Blunt abdominal aortic disruption (BAAD) in shear fracture of the adult thoraco-lumbar spine: case report and literature review

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Abstract To present a rare case of association of abdominal aorta rupture and flexion-distraction fracture of thoracolumbar spine and to review the literature on this condition. In non-penetrating abdominal traumatic injuries with flexion-distraction fractures of the thoracolumbar spine, rupture of the abdominal aorta is an extremely rare occurrence but its outcome is potentially lethal. This association of skeletal and vascular lesions mainly affects young patients and involves the thoraco-lumbar junction and the portion of the aorta that lies in front of it. The authors analyze the pertinent literature and describe a case, operated in two sittings, of a traumatic lesion of the aorta attributable to a fracture of L1, focusing on mechanism of damage, diagnosis and surgical treatment. At 2-year follow-up examination, there were no neurological deficits. A review of the pertinent literature has shown that mortality can be reduced by a meticulous clinical and radiological work-up for a correct diagnosis followed by surgical repair of any damaged vessels. The possibility of performing a

rapid diagnosis by means of total-body CT-scan plus CT-angiography allows repair of vascular damage, stabilization of the patient's hemodynamic conditions and, subsequently, surgical treatment of the vertebral fracture.

Keywords Aortic disruption · Shear fracture · Surgery · Vascular damage · BAAD

Introduction

In non-penetrating abdominal traumas, the association of abdominal aorta rupture and flexion-distraction fracture of thoracolumbar spine is a rare but possible and potential lethal event [7, 17, 32, 34]. A few cases reported in literature regard both young and children and sometimes they are sequential to seat-belts use during road accidents at high velocity of collision [6]. A review of the literature was conducted using Pubmed. The search was undertaken using the terms “aortic disruption,” “shear fracture,” and “Blunt abdominal aortic disruption (BAAD).” References from the retrieved reports were checked to identify other possible reports. We selected manuscripts reporting a BAAD after vertebral fracture. Data extracted included year of the report, number of patients, male/female ratio, age distribution, location and type of BAAD, location and type of vertebral fracture, treatment, and clinical outcomes (Table 1). In the literature published during the last 40 years, only 21 cases of sub-diaphragmatic aortic lesion associated with thoraco-lumbar or lumbar fracture have been described. The level of the fracture was predominantly L1–L3. In just two cases, the fractured level was T12–L1, and in both of these the fracture was type A.2.2. Average patient age was 38 years (range 19–72), and only 5 were older than 60. In the literature, where this

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information was available, treatment of the vertebral lesion consisted of fusion and/or internal fixation in seven cases, conservative treatment in four. The type of vascular lesion was described in all cases but five and consisted of an intimal flap in seven cases, dissection or transaction in nine and as a false aneurysm in one. In 14 cases, it was treated by immediate open surgical repair, in five by endovascular procedures and in two by conservative treatment. Repair of both lesions, spinal and vascular, achieved full recovery in about 50% of cases. Mortality was 20%.

Materials and methods

Case description

A 20-year-old man was admitted to our Emergency Department after being involved in a car collision: he had been travelling as a back seat passenger and had not been wearing a seat-belt when another car impacted laterally at high velocity. Physical examination showed a GCS score of 15 with a soft, moderately distended abdomen, and unstable hemodynamic conditions (PA 80, pulse frequency 130, Hb 7.2). A total-body spiral CT-scan and

CT-angiography documented: frontal skull fracture with rupture of the sinus, pneumocephalus, and contusion of the right frontal parenchyma (Fig. 1a); fracture-dislocation of L1, classified as Magerl type C (Fig. 1); retroperitoneal hematoma and a suspected rupture of the spleen. CT-angiography documented dilatation of the posterior wall of the aorta at the level of the injured vertebral body and dissection of the renal artery (Fig. 1c, d). The patient was submitted to an urgent xifo-pubic laparotomy that brought to light a voluminous hemoperitoneum, rupture of the spleen which required splenectomy and laceration of the entire thickness of the abdominal aorta: the para-renal segment of the aortic vessel was replaced with a Dacron patch of 11 mm, suturing the right renal artery onto the patch. Finally, a PTTE by-pass of the left renal artery was performed. 10 days later, the patient underwent a neuro-surgical operation to reconstruct the frontal sinus (Fig. 2a). 5 days after this operation, the patient underwent an MRI for surgical planning, and, subsequently, surgical stabilization of the L1 vertebral fracture was performed using pedicular screws at L2 level, laminar hooks at T10–T11 level, longitudinal rods, and postero-lateral arthrodesis (Fig. 2b). Postoperative control investigations confirmed an excellent cranial and spinal outcome while angiography

Table 1 Summary of 21 cases culled from the literature and our personal report

Authors	year	Age/sex	Vertebral injury	Deficit	Type of BAAD	Repair of BAAD/fracture	Outcome
Campbell [4]	1969	24/M	L1 wedge	nr	Intimal flap	Open/conservative	FR
Rybak [28]	1969	40/F	L	y	na	Open/na	nr
Thal [31]	1971	38/F	L	n	na	Open/na	FR
Blute [3]	1973	78F	L	y	na	Open/na	Died
Danto [8]	1976	28/F	L2	y	Intimal flap	Open/fusion	FR
Dunlop [12]	1986	67/M	L	y	na	Open/na	nr
Stambough [29]	1989	50/M	T12 shear	y	Transection	Open/fixation	Died
Randhawa [23]	1990	19/M	L2–L3	y	Intimal flap	Open/fixation	pr
Rittstieg [25]	1994	62	L1	na	na	na	na
Reaney [24]	1995	21/F	L2 chance	nr	Intimal	Open/nr	nr
Roth [26]	1997	21/M	L2	n	Intimal	Open/nr	FR
Naude [20]	1997	71/W	L2	n	Transection	Open/conservative	Died
Shweiki [30]	2000	28/M	L2 chance	nr	Intimal flap	Endovascular/fixation	FR
Perry [21]	2000	21/M	L2 chance	n	Dissection	Endovascular/fixation	
Fontaine [14]	2001	21/M	L3 chance	nr	Dissection	Open/fixation	FR
Voellinger [33]	2001	21/M	T12 disloc.	nr	Transection	Endovascular/nr	FR
Inaba [17]	2001	29/M	L3 chance	y	Dissection	Endovascular/nr	FR
Inaba [17]	2001	52/F	L1 chance	nr	Dissection	Conservative	Died
			L2 burst				
Inaba [17]	2001	62/F	L1 shear	y	Intimal flap	Conservative	FR
Rubin [27]	2006	23/M	T12 split	n	False aneurysm	Endovascular/conservative	FR
Gordon [16]	2007	46/F	L1 burst	y	Transection	Open/conservative	Died
Our case	2009	20/M	L1 shear	n	Dissection	Open repair/fixation	FR

BAAD blunt abdominal aortic disruption; na not available data; nr not reported by the authors; FR full recovery; PR partial recovery; y yes; n no

Fig. 1 **a** CT-scans of the skull: frontal skull fracture with rupture of the sinus, pneumocephalus and contusion of the right frontal parenchyma. **b** Total-body spiral CT-scan and 3-D reconstruction: fracture-dislocation of L1, classified as Magerl type C. **c** and **d** Total-body spiral CT-scan and CT-angiography with 3-D reconstruction: dilatation of the posterior wall of the aorta at the level of the injured vertebral body and dissection of the renal artery

Fig. 2 **a** Postoperative CT-scans of the skull: complete reconstruction of the frontal sinus. **b** Postoperative sagittal CT-scan of thoraco-lumbar spine: surgical stabilization of the L1 vertebral fracture using pedicular screws at L2 level, laminar hooks at T10–T11 level, longitudinal rods and postero-lateral arthrodesis

Fig. 3 X-rays control performed at 2-year follow-up

documented a partial obstruction resulting in renal ischemia. At 2-year follow-up clinical and radiological examination, there were no neurological deficits, the only symptom being medically controlled arterial hypertension (Fig. 3).

Discussion

In severe thoraco-abdominal trauma, the presence of one or more vertebral fractures is described in approximately 10% of cases [14], whereas the incidence of vertebral damage associated with lesions of the internal and mesenteric organs is described in as many as 70% [1]. The “seat-belt syndrome” was described for the first time by Garrett in 1962 in reporting the association of injuries of the thoraco-

lumbar spinal column and of the internal organs of the abdomen [9, 15]. In 1979, Dajee used the term “seat-belt aorta” to define particular types of abdominal aorta damage caused by the effects of the 2 or 3-point seat-belt during a high-impact vehicle collision [2, 3, 8, 23]. In both of these syndromes, the type of vertebral fracture that occurs is typically either a Chance fracture or a fracture-dislocation of the thoraco-lumbar or lumbar segment [5]. The morphological and biomechanical features of these two types of injury are well known [18]: they are mainly attributable to a trans-osseous or trans-ligamentous lesion produced by flexion-distraction forces, without significant dislocation, or to lesions in which flexion, distraction, and shear forces act to produce translation and either anterior or lateral vertebral dislocation. In the case described here, regarding a young male patient, a particular sub-type of vertebral

fracture caused by flexion-distraction forces occurred, classified as a shear injury [18]. This type of injury consists of a C1.2.4 fracture with vertebral body separation outside the spinal canal according to Magerl's classification [18]. Our case resembled the one described by Stambough et al. [30] and Inaba et al.'s case 3 [17]. Owing to the complexity of the osteo-capsular ligamentous lesions that characterize this type of lesion, it is extremely unstable [22].

In such lesions, the mechanism responsible for vascular damage, comprising laceration of the abdominal aorta [17], is still not entirely clear. In non-penetrating abdominal traumatic injury, occurring in patients with their seat-belt fastened, vascular damage has been attributed to the action of direct and indirect forces generated by the rapid deceleration of a vehicle involved in a high-speed collision [23, 26]. The action of direct forces crush the aorta between the vertebral column and the seat-belt: when the vertebrae are fractured by these forces, the resulting bone fragments may lacerate the aorta [10, 17, 19], similarly to that which occurs in anterior osteophytosis [11]. The effects of the indirect forces, that are produced by hyper-flexion of the torso and, consequently, of the abdominal aorta, are both mechanical (sudden longitudinal stretching by distraction forces) and hydraulic (acute increase of intraluminal pressure) and combine to produce a BAAD [8]. Some pre-existing vascular or vertebral pathologies, such as atherosclerosis or ankylosing spondylitis, may predispose toward aortic damage [13]. In 2001, Inaba [17] identified three types of aortic damage resulting from closed abdominal trauma, each with a characteristic clinical picture and specific diagnostic and therapeutic features. The first type is an uncontained, full thickness laceration, followed by hemodynamic shock, which requires rapid intraoperative recognition and immediate surgical repair. The second type is a contained full thickness laceration and intimal dissection: since the patient's hemodynamic conditions are stable, although there may be signs of vascular insufficiency, it is possible to decide the best treatment option, either endovascular or prosthetic, on the strength of angiography. Finally, the third type is a contained full thickness laceration and intimal dissection in the total absence of symptoms: in this event, the diagnostic work-up should be angiographic evaluation to establish the need for either surgical treatment or clinical observation. In our case, the vascular lesion was consistent with type 1 according to the above classification: however, the evidence of hemodynamic instability and the need for emergency surgery were the result of the retroperitoneal hematoma caused by rupture of the spleen rather than bleeding from laceration of the aorta.

By analyzing the findings reported in our review, it seems safe to say that sub-diaphragmatic lesions of the aorta associated with a thoraco-lumbar or lumbar fracture

predominantly occur in young adults: the survival rate is good in patients under 40 years of age after surgical repair of the multiple lesions, whereas the mortality rate in patients aged 50 or more is high. In the majority of cases, the vascular lesion is repaired via an open surgical procedure associated with explorative laparotomy. Surgical stabilization should be performed as soon as possible, especially if the patient also presents progressive neurological damage.

Conclusions

Shear-type fractures of the thoraco-lumbar spine can be associated with rupture of the aortic artery in a pathological condition known as "seat-belt aorta." In such cases, mortality is high due to severe bleeding from the aorta. The possibility of performing a rapid diagnosis by means of total-body CT-scan plus CT-angiography allows repair of vascular damage, stabilization of the patient's hemodynamic conditions and, subsequently, surgical treatment of the vertebral fracture.

Conflict of interest None of the authors has any potential conflict of interest.

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