ORIGINAL ARTICLE

TRAUMATIC GREAT VESSEL INJURIES IN CHILDREN: A 10-YEAR EXPERIENCE OF A PEDIATRIC INTENSIVE CARE UNIT IN A TERTIARY HOSPITAL CENTER

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Abstract

Introduction: *Traumatic injuries of the great vessels are rare but life-threatening in most cases. Road traffic crashes are the main cause of preventable traumatic injuries in Europe, namely great vessel injuries. Management of this condition in the pediatric population is poorly established and documented. We present our experience in assisting traumatic patients with traumatic great vessel injuries at a tertiary center Pediatric Intensive Care Unit. We also reviewed the approaches and clinical outcomes reported in the literature on behalf of this case series.*

Methods: *We conducted a retrospective review of traumatic injuries reported from 2012 to 2021 at our Pediatric Intensive Care Unit. Patients under 18 years old who were victims of traumatic great vessel injuries were selected. Demographic and clinical data from these patients were collected until September of 2025 and analyzed.*

Results: *Of the 260 trauma patients admitted to the Pediatric Intensive Care Unit, there were 4 (1.5%) cases of traumatic great vessel injuries associated with trauma. Three patients (75%) were male, and the mean age was 15.5 ± 1.7 years (range 13–17). The mechanism of trauma was blunt thoracoabdominal trauma from road traffic crashes in 3 patients and an abdominal stab wound due to aggression in 1 patient. The mean Modified Injury Severity Score and standard deviation were 15.5 ± 0.9. All patients required emergent surgery at hospital admission. The mean PICU stay and standard deviation were 24.7 ± 7.8 days. The median follow-up period was 71 (51–158) months. No major vessel complications or deaths were identified.*

Conclusion: *Traumatic great vessel injuries are rare, severe, and difficult to diagnose in children; however, early recognition and treatment are essential to improve survival. Prevention of trauma resulting from high-speed accidents and domestic violence among adolescents must be promoted by healthcare services, as well as by authorities and social and political entities.*

Keywords: *Trauma; Great Vessel Injuries; Pediatric Intensive Care Unit*

INTRODUCTION

Traumatic injury remains the leading cause of morbidity and mortality in the pediatric population after the age of five in the Western world. Road traffic crashes (RTC) are the most common cause, followed by drowning in Europe [(1)] and firearm-related injuries in the United States [(2)]. Trauma is not only a preventable cause of premature death but also a source of lifelong morbidity and high healthcare costs. RTC are estimated to be the ninth leading cause of disability-adjusted life-years (DALYs) lost in Europe among children under 15 years of age [(1)].

In this context, traumatic great vessel injuries (TGVI) are rare and usually associated with major trauma. The actual incidence in the pediatric population is unknown but has been estimated to reach up to 15% in adults [(3)]. Aortic disruption at the level of the ligamentum arteriosum is the most common TGVI, typically caused by deceleration forces in blunt thoracic trauma (BTT) [(4,5)]. TGVI represent high-risk lesions with severe associated morbidity and mortality rates as high as 75%, with the majority of victims dying at the scene of the incident [(3,4)].

Prompt diagnosis of TGVI may be challenging, and management of this condition is not fully established. In

the present article, we describe our 10-year experience in managing traumatic patients with TGVI at our tertiary center Pediatric Intensive Care Unit (PICU) and review the diagnostic approaches, management strategies, and clinical outcomes reported in the literature, highlighting the anatomical, physiological, and social dimensions that must be taken into consideration when treating the pediatric population.

MATERIALS AND METHODS

This study received ethical approval from the São João Health Center Medical Ethics Committee.

A retrospective review of traumatic injuries reported from 2012 to 2021 at the PICU of São João Hospital Center was performed. All patients admitted to the PICU with injuries involving the aorta, superior vena cava, inferior vena cava (IVC), pulmonary artery, or pulmonary vein were included. Patients with an unclear diagnosis of TGVI, due to the absence of definitive imaging or intraoperative recognition of the lesion during surgical exploration, were excluded.

Medical records were reviewed to collect data on the mechanism of injury, type of TGVI, clinical presentation, diagnostic approach, management, and subsequent morbidity and mortality outcomes. Follow-up clinical records were reviewed up to September 2025 to ensure updated and complete outcome data. The Modified Injury Severity Score (MISS) was calculated for each patient.

All data collection and statistical analyses were conducted using SPSS Statistics for Windows, Version 26 (IBM Corp., Armonk, NY). Descriptive statistics are presented as numbers and percentages for categorical variables, and continuous variables are presented as mean and standard deviation or as median and range when the empirical distribution of the variable was skewed.

RESULTS

A total of 260 trauma patients were admitted to the PICU between January 1st, 2012, and June 30th, 2021. Four of these patients (1.5%) presented with TGVI at PICU admission: three thoracic aortic ruptures (TAR) and one inferior vena cava (IVC) laceration.

Patients with TAR sustained blunt trauma related to road traffic crashes, while the IVC laceration resulted from penetrating trauma due to a stab wound. Three patients (75%) were male, and the mean age was 15.5 ± 1.7 years (range 13–17). Associated injuries are described in Table 1. The mean Modified Injury Severity Score (MISS) and standard deviation were 15.5 ± 0.9. All patients required emergent surgery at hospital admission. The mean PICU stay and standard deviation were 24.7 ± 7.8 days. The median follow-up period was 71 (51–158) months. No deaths occurred in this group.

Case 1

A 17-year-old boy was transferred to our hospital after being struck by a high-speed vehicle. He was conscious and tachycardic at admission, with diminished breath sounds over the left hemithorax and macroscopic hematuria. Computed tomography (CT) revealed rupture of the aortic arch with pseudoaneurysm and active hemorrhage, hemomediastinum, left hemothorax, left diaphragmatic laceration with gastric herniation, multiple left rib fractures, left pulmonary contusion, splenic laceration, left renal laceration, and adrenal contusion with mild hemoperitoneum. No coagulation abnormalities were identified. The patient's MISS was 13.

He underwent emergent left thoracotomy, which confirmed a tear at the aortic isthmus and descending aorta. A clamp-and-sew repair was performed with interposition of a 22-mm synthetic graft using a Gott shunt for 45 minutes. The diaphragmatic rupture was repaired with polypropylene sutures with pledgets. Figure 1 shows postoperative CT findings. He required intraoperative platelet and plasma transfusion and vasoactive support for 48 hours. Hypertension was managed with intravenous sodium nitroprusside, followed by oral amlodipine and lisinopril from postoperative day 5.

Anuric acute kidney injury secondary to rhabdomyolysis required hemodiafiltration with citrate for 25 days and one session of hemodialysis, after which renal function and diuresis gradually recovered. A large thoracic wall hematoma at the surgical site required revision and drainage on postoperative day 24. He was extubated on day 25, began a physical rehabilitation program for neuromuscular weakness and atrophy three days later, and was discharged home on day 79 with amlodipine, lisinopril, and clonidine.

Case 2

A 13-year-old boy, a victim of a high-impact car accident, was transferred to our hospital under mechanical ventilation. He was admitted hemodynamically stable after fluid resuscitation and transfusion of four units of plasma. He presented with first- and second-right rib fractures associated with mild pneumothorax, which was drained.

CT imaging showed a contained rupture of the descending thoracic aorta without hemomediastinum, bilateral pulmonary contusions, rupture of the left diaphragm with herniation of the stomach and colon, and splenic and right renal lacerations with mild hemoperitoneum. Additional injuries included fractures of C2, C6–C7, L3–L4, the right scapula, sacrum, right pubic ramus, and left femur, resulting in a MISS of 18. No coagulation abnormalities were identified.

He underwent emergent left thoracotomy, during which a 2-cm tear of the proximal descending aorta contained by the adventitia and a 12-cm diaphragmatic rupture were identified. A clamp-and-sew repair was performed with interposition of a 16-mm synthetic graft using a Gott shunt for 22 minutes. The diaphragmatic rupture was repaired with a triple-layer nonabsorbable suture. One unit of plasma and one unit of red blood cells were transfused intraoperatively.

Two days after admission, he underwent temporary osteotaxis of the left femur, which was converted to definitive osteosynthesis on day 10. During the PICU stay,

Figure 1 *Eight-month thoracic CT scan control of case 1.*

Figure 2 *Six-month month thoracic CT scan control of case 2.*

he developed refractory hypertension, which was controlled after 13 days with propranolol, followed by oral amlodipine and clonidine. He was extubated on day 5 and recovered without major sequelae, being discharged home on day 18. After 61 months of follow-up, he continues to require amlodipine for hypertension control. Follow-up CT scans showed no graft-related complications (Figure 2).

Case 3

A 17-year-old boy, a victim of a motorcycle accident resulting in a fall from a cliff, was transferred to our hospital. He remained conscious and hemodynamically stable. Abdominal examination revealed a left flank bruise consistent with handlebar impact, associated with subcutaneous emphysema and tenderness.

CT imaging demonstrated a de novo pseudoaneurysm compatible with aortic transection at the transition between the aortic arch and the descending aorta, bilateral pulmonary contusions, pneumoperitoneum with diffuse mesenteric and small bowel densification, bilateral minor renal contusions, and rupture of the left flank abdominal muscles (Figure 3). No hematological or hemostatic abnormalities were identified. His MISS was 14.

He underwent emergent left thoracotomy and laparotomy. A 3-cm tear of the medial aspect of the proximal descending aorta, adjacent to the ligamentum arteriosum and contained by the adventitia, was repaired using a clamp-and-sew technique with interposition of a 20-mm synthetic graft and 28 minutes of partial aorto-aortic bypass using a portable extracorporeal circulation system, with heparinization targeting an activated clotting time of 180 seconds.

Abdominal exploration revealed extensive peritonitis, ileal transection, and complete rupture of the left flank abdominal musculature. He underwent jejunostomy and abdominal drainage. He was extubated on the first postoperative day. Due to uncontrolled multiple abdominal wall abscesses and thoracotomy and laparotomy wound dehiscence, he required multiple reoperations for infection control and staged wound closure using a shoelace system and negative pressure therapy. Restoration of intestinal continuity was achieved on day 36, parenteral nutrition was maintained for 40 days, and he was discharged home on day 50.

He remained on bisoprolol for two years for hypertension control. Four years after the accident, he underwent repair of an incisional abdominal hernia at the previous laparotomy site. No complications related to the aortic graft were identified during 51 months of follow-up, including on serial thoracic CT scans (Figure 4).

Case 4

A 16-year-old girl, a victim of domestic violence, was admitted to the emergency department with multiple stab wounds. She was conscious, normotensive, and tachycardic at admission, and presented with 23 stab wounds involving the scalp, thoracic and abdominal walls, cervical and lumbar regions, left hand, and right upper limb, associated with extensive subcutaneous emphysema extending from the right arm to the cervical region. Her MISS was 14.

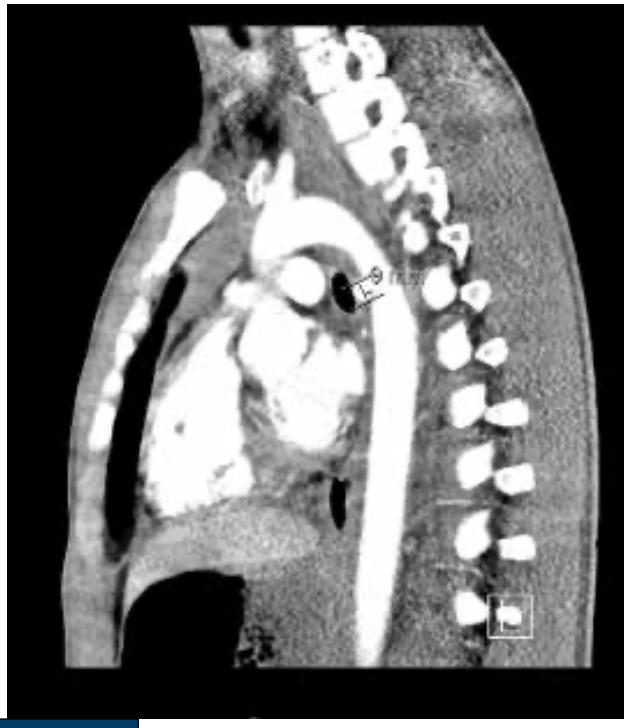

Figure 3 *Thoracic CT scan at admission of case 3, showing a 9mm de novo pseudoaneurysm due to aortic tear.*

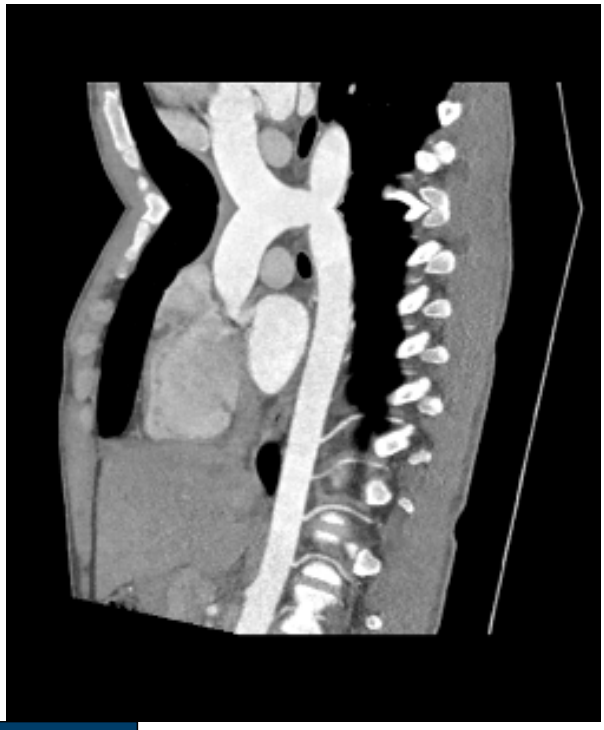

Figure 4 *Nine-month thoracic CT scan control of case 3.*

CT imaging revealed a moderate right pneumothorax and a large retroperitoneal hematoma with laceration of the infrarenal IVC (Figure 5). She underwent emergent laparotomy with venorrhaphy of the anterior and posterior walls of the IVC, repair of two small bowel perforations, three colonic perforations, and closure of multiple soft tissue and skin wounds. Two units of red blood cells were transfused intraoperatively.

She was extubated 24 hours postoperatively, with no complications during hospitalization, and was discharged home on day 8. During a 158-month follow-up period, no complications related to the IVC injury were identified. She developed post-traumatic stress disorder, which has been managed with psychiatric follow-up and psychological therapy to date.

He was readmitted twice for Dressler syndrome at 2 and 5 months after surgery, managed conservatively with antibiotics and anti-inflammatory therapy. Thereafter, he remained under regular follow-up for blood pressure control, with normal renal function, maintaining antihypertensive therapy with lisinopril and amlodipine. No prosthetic complications were detected, and no surgical revision was required during 81 months of follow-up. Figure 1 also shows a follow-up CT scan performed eight months after surgery, with no evidence of anastomotic complications, pseudoaneurysm, or graft-related issues.

DISCUSSION

Diagnosis of TGVI may be difficult, as symptoms may not manifest for several hours and imaging studies may be inconclusive. Approximately half of children with blunt thoracic trauma (BTT) present intrathoracic lesions, but only 50% of thoracic TGVI show external signs of injury [4,5]. Chest radiograph findings, such as mediastinal widening, loss of definition of the aortic silhouette, esophageal or main bronchus deviation, and first and second rib fractures, may underestimate 38% of thoracic TGVI[4,5]. The elastic structures of children's thoracic walls allow lung, mediastinal, and vascular injuries to occur in the absence of major rib fractures[4,5]. On the other hand, according to Hamilton et al., first rib fractures without mediastinal abnormality, although associated with significant multisystem injury, do not correlate with vascular injuries [6]. Given the anatomical, physiological, psychological, and epidemiological differences, pediatric trauma victims require a different approach from adults [5].

CT angiography remains the gold standard for TGVI, allowing accurate diagnosis and supporting decision-making for management [5,7]. However, its use in pediatric patients is cautious due to concerns about radiation exposure [6]. In our series, all patients were diagnosed by CT scan in the context of severe trauma with high suspicion of internal lesions. Transesophageal echocardiography has also been reported as useful for TGVI diagnosis [5,7].

Pulmonary contusions are more common in children than adults and represent additional physiological stress due to atelectasis, parenchymal consolidation, and interstitial complications, often requiring fluid and ventilatory support. Pulmonary contusion in patients with TGVI may contribute to up to one-third of casualties [4]. All patients with BTT in our series had pulmonary contusions, with no major associated morbidity or mortality.

Diaphragmatic rupture in blunt trauma has a prevalence of 0.1%, usually occurs on the left side in a posterolateral position, and requires operative repair to prevent complications such as lung compression and visceral herniation with potential strangulation. When present, liver or spleen injury should be suspected, as they are associated in 78% of cases. Nevertheless, 40–50% of diaphragmatic ruptures are missed in the acute phase and may not be diagnosed for weeks or years [5]. In our series, 2 of the 3 patients with BTT had left diaphragmatic ruptures that were promptly diagnosed and repaired.

Spine injuries are more common in adolescents. Up to 17% of patients with thoracic aortic injuries may suffer paraplegia [5,8]. Fortunately, no cases of paraplegia or motor sequelae were observed in our series.

Advances in pre-hospital medical care over the past years have allowed an increasing number of patients with TGVI to reach trauma centers and survive [1,9]. Despite the best efforts and availability of experienced emergency teams, TGVI remains a highly lethal injury [10]. Tiao et al. reported no TGVI cases in a large series of 1,409 blunt traumas admitted to PICU, which may be explained not only by the rarity of the condition but also by the fact that most patients died at the scene [3]. However, it is estimated that 67–90% of patients who survive until diagnosis will survive thereafter [5,8]. According to Allen et al., major vascular lesions are an independent risk factor for mortality in trauma patients. They found that the most lethal arterial injuries occur in BTT, whereas most fatal venous lesions appear in penetrating abdominal trauma, both due to exsanguination in noncompressible regions [9,10]. In our series, we presented four cases of successful management of these two life-threatening vascular injuries. Unfortunately, we could not ascertain the number of patients with major vascular injuries who died at the scene or in the emergency department prior to ICU admission.

Management of TGVI involves multiple controversial and imprecise strategies, due to the lack of clinical experience with this rare entity [11]. Children are more prone to hypoxemia due to reduced functional residual capacity and higher oxygen consumption; hence, prompt preoxygenation and ventilatory support are required for airway management [5]. The absence of chronic cardiovascular disease and preserved early-life cardiac function allow children to compensate for hypovolemia up to 40% of blood loss. However, the pediatric mediastinum lacks fixation, permitting visceral displacement that can compromise preload and cause severe hypotension [5]. Massive transfusion protocols are well established for adults, but there is a lack of consensus on damage control resuscitation in the pediatric population [10].

Most cases of TGVI require emergent surgical repair, which is technically demanding and infrequently performed by surgeons due to its low incidence. An American survey of 414 pediatric surgeons at Level I and Level II pediatric trauma centers showed that 20% of residents completed their fellowship without any experience in vascular trauma.

Figure 5 *Thoracic and abdominal CT scan at admission of case 4.*

Additionally, vascular surgeons may have limited experience with pediatric trauma. This reality may negatively impact outcomes and highlights the importance of institutional protocols for definitive management of vascular trauma[11].

Endovascular procedures to control hemorrhage or as definitive treatment are increasing in adult vascular trauma and have been shown to reduce in-hospital mortality and sepsis compared with open surgery [7,9,12]. Their application in children remains unclear, with only a few reported cases. Limitations include the scarcity of appropriately sized devices and the greater susceptibility of pediatric vascular tissues to iatrogenic dissection, spasm, and thrombosis[8,12]. Hence, urgent open surgery using the clamp-and-sew technique with synthetic interposition graft, as preferred in our series, remains the most common approach to arterial TGVI such as aortic disruption [5,8]. Blunt trauma vascular injuries produce shear and traction forces that complicate primary suture repair [13]. Grafts and endografts cannot accommodate a child's growth, which may lead to migration or pseudo-coarctation. Some developing materials, such as bioabsorbable grafts and stents, may overcome this issue[5,8,12].

Regarding venous TGVI, Branco et al. analyzed the largest American series of TGVI and found IVC injuries in 30–40% of abdominal vascular injuries, mostly from penetrating trauma [9]. Penetrating trauma typically produces a focal, regular incision in the vessel. For IVC injuries, the most frequently selected treatment is primary repair with venorrhaphy, as shown in case 4. When a conduit is needed, autologous grafts such as reversed saphenous vein are

Table 1 **Injuries associated to TGVI.**

Injury	N(%)
Cervical fractures	1 (25%)
Thoracic injuries	1 (25%)
Hemothorax	2 (50%)
Pneumothorax	3 (75%)
Pulmonary contusion	2 (50%)
Rib fractures	2 (50%)
Intra-abdominal injuries	
Hemoperitoneum	2 (50%)
Solid organ injury	3 (75%)
Intestinal rupture	2 (50%)
Extremity injuries	3 (75%)

preferred over synthetic grafts due to lower infection and thrombosis rates [13]. Endovascular treatments for IVC injuries are much less commonly used than for aortic lesions, particularly in the pediatric population [9].

Children are considered vulnerable road users, not only because of their cognitive capacity to evaluate risk but also due to the high mechanical energy they absorb due to their small stature. This risk diminishes as children mature and is replaced by risk-taking behavior in adolescents. Boys are known to be more prone to suffer and die from RTC than girls, especially in this age group [1]. In our series, the RTC-related TGVI cases involved two teenage boys in high-speed accidents with unknown seatbelt use, and one motorcycle driver. Although RTC remain the main cause of unintentional traumatic mortality in the pediatric population, there has been a significant reduction in recent decades due to preventive measures and improvements in healthcare[2]. Vehicle speed control is the most important factor to prevent serious injury in RTC. Seatbelts and child restraints reduce injuries by 45–55% and 60–95%, respectively [1]. Therefore, prevention of severe accidents is key to saving lives in major trauma and TGVI patients.

CONCLUSION

TGVI are rare, severe, and difficult to diagnose in children, but early recognition and treatment are essential to improve survival. TGVI must always be considered when attending a major trauma patient and should be managed according to clear institutional protocols for damage control resuscitation and vascular intervention.

These cases highlight the severity of RTC in high-speed accidents and the growing number of victims of domestic violence among adolescents in our population. This reality requires attention not only from healthcare services but also from authorities, social, and political entities, which should collaborate to promote primary, secondary, and tertiary prevention strategies.

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Conflict of Interest

None.

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