial Pressure

SAPS2: Simplified Acute Physiology Score

TBI: Trauma Brain Injury

TEE: TransEsophageal Echocardiography

TRISS: Trauma and Injury Severity Score

USA: United State of America

WLS: Withdrawn Life Support

Declarations

Ethics approval and consent to participate:

The TraumaBase® group obtained approval for this study, including waived informed consent from the Institutional Review Board (Comité pour la Protection des Personnes, Paris VI-Pitié-Salpêtrière, France). The database was approved by the Advisory Committee for Information Processing in Health Research (Comité Consultatif sur le Traitement de l’Information en matière de Recherche dans le Domaine de la Santé), and the French National Commission on Computing and Liberty (Commission Nationale Informatique et Liberté).

Consent for publication:

The manuscript does not contain any individual person’s data in any form.

Availability of data and materials:

The datasets generated and/or analysed during the current study are not publicly available due the TraumaBase® policy for publication but are available from the corresponding author on reasonable request.

Competing interests:

The authors declare no competing interests regarding the content of the manuscript.

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Authors' contributions:

Study concept and design (SRH, MJC, JD), data acquisition (BL, MJC, DG, EH, IR, ND, AN, AM, VB, QM, OM, SRH), data analysis (BL, MJC, SRH), data interpretation (BL, MJC, SRH), drafting (BL, MJC, SRH), critical revision (BL, MJC, SRH, PJ, OM, JD). All authors read and approved the final manuscript.

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Figures

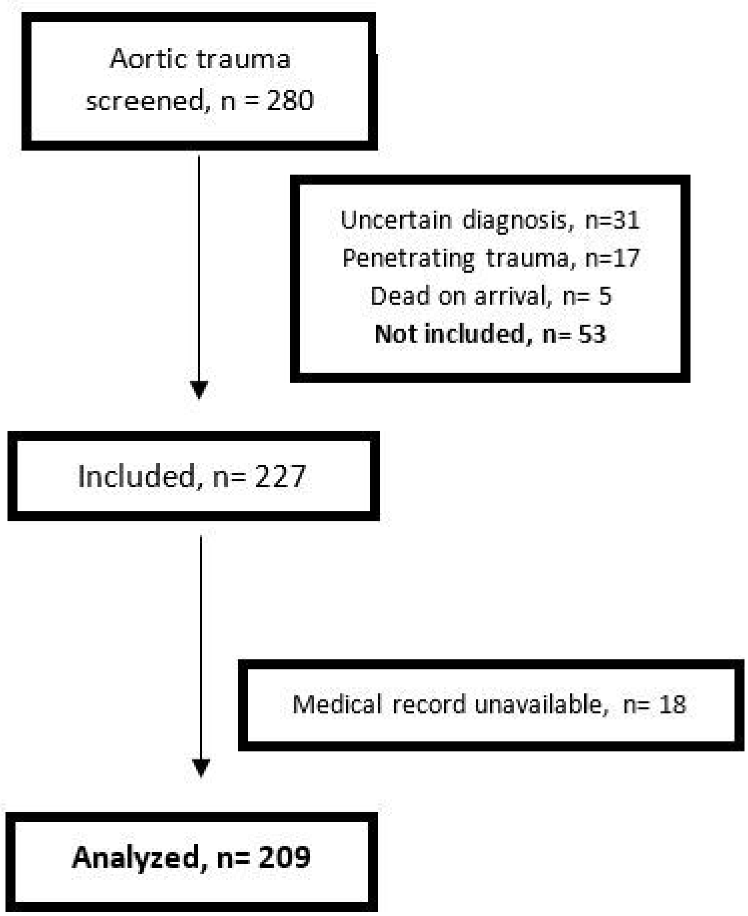
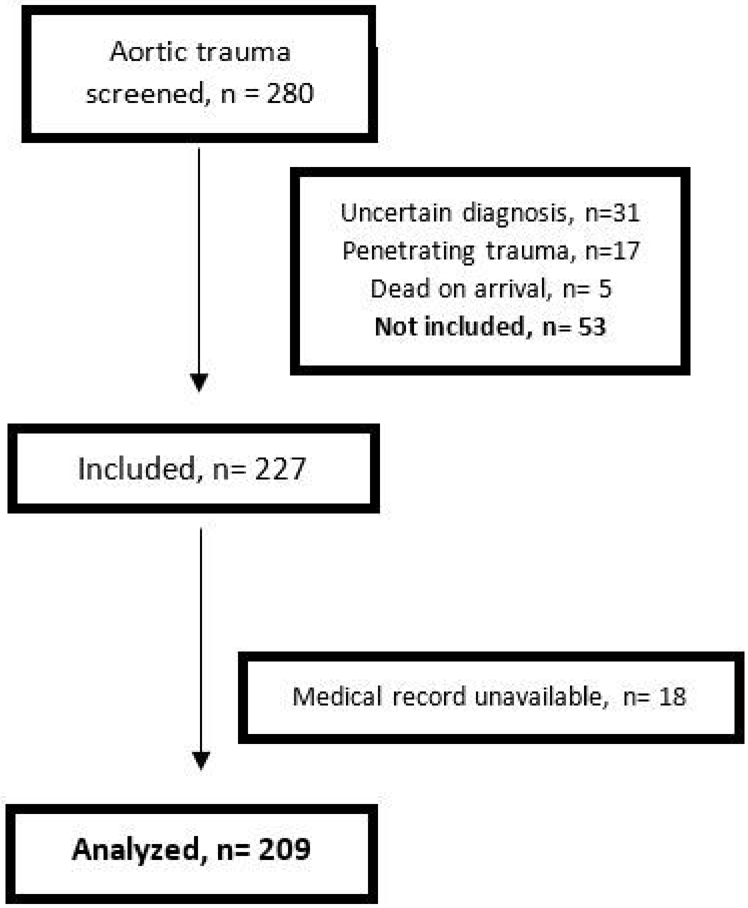


Figure 1

Flow chart of the study



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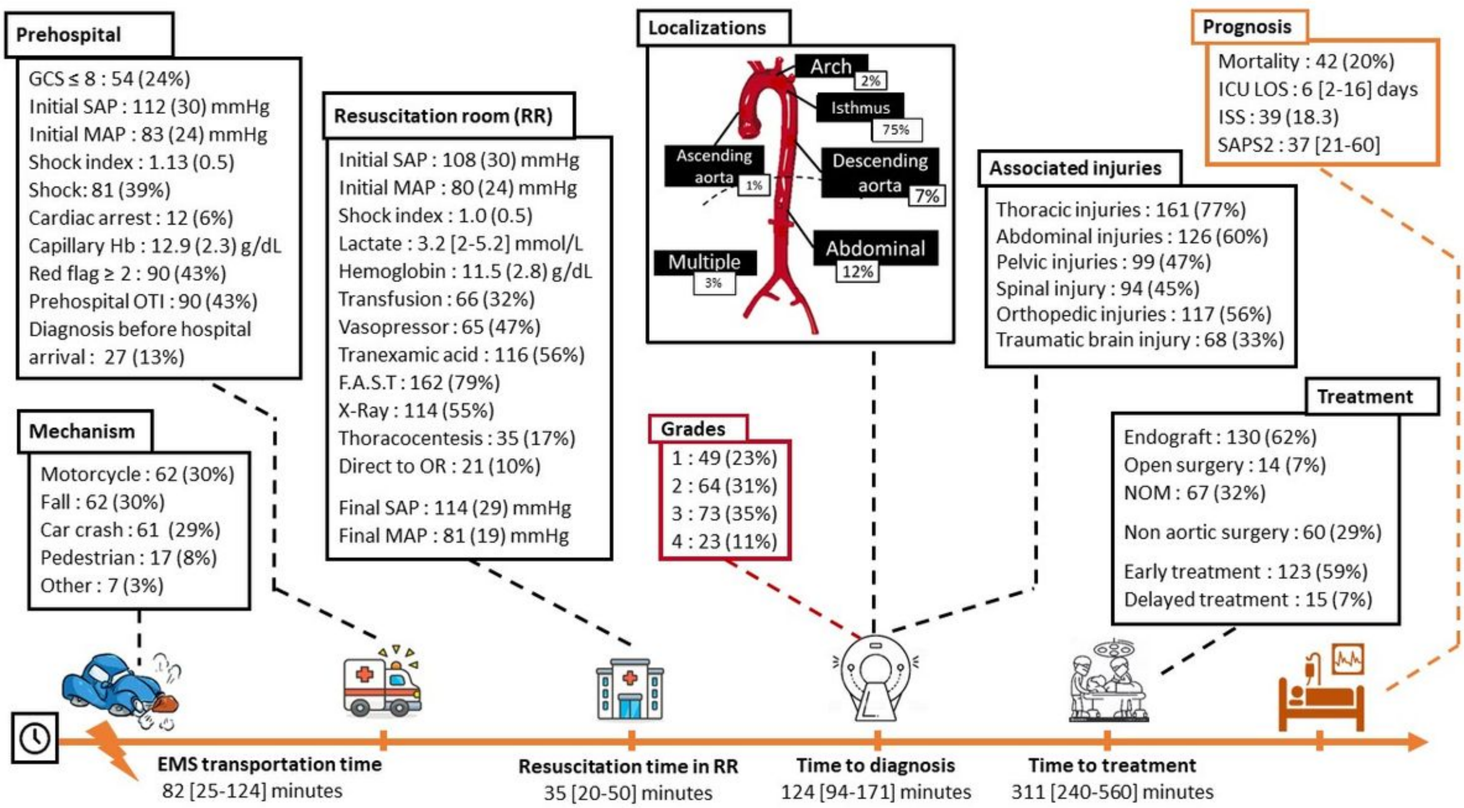
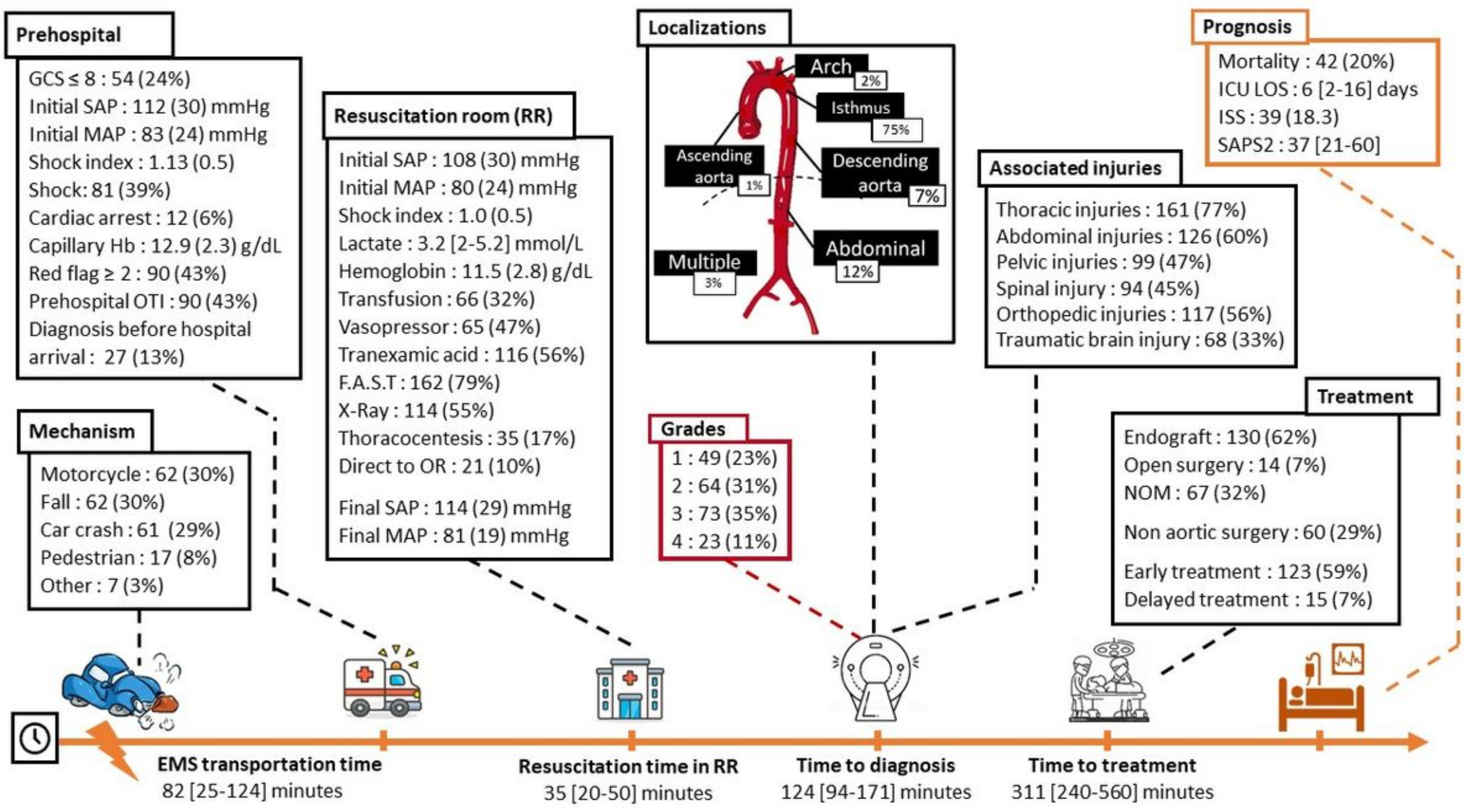


Figure 2

Observed patient pathway GCS = Glasgow Coma Scale, SAP = Systolic Arterial Pressure, MAP = Mean Arterial Pressure, Hb = hemoglobin, FAST = Focused Assessment with Sonography for Trauma, OR = Operating Room, ICU LOS = Intensive Care Unit length-of-stay, ISS = Injury Severity Score, SAPS2 = Simplified Acute Physiology Score 2, NOM = Non operative management, EMS = Emergency Medical Services, RR = Resuscitation room, OTI = Orotracheal intubation.



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