Blunt trauma of the thoracic aorta: mechanisms involved, diagnosis and management

Trauma fechado da artéria torácica: mecanismos envolvidos, diagnóstico e manejo

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Abstract

Traumatic rupture of the thoracic aorta is a life threatening situation, and may be secondary to several mechanisms; mainly penetrating or iatrogenic lesions and blunt trauma. Although penetrating mechanisms predominate, the number of patients with aortic disruption due to blunt trauma has continued to increase. This paper shows an overview focusing on the pathogenesis, diagnosis, timing and type of treatment regarding traumatic injuries of the thoracic aorta; it also reports the experience of one single center that deals with these lesions.

The major difficulty in the evaluation data on blunt aortic injury is that retrospective reviews often group together patients with all types of aortic lesions, comparing outcomes for injuries in different locations, with diverse methods of repair and different surgeons and/or institutions.

Key words: trauma, thoracic aorta, treatment.

Resumo

A ruptura traumática da aorta torácica é uma situação que expõe o paciente a risco de vida e que pode ser causada por vários mecanismos, principalmente por lesões penetrantes ou iatrogênicas e traumas contusos. Embora os mecanismos penetrantes predominem, o número de pacientes com rotura da aorta devido a trauma contuso tem aumentado. Este artigo apresenta um panorama, enfocando patogênese, diagnóstico, urgência e tipo de tratamento referentes a lesões traumáticas da aorta torácica; o artigo contém, além disso, um relato de experiências de um centro que trata essas lesões.

A maior dificuldade na avaliação de dados sobre lesão contusa da aorta é que as revisões retrospectivas freqüentemente classificam em um mesmo grupo os pacientes com todos os tipos de lesões da aorta, comparando resultados de lesões em diferentes localizações, com diferentes métodos de reparo e diferentes cirurgiões e/ou instituições.

Palavras-chave: trauma, aorta torácica, tratamento.

Aortic injuries may be secondary to several mechanisms; mainly penetrating or iatrogenic lesions and blunt trauma.[1-3] In a recent large autopsy study, Dosios et al.[4] showed that all penetrating trauma victims died before reaching the hospital, whereas 5.5% of the blunt trauma victims were admitted to hospital alive; therefore surgeons will generally face blunt thoracic aortic traumas.

Blunt aortic injury occurs as the result of motor vehicle accidents, falls, and crush injuries and it may account for 10 to 15% of deaths caused by vehicular crashes.[5]

It is estimated that between 70 and 90% of patients sustaining this injury die at the scene from free aortic rupture. The 10 to 20% of patients with thoracic aorta injuries who survive long enough to reach the hospital have a dismal prognosis: it has been estimated that approximately 30% of them will succumb within six hours, 40 to 50% within 24 hours and 90% within four months, unless expedient and proper diagnostic and therapeutic measures are undertaken.[6]

Pate et al. found that associated injuries were present in more than 90% of patients with aortic transection, and 24% of them required a major operation before aortic repair.[7]

The major complications of survivors diagnosed and treated are related to associated injuries and spinal cord ischemia after surgical treatment.

The characteristics of thoracic aorta injuries have made it difficult for single centers to accumulate large

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J Vasc Br 2003;2(3):197-210.

series of patients. Most studies are retrospective, performed on relatively small populations[8-10] or done over long time periods[11-12] or concentrated on one particular method of treatment.[13-16] Thus, many questions and controversies persist with regard to the optimal methods of diagnosis and treatment of this pathology.

Pathogenesis

Mechanisms of trauma

Over 90% of thoracic great-vessel injuries are caused by penetrating trauma.[1]

Penetrating injuries include complete or partial transections and arteriovenous fistulae. Most penetrating lesions are located at the ascending aorta and arch branches, with a very poor prognosis, which renders them rare in the clinical setting.[4]

Although penetrating mechanisms predominate, the number of patients with aortic disruption due to blunt trauma has continued to increase.[17]

Aortic rupture in blunt trauma results most commonly from sudden high speed deceleration and less frequently from chest compression (Figure 1).

Figure 1 - Common mechanism of aortic injury: a high-speed frontal deceleration collision.

Other mechanisms involved in blunt aortic injuries might include compression of the vessels between bony structures, such as sternum and spine, and profound intraluminal hypertension during a severe traumatic event.[18-20]

Lesion topography

The typical point of injury is located in the most proximal descending aorta, at the site of insertion of ligamentum arteriosum, just distal to the origin of the left subclavian artery (Figure 2).[6] At this point, a highly mobile region of the aorta is placed between two fixed segments: the aortic arch is anchored with the neck vessels including the left subclavian artery, and the descending thoracic aorta is fixed to the thorax by the ligamentum arteriosum and by the intercostal vessels. The mobile part of the aorta, which is the distal part of the arch and the most proximal part of the descending, is only loosely fixed to the chest wall by the parietal pleura. With abrupt thorax deceleration the fixed portions decelerate with the chest, but the loosely fixed part continues to move forward until they finally decelerate: aortic rupture occurs at the interface between these two parts.[21]

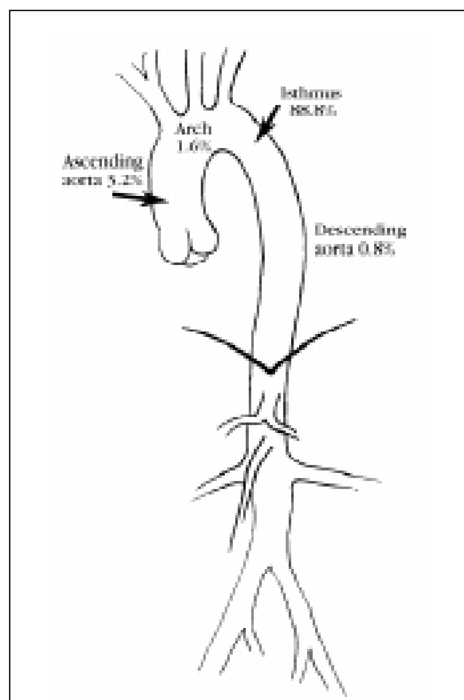

Figure 2 - Principal location of thoracic aortic lesions.

Total rupture or transection apply to the full thickness separation of the aorta, which can be partial or circumferential. On the other hand, injury or partial rupture refers to lesions without a complete wall disruption. True traumatic dissection, which involves a longitudinal separation of the media along the length of the aorta, has rarely been reported.[22]

Diagnosis

Each clinical situation, depending on patient's general status, must be individually judged searching for the best diagnostic studies.

Anamnesis

Although an accurate history and physical examination are necessary, clinical signs and symptoms are often lacking in these patients. A high index of suspicion is the cornerstone for timely diagnosis of thoracic aorta injuries. Aortic injury must be suspected in any patient with high-energy trauma to the chest.

Clinical findings

Aortic trauma is often obscured by the presence of other serious injuries.[21]

Nevertheless, if the diagnosis is made, it can overshadow the presence of other severe and more lethal lesions. Head trauma, massive abdominal hemorrhage, extensive burns and respiratory distress mandate the delaying treatment of traumatic aortic injuries. On the other hand, the radiological finding of an expanding mediastinal area, increasing hemothorax and/or anuria, gives priority to the treatment of a thoracic aortic lesion.

The clinical signs can be as unspecific as interscapular or thoracic pain, which can happen with aortic adventitia distension. However, patients can rarely present more specific syndromes like an aortic "pseudocoarctation", coursing with superior member hypertension and reduced or absent femoral pulses.[23] Intimal flaps or dissections can cause ischemic complications, and finally if a total rupture is present, bleeding into the mediastinum and pleura will cause hemodynamic instability, worsening pain and death in the majority of cases.

Imaging studies

The diagnostic practice depends on patient's conditions on hospital admission. The kind of aortic and associated lesions influence the outcome and diagnostic protocol, according to the patient's hemodynamic status.

Chest radiograph

The first step is to obtain a chest radiograph, as initial radiological evaluation, in every high-speed trauma patient with suspected blunt traumatic aortic injury. There are several radiological findings reported for traumatic aortic rupture. Many studies have shown that the widened mediastinum on chest radiographs is present in more than 90% of thoracic aortic injuries.[24] (Figure 3). Other frequent signs are irregularity or blurring of the aortic knob contour, presence of a left apical cap and a tracheal displacement.[25] With a 90% sensitivity, a 25% specificity, and a 95% negative predictive value, the chest radiography is a valuable screening tool for mediastinal hemorrhage, but is worth little as far as definitive diagnosis is concerned.[26] It is important to obtain serial follow-up chest films in patients with a high clinical suspicion for aortic lesion, because radiographic abnormalities may be absent on initial evaluation.

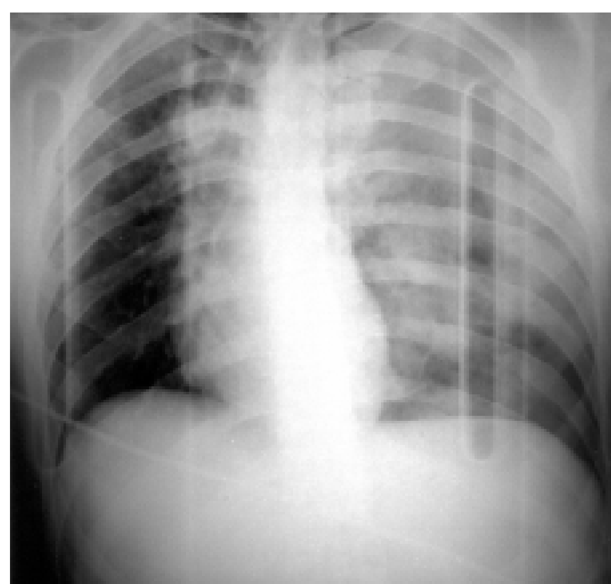

Figure 3 - Chest radiograph showing a widening mediastinum and left lung contusion.

Spiral computer tomography (SCT)

Spiral computer tomography is currently considered not only as a screening method to select patients for thoracic aortography, but also as a definitive diagnostic procedure, since it recognizes aortic injuries and rupture (Figure 4). Comparing it to aortography, it is less invasive, faster to obtain, more readily available and less expensive.[27]

Figure 4 - SCT demonstrates: thoracic aortic injury at the descending part with vessel wall irregularity and left hemothorax.

Some direct signs of aortic lesions at SCT are intimal flap, intramural hematoma or dissection, aortic wall or contour irregularity, pseudoaneurysm and pseudo-coarctation.[28] The presence of a hemomediastinum is well characterized by a SCT and represents an important indirect sign of aortic trauma. The use of 2D and 3D reconstructions on SCT aortography creates images very close to those obtained by conventional aortography,[29] providing the surgeon with important anatomic information. A normal mediastinum and a regular aorta seen on SCT[1] have been considered a sign of 99.9% of negative predictive value for aortic lesions.

A total body study can also provide important information regarding associate lesions.

Angiography

Aortography is traditionally considered the "gold standard" imaging study to detect aortic injury, to define its location and extent. It also provides important information about the vascular anatomy that can influence the operative strategy. The demonstration of an irregular or discontinued contour of the aortic lumen represents the aortographic diagnosis of blunt traumatic aortic injuries. Intimal flap, aortic dissection, posttraumatic coarctation, or luminal outpouching relating to a pseudoaneurysm are other aortographic patterns caused by blunt traumatic aortic lesions. Thoracic aortography can detect blunt traumatic aortic injuries with a sensitivity and specificity of 95 to 99% and 94 to 100%, respectively.[31-33] False negative examinations relate to incomplete series, inadequate injections or projections. False positives often relate to prominent ductus diverticulum or from ulcerated atheromas.

Transesophageal echography (TEE)

Transesophageal echography (TEE) combined with color Doppler flow mapping can accurately demonstrate isthmic lesions[34-36] (Figure 5). This diagnostic method can be rapidly and simultaneously realized with other procedures like mechanical ventilation or laparotomy. TEE may be very useful for unstable patients, since it is not possible to perform other time consuming studies in such cases.

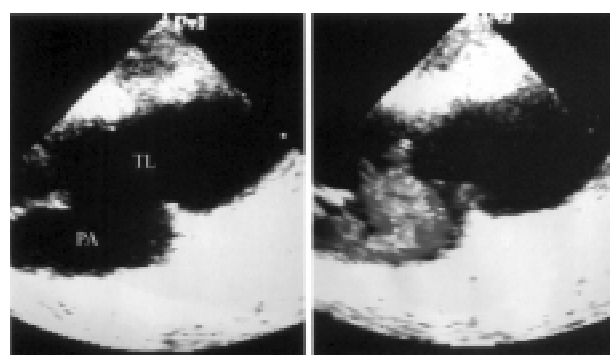

Figure 5 - TEE showing a post isthmic aortic pseudoaneurysm with a clear large neck and high velocity flow inside.(TL: true lumen; PA: pseudoaneurysm)

Magnetic resonance angiography (MR-A)

The results of magnetic resonance angiography MR-A) are comparable to those of SCT and conventional aortography. Nevertheless, MR has several limitations as the time spent completing the exam and the inaccessibility of the patient during examination, which exclude its routine use in urgent cases.[26]

Intravascular ultrasound (IVUS)

Intravascular ultrasound (IVUS) imaging has been described as a complementary method for clarifying slight focal aortic abnormalities not visible with thoracic aortography. Its use is until now limited and mainly associated with endovascular procedures.[37]

Diagnostic practice for traumatic aortic injury is based on mechanism of injury, chest radiography and SCT scan or aortography; all of these modalities have limitations and thus must be considered in concert.

Treatment

Timing

The treatment of patients who survive to reach the hospital remains controversial. The original strategy of immediate aortic repair[38] has been challenged by recent reports of successful delayed repair.[39]

Although traumatic rupture of the thoracic aorta has traditionally been considered a surgical emergency, there is a patient population for whom non-operative management may be appropriate.

Indications for urgent operative repair include hemodynamic instability, increasing hemorrhage from the chest tubes, and radiographic evidence of an expanding hematoma.

Delayed repair may be considered in selected hemodynamically stable patients, who may not necessarily benefit from immediate repair, including patients with severe head injuries, risk factors for infections (major burns, sepsis, heavily contaminated wounds), severe multisystem trauma with poor physiologic reserve.

The basis for non-operative management is that maintaining the systolic blood pressure below 120 mmHg or mean arterial pressure below 80 mmHg significantly reduces the risk of rupture.

The risk of fatal rupture of the periaortic hematoma in hemodynamically stable patients has been estimated to be 4,5% within the first 72 hours, but it does not increase if conservative treatment is further continued.[39]

This might be related to the maintenance of aortic adventitia continuity in patients who survive, and, hemorrhage is contained by the surrounding mediastinal structures. These patients may develop chronic pseudoaneurysms.

Although a small risk of free rupture still remains, data supports the concept that non-operative management of aortic lesions can be utilized safely in selected cases. In some cases of smaller aortic tears, the lesion may heal on its own.

The downside of the delayed repair is that due to the extensive scarring at the site and around the injury, the surgical dissection of the aorta is more difficult and tedious, unless an endovascular procedure could not be performed.

Current indications for delaying the aortic repair in the hemodynamically stable patient include: trauma to the central nervous system with coma, respiratory failure from lung contusion, body surface burns, blunt cardiac injury, tears of solid organs that will undergo non-operative management, retroperitoneal hematoma, contaminated wounds, age 50 years or older, medical comorbidities.[22]

Approach

Patient positioning and skin incision are important, as adequate exposure is mandatory for proximal and distal control of great vessels (Figure 6). General exposure and skin preparation should include the anterior neck, thorax, abdomen and a lower extremity. When a subclavian injury is suspected, the ipsilateral arm should be prepared and draped in a fashion that maintains free mobility of the shoulder.

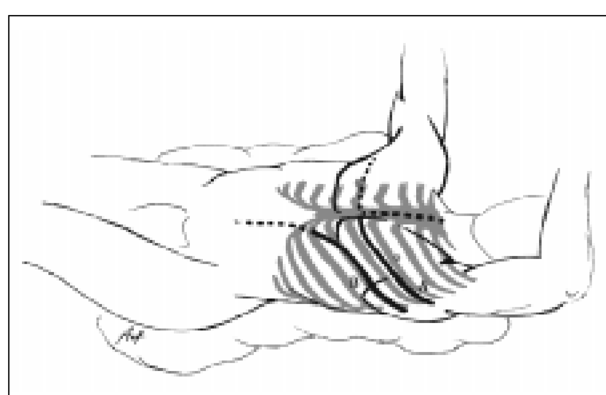

Figure 6 - Most common approaches to the thoracic aorta: (A) Posterolateral thoracotomy, with possible abdominal extension; (B) anterior thoracotomy, with possible contra-lateral extension and/or sternotomy.

The left posterolateral thoracotomy provides excellent exposure to virtually all portions of the hemithorax.[40]

This approach may allow a transverse sternotomy in case of difficult control of the proximal aorta. Associated phrenoceliotomy may be performed to treat previous undiagnosed abdominal vascular and visceral injuries.

For hypotensive patients with undiagnosed injury, the best approach to thoracic trauma surgery is the left anterior thoracotomy on fourth intercostal space, with patient in supine position.

This is also the incision of choice for rapid access to the mediastinum for open cardiac massage. When additional exposure is needed, an anterior thoracotomy may be extended across the sternum in the midline; it is also possible to extend the incision posteriorly, in order to have a better control of proximal aorta.

A median sternotomy is preferred for injuries of the ascending aorta and of the innominate and proximal carotid arteries. Extension into the neck, along the anterior border of the right sternocleidomastoid muscle, allows access to the proximal right subclavian artery, and to the right vertebral artery.

A thoracosternotomy[41] associates the anterolateral thoracotomy through the third intercostal space to a median sternotomy. This procedure permits a rapid access to the mediastinum, to have the control of the proximal aorta and if it is necessary, to perform cardiopulmonary bypass.

Techniques of organ perfusion/repair

Debates regarding the optimal management of injury to the thoracic aorta after trauma continue because of concerns about spinal cord ischemia and the potential for paraplegia. Several methods for indirect assessment of perfusion are available during thoracic and thoracoabdominal aortic surgery, however in emergency situations, the operation needs to be performed as expeditiously as possible without these techniques.

The technique of choice is indeed dictated by the urgency of the patient's condition, availability of technical personnel and surgeon preference at each hospital.

Clamp and sew

The single clamp-and-sew method of repair has many strong advocates, who point to its simplicity, the low paraplegia rate if cross clamp times are short, and a low mortality rate as compared with approaches that use heparin.[16,24,42]

Sweeney et al.[43] reported a mortality rate of 12% and a permanent paraplegia rate of 1.3% with a mean cross-clamp time of 24 minutes. However, a cross-clamp time this brief cannot be guaranteed[9] and most surgical groups do not meet this mark.[44,45]

Experimental data and clinical series have demonstrated that the occlusion of the descending thoracic aorta for more than 30 minutes is associated with the development of postoperative spinal cord ischemia. When the clamping time reaches one hour there is a correlate risk of paraplegia of approximately 40%.[45-47]

The average international cross-clamp time, as reported by Von Oppel and co-workers, is 41 minutes.[47]

Even those who advocate the clamp-and-sew technique have patients with paraplegia, because of unexpectedly long cross-clamp times. Most recently, groups using this technique reported paraplegia rates ranging from 2 to 24% (Table 1).

This is in contrast to the result of 0 to 7% achieved by those who use active distal support.[7,45,50]

Active distal circulatory support

Active distal circulatory support is very effective in reducing the risk of paraplegia, particularly when long cross-clamp times are needed.

Simple aortic clamping is known to raise cerebrospinal fluid pressures, which could exacerbate intracranial injuries. Unloading of the proximal aorta with an active distal support system may minimize that rise.

The adjuncts for distal aortic perfusion reduce but do not eliminate the risk of neurological deficits.[49] Distal support has another theoretical advantage over simple clamping: it provides proximal cardiac unloading,[51] which may be helpful in elderly patients and in those with myocardial contusions.

The most common methods of distal circulatory support are complete (CPB) and partial (PCPB) cardiopulmonary bypass, or left atrial to aortic or femoral bypass (left heart bypass, LHBP).

Table 1 - Literature results of TRTA* repair with clamp and sew technique

Author	Year	Patients	Mortality (%)	Paraplegia/ Paraparesis (%) †
Schmidt[14]	1992	32	5 (16)	1 (3.7) †
Maggisano[39]	1995	36	3 (8)	1 (3.0) †
Sweeney[43]	1997	71	9 (13)	1 (2.0) †
Fabian[45]	1997	73	11 (15)	12 (16.4)
Attar[48]	1999	54	12 (22)	10 (24.0) †
Jahromi[49]	2001	21	2 (10)	3 (16.0) †

* TRTA = trauma of the thoracic aorta. † Related to live patients.

Cardiopulmonary bypass

Cardiopulmonary bypass (CPB) has the ability to oxygenate, scavenge shed blood and heat and cool as desired.[7,44] However, the use of full anticoagulation in a multiply injured patient may increase the risk of bleeding and death. For this reason, complete cardiopulmonary bypass has largely fallen into disfavor. Patients with thoracic aortic injuries at multiple levels who require extensive repair are notable exceptions.[52]

Partial cardiopulmonary bypass (PCPB) with heparin-bonded circuits has been validated as an attractive option in the setting of TRTA (trauma of the thoracic aorta) as a means of avoiding the use of systemic heparinization. Cannulation of the right atrium via the femoral vein is simple and provides a clear, unobstructed field in which to work.[52]

As opposed to LHBP, it can provide adequate distal circulatory support and safely heat, cool, oxygenate and transfuse as required. Improved oxygenation may also be attained with PCPB in the presence of lung contusions.[7] Some literature results are seen in Table 2.

Table 2 - Literature results of TRTA* repair using partial-(full) CPB technique

Author	Year	Patients	Mortality (%)	Paraplegia/ Paraparesis (%)
Soyer[50]	1992	43	3 (7.0)	0
Pate[7]	1995	88	6 (7.0)	2 (2.0)
Fabian[45]	1997	39	5 (12.8)	3 (7.7)
Fabian (full)[45]	1997	22	5 (22.7)	1 (4.5)
Gammie[44]	1998	10	1 (10.0)	0
Attar[48]	1999	43	7 (16.0)	0
Jamieson[53]	2002	42	5 (12.0)	0

* TRTA = trauma of the thoracic aorta.

Left heart bypass (LHBP)

LHBP, which is connected between the left atrium and distal aorta or a femoral artery, can be used with little or no heparin because an oxygenator is not required.

However, it has some limitations: LHBP systems do not incorporate a heat exchanger and are dependent on adequate pulmonary function for oxygenation. Cannulation of the left atrial appendage or pulmonary vein can sometimes be difficult in the presence of an extensive mediastinal hematoma; additionally, because of the risk of air embolization in these closed systems, physicians are reluctant to rapidly infuse volume through them.

Injuries to the aortic arch, innominate artery, or ascending aorta, which represent a minority of aortic trauma cases, cannot be repaired with LHBP. Full cardiopulmonary bypass or even profound hypothermic circulatory arrest may be necessary. Furthermore, in patients who present in extremis, necessitating immediate control of hemorrhage and restoration of blood volume before repair, partial bypass may offer no advantage.

However, the majority of aortic transections occur at the isthmus and patients who survive are usually hemodynamically stable, with the periaortic hematoma contained in the mediastinum. These injuries can be complex or close to the proximal cross-clamp, thus complicating and potentially prolonging the repair. The adjuvant use of LHBP (Table 3) may help in extending the critical window.

Surgical techniques

Injury usually originates in the medial side of the aorta at the level of the ligamentum arteriosum.

The object of initial operative approach is to obtain the proximal and distal control of the descending thoracic aorta.

Vascular clamps are applied to three locations: proximal aorta, distal aorta and subclavian artery. The hematoma is entered, and back bleeding from intercostal arteries is controlled. Care is taken to avoid indiscriminate ligation of intercostal vessels: only those required for adequate repair should be ligated.

During aortic reconstruction clamps should be moved as close as possible to the site of injury, in order to reduce spinal cord ischemia, especially with the clamp-sew technique.

Primary suture and graft interposition are the main strategies of aortic repair after a traumatic lesion.

The first is usually the preferred choice because it is simple and fast. This technique is adequate in cases of partial laceration, but also in disruptions when aortic stumps are not too distant and severely damaged.

Frequently, in aortic trauma, adventitial layers are retracted and must be carefully included in the aortic suture; during this phase, the esophagus must be accurately separated from the posterior aortic wall. Teflon-felt pledgets can be useful to strengthen a friable suture line. Finally, the absence of a prosthetic graft decreases risk of infection.

Table 3 - Literature results of TRTA* repair using LHBP technique

Author	Year	Patients	Mortality (%)	Paraplegia/ Paraparesis (%)
Read[61]	1993	16	2 (13.0)	0
Kipfer[62]	1994	10	0	0
Contino[63]	1994	24	5 (20.8)	0
Fabian[45]	1997	69	10 (14.5)	2 (2.9)
Gammie[44]	1998	14	1 (7.0)	0
Symbas[64]	2002	19	5 (26.0)	0

* TRTA = trauma of the thoracic aorta.

Graft interposition has been used in more than 85% of the reported cases,[11] and is advisable when more than 2 cm of vessel are injured. The aorta is grafted with a straight Dacron® Vascular graft which is kept as short as possible.

Complications

Significant postoperative complications related to the thoracic injury can develop in these patients. Cardiac, renal, pulmonary and neurological morbidities have been reported in literature with rates of up to 50%.[59]

The most common complications reported were: adult respiratory distress syndrome and pneumonia (29.5%), severe systemic hypertension (20.5%), coagulopathy, renal failure, serious cardiac arrhythmias, late tension pneumothorax and thoracic wound infection.[7]

Paraplegia is the most devastating complication after repair of descending aortic transection, since most of the patients who suffer blunt aortic injury are young. The personal loss caused by paraplegia and the economic impact on society are enormous.

The two central issues associated with prevention of paraplegia are duration of cross-clamp and use of distal aortic perfusion.

Patients with acute aortic rupture are at a greater risk for paraplegia during aortic repair than patients with chronic aneurysms or coarctation.

This increased risk is likely due to the lack of preformed collaterals, along with the additional complication unique to trauma patients, including pulmonary and cardiac contusions, shock, hypoxia and hyposmolality from fluid overload.[7]

Late deaths, in fact, are most often due to multiple organ failure.[60]

As any major thoracic aortic surgery, these operations carry a high risk of bleeding with coagulopathy and the need for massive transfusion; acute renal failure, acute respiratory failure with the need for prolonged mechanical ventilation.

Nevertheless, whatever the type of lesion and the surgical technique, most deaths are secondary to associated lesions.

Endovascular intervention

Despite advances in surgical and perioperative care, conventional surgery for acute aortic rupture still carries a significant morbidity and mortality. Thus, endovascular procedures may be an attractive option for treating these kinds of lesions, and patients with other important comorbidities[61] (Figures 7A and 7B).

Theoretical advantages of stent-grafting are multiple: the absence of aortic cross-clamping prevents rising of intracranial pressure in some situations as severe head injury; patients with pulmonary contusions do not need one-lung ventilation as used for conventional surgical repair.

Critical statements have pronounced a high risk of spinal cord ischemia due to the exclusion of intercostal arteries during endovascular treatment. Nevertheless, the placement of vascular stent grafts has not yet been shown to increase the risk of paraplegia as compared to conventional surgical intervention. The largest series of thoracic aortic diseases electively treated with endoluminal grafts reported a paraplegia rate of 3.6%.[62]

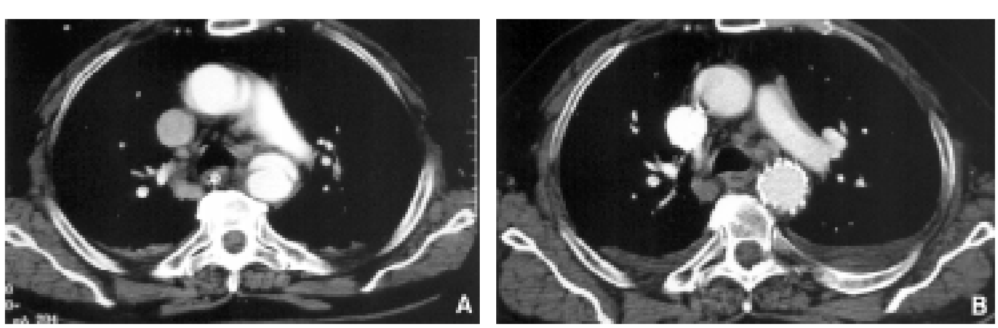

Figure 7 - A less invasive technique: (A) isthmic injury with localized dissection and (B) endovascular exclusion showed with CT scan.

Up to 70% of traumatic aortic injuries affect the isthmus segment. Thus, only a few branches to the spinal cord might be excluded by the endoprosthesis.

Lachat et al.[63] have reported significant lower rates of morbidity and mortality for stent grafting of acute aortic lesions demonstrating the benefits and advantages offered by this minimally invasive technique. In their report patients were hemodynamically stable to undergo contrast enhanced computed tomography (CT) and angiographic evaluation to determine the suitability for stent grafting. TEE and IVUS have been described by these and other authors as helpful associated diagnostic studies.[64] Early endovascular treatment was considered in the management of stable non-bleeding lesions, after recovery of associated life threatening injuries. The rupture had to be contained, with a proximal neck of normal appearance with length greater than 5 mm, and a diameter of 36 mm or less. Depending on the associated lesions and the bleeding risk, no heparin at all or a maximum dose of 5,000 IU was intravenously administrated and completely reversed after stent graft delivery. Immediate technical success rate was 100% as the aortic lesion could be excluded in all the cases; there was one early death due to hemorrhagic shock in a patient with a semicircular rupture who probably had an undetected incomplete proximal sealing.

Because most injuries occur at the aortic isthmus, much concern has been raised regarding the placement of rigid devices in an angulated aortic arch. As previously described, this can cause an inadequate seal of thoracic aorta. However, this has been largely overcome with newer and more flexible devices.

This new therapeutic strategy has few drawbacks worth describing. The delivery systems caliber are actually of large diameter (18 Fr to 24 Fr), being difficult to introduce through small and spastic arteries of young people or tortuous and calcified arteries of older people. A further concern is the stock inventory of devices, which must be available for emergency cases in different sizes and lengths.

Another topic of concern is the relatively young population suffering from aortic trauma: stent-grafts are actually produced mainly for treatment of chronic aortic pathologies, especially aneurysms, and do not come in adequate diameters for the small vessels of young people. Moreover, the mean age (38.7 years)[45] of this population raises many questions about the long-term follow-up after endoluminal treatment.

Additional studies on the role of endovascular interventions in aortic injury are required to acchieve a stronger support for its use in this scenario.

Our experience

Between January 1993 and April 2003, 20 patients with acute injury or rupture of thoracic aorta were admitted to the Emergency Department of our Institution. There were 16 (80%) males and four (20%) females whose ages ranged from 19 to 77 years (mean age of 43 years). Fifteen patients had history of motor vehicle crash, two suffered from a motorcycle crash and three had lesions secondary to penetrating traumas.

Seven patients died in the emergency department, five of them arrived in extremely critical conditions. The other two died during urgent thoracotomy dictated by hemodynamic deterioration, before bleeding could be controlled.

An early chest radiograph was obtained in fourteen patients. SCT and/or aortography studies were performed in 12 patients with stable hemodynamic conditions. Three cases also underwent TEE.

Associated lesions were found in every patient of our series (Table 4), and were present mainly in those cases that died in the emergency department. The most common lesions were other thoracic injuries in 16 patients.

Table 4 - Localization of concomitant injuries

Injury	n
Other thoracic traumas (including fractures and great vessels)	16
Abdominal visceral	8
Closed-head injury	7
Peripheral fractures	6
Head fractures	4
Abdominal vascular	2
Neck fracture	1

Table 5 summarizes the clinical and surgical features of patients.

Table 5 - Patients admitted to our service with thoracic aortic trauma

Case	Sex	Age	Lesion Characteristics	Procedure	In-hospital Outcome	Follow-up
1	M	31	Isthmic rupture (MVC)	Autopsy findings		
2	M	31	Descending thoracic aortic dissection and rupture (MVC)	Graft interposition (Clamp and sew)	Discharged	Alive after 96 months
3	M	28	Isthmic rupture (MVC)	Urgent thoracotomy	Death in emergency-room (hemorrhagic shock)	
4	M	38	Ascending aorta perforation (STAB WOUND-large fork for cooking)	Sternotomy (Simple suture)	Discharged	Alive after 60 months
5	M	68	Isthmic rupture (MVC)	Autopsy findings		
6	M	19	Descending-thoracic aorta perforation (GUNSHOT)	Urgent thoracotomy	Death in emergency room (hemorrhagic shock)	
7	M	17	Isthmic rupture – (MVC)	Graft interposition (LHBP)	Discharged	Alive after 36 months
8	M	43	Descending thoracic aortic perforation (METALLIC BAR for building construction)	Urgent thoraco-phrenolaparotomy	Death in surgery room (uncontrolled bleeding)	
9	F	35	Isthmic rupture (MVC)	Autopsy findings		
10	M	26	Descending thoracic aortic injury-pseudoaneurysm (MC)	Graft interposition (LHBP)	Discharged	Alive after 30 months
11	M	63	Isthmic injury – pseudoaneurysm (MVC)	Endovascular exclusion	Discharged	Alive after 18 months
12	F	56	Isthmic rupture (MVC)	Graft interposition (Clamp and sew)	Death in immediate post-operative period (cardiac arrest)	
13	F	63	Ascending aorta rupture (MVC)	Graft interposition (CPB)	Discharged	Alive and paraplegic after 10 months
14	M	52	Isthmic injury – pseudoaneurysm (MVC)	Endovascular exclusion	Discharged	Alive after eight months
15	M	34	Isthmic injury pseudoaneurysm (MVC)	Graft interposition (LHBP)	Discharged	Alive after six months
16	M	56	Ascending rupture (MVC)	Autopsy findings		
17	M	48	Isthmic injury – pseudoaneurysm (MVC)	Graft interposition (LHBP)	Death in post-operative period (MOF)	
18	F	42	Isthmic injury – pseudoaneurysm (MVC)	Graft interposition (LHBP)	Discharged	Alive after two months
19	F	22	Isthmic and diaphragmatic aortic rupture (MC)	Autopsy findings		
20	M	77	Isthmic localized dissection (MVC)	Endovascular exclusion	Discharged	Alive after one month

MVC: motor vehicle crash; MC: motorcycle crash.

Hospital mortality for patients undergoing surgical and endovascular repair was 3/13 (23%). The first case was of a 56-year-old woman involved in a motor vehicle accident. Thoracic aortic rupture repair was performed using clamp and sew technique, and during wound closure, she suffered from an irreversible cardiac arrest.

The second was of a 43-year-old man who died of uncontrolled bleeding during repair of a penetrating lesion of the median thoracic aorta. The third death was in of a 48-year-old man who underwent repair of an isthmic pseudoaneurysm using LHBP, and died on the 12th postoperative day of multiple organ failure.

One patient developed paraplegia following a graft interposition with CPB. The other nine suffered no major complications, and were discharged in good condition.

Conclusion

The major difficulty in the evaluation data on blunt aortic injury is that retrospective reviews often group patients with all aortic lesions together, comparing outcomes for injuries in a variety of aortic locations, with diverse methods of timing and vessel repair. At the same time, the treatment depends on the surgeon's experience at different institutions.

Concomitant severe lesions are usually present in patients suffering from aortic trauma, thus diagnostic and therapeutic timing must be properly and rapidly established. Polytrauma patient should be managed under a multidisciplinary approach, and treated in specialized centers.

Other studies on the role of endovascular interventions in aortic trauma should be carried out to achieve a stronger support for its use in this scenario. Preliminary results permit the vascular surgeon to consider endoluminal treatment as a valuable alternative in selected cases.

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