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CASE REPORT

Multi-organ trauma with rupture and Stanford type B dissection of thoracic aorta. Management sequence. Current possibilities of medical treatment

Authors' Contribution:
A – Study Design
B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection

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ABSTRACT: A case of a 46-year-old car driver struck with great force by a tram through the driver's door is presented. The main trauma consisted in chest injury with multi-rib fracture along with rupture and dissection of the thoracic aorta. Immediate medical rescue actions consisted only in procedures necessary to support vital functions; the patient survived owing to being promptly transported to the Emergency Department to undergo thoracotomy and laparotomy with massive blood transfusion. Polytrauma angio-CT scan revealed a posttraumatic thoracic aorta lesion which in turn was treated by deployment of an endovascular thoracic stent graft. This way, the immediate risk of death was averted, and the remaining traumatic lesions and conditions could be treated. Patient was discharged to a Rehabilitation Center on the 49th day of treatment. The authors stress that trauma resulting from accidents with this particular mechanism, i.e. lateral car crash on the driver's side with the driver's door being staved in by the tram, should be managed by immediate transport of the patient to the Emergency Center. In such cases early drainage of the pleural cavity can deteriorate patient's status by increasing the bleeding from the ruptured aorta.

KEYWORDS: blunt thoracic aortic injury (BTAI), lateral car crash, multi-organ trauma, thoracic endovascular aortic repair (TEVAR), traumatic aortic pseudoaneurysm, treatment

ABBREVIATIONS

BTAI – blunt thoracic aortic injury
CTA – computed tomography angiography
ER – Emergency Room
ERT – Emergency Rescue Team
FAST – focused assessment with sonography for trauma
FFP – fresh frozen plasma
HES – hydroxyethyl starch
HFOV – high-frequency oscillatory ventilation
ISS – Injury Severity Score
PEEP – positive end-expiratory pressure
PLT – Platelets (Thrombocytes)
pRBC – packed red blood cells
RCT – computed tomography
RSI – rapid sequence intubation
SG – sonography
SVS – Society for Vascular Surgery
TEVAR – thoracic endovascular aortic repair

INTRODUCTION

Modern-day management of multi-organ trauma is a systemic effort of collaborating units which starts with the rescue call being followed by actions of fire brigades, ambulance services, emergency rooms (ERs) acting as hospital admission units, and hospital departments. Each unit should promptly and properly perform their duties and transfer the patient to the next unit. Final destination facilities include trauma centers or multi-organ trauma management departments and, later on, surgical and rehabilitation departments. The success of the management depends on the time as well as on the involvement of the medical personnel from medical rescuers at the site of the accident to vascular surgeons and the trauma center staff. Proper decision making is crucial in urgent and dramatic situations.

Therefore, the authors are reporting on a case of a multi-organ trauma with predominant rupture and dissection of the thoracic aorta and provide a critical assessment of medical management provided.

CASE REPORT

On 21 January 2017, at 6:10 p.m., a small passenger car driven by a 46-year-old male had pulled – for unknown reasons – from under an overpass right in front of a fast-moving tram. As a consequence, a lateral crash occurred with the tram hitting the driver's door and hauling the car over a distance of nearly 40 meters. The car had no side airbags or air curtains.

At 6:16 p.m., an emergency rescue team (ERT) intervention was requested, and a primary team of 2 rescuers arrived at the site 3 minutes later. Quick assessment of the situation revealed one person (the driver) being jammed in the vehicle. With access to

Fig. 1. Lateral impact of the car driver's door with inward protrusion of the door as predictive factor of serious injury of the driver.

the victim being restricted, rescuers observed no evident injuries, GCS 8, radial artery pulse tension poor, respiratory rate above 30 breaths per minute. Patient received passive oxygen therapy and was placed in a cervical collar.

At 6:32 p.m., a firefighters' team (which had arrived soon after the ERT) managed to remove the victim from the car within 8 minutes despite the car and the tram being jammed together. Patient was placed on a spinal board and transported into the ambulance. At 6:32 p.m. patient's body was exposed and examined in the ERT ambulance: GCS 8 (eye response 2, verbal response 2, motor response 4), heart rate 137 bpm, blood pressure 70/50 mmHg. Pupils symmetrical, with normal reaction to light. Head skin abrasions, skull bones unremarkable; neck unremarkable, good venous filling; chest instability with crackling of fractured rib segments on the left, reduced audibility of auscultation murmurs on the left, apparent respiratory symmetry. Breath shallow, insufficient. Abdomen: soft, not tender, long bones with no apparent fractures. Superficial wounds on the left side of the head, chest, and thigh, The ambulance rescue protocol was as follows: rapid sequence intubation (indications: GCS 8, SpO2 below 75% despite passive oxygen therapy using an oxygen mask with reservoir bag, flail chest, grave overall condition) followed by ventilation using a self-inflating bag. After intubation, left-sided pleural tap was performed using two 14G catheters to evacuate air followed by blood.

Preparation for transport: analgosedation – morphine, midazolam, relanium, respiratory support – inspiratory capacity 5 mL/kg b.w. (sparing rate due to chest trauma; respiratory rate 10 breaths/min, oxygen 45%, positive end-expiratory pressure (PEEP) 5 cm H_2O, peak pressure 20–25 cm H_2O. Life signs after intubation: heart rate 96 bpm, blood pressure 60/40 mmHg, oxygen saturation 98%. Fluid therapy restricted due to suspected internal bleeding.

At 6:50 p.m., the ambulance left the accident site; hospital Emergency Room was contacted by radio and notified of a multi-organ trauma case. At 7:00 p.m. the ambulance arrived at the hospital and the patient was transferred to the ER. Between 7:10 and 7:30 p.m., rescue action was continued at the ER, blood samples were collected for cross-matching tests (7:20 p.m. – RBC 3.71 × 106/μL, hemoglobin 11.9 g/dL, hematocrit 33.9%, PLT 250 × 103/μL, coagulation parameters within normal limits). A FAST examination was performed, confirming the presence of fluid within left pleural cavity and peritoneum.

A decision was made to deploy a suction drain within the left pleural cavity. Drain deployment resulted in a large quantity of blood flowing out of the pleural cavity with secondary circulatory arrest. The patient was immediately transferred to the operating room with continuous heart massage. Emergency surgery following circulatory arrest started at 7:30 and was completed at 9:50 p.m. The surgery involved left-sided thoracotomy to retrieve ca. 400 mL of blood, seton drainage of the thorax, restoration of hemostasis at bleeding sites (predominantly intercostal vessel injuries), and removal of several fragments of fractured ribs. Following subsequent laparotomy, soaked absorbent clothes were removed from the thorax, hemostasis was reestablished, a drain tube was deployed within the pleural cavity and suction drainage was performed.

Laparotomy was performed by midline incision to reveal the presence of ca. 300 mL of blood; torn spleen was removed, continuous hemostatic suture and hemostatic sponge were applied to the torn left hepatic lobe, a diaphragmatic rupture, ca. 5 cm in length, was sutured, retroperitoneal checkup was performed and a drain tube was deployed in this region due to the apparent damage to the upper left renal pole.

In-procedural anesthesia: central venous port was placed in the right internal jugular vein; due to severe hemorrhagic shock, patient required adrenalin injections (2 x 1 mg i.v.) and continuous noradrenalin infusion (flow rate 1.0–0.5 μg/kg/min). Perioperative blood loss (procedure duration: 2 h) was estimated at 4000 mL; during the surgery, the patient received 7 U of packed red blood cells (pRBC), 1200 mL of fresh frozen plasma (FFP), 1000 mL of colloid solution (Gelaspan), 1000 mL of multi-electrolyte solution (Optilyte), 3 g of $CaCl_2$ i.v., 2 g of tranexamic acid (Exacyl) i.v., 2 mg of recombinant coagulation factor VIIa (Novo Seven). After the procedure, patient was transferred for further management to the Multi-organ Trauma Treatment Center (MTTC) at the same hospital.

Patient's condition was slightly improved at that time. Upon admission to the Center, patient's life signs were as follows: blood pressure 140/80 mmHg, heart rate 140 bpm (continuous infusion of noradrenalin 0.5 μg/kg/min), SpO2 100% (FiO2 0.5), body temperature 34.4°C – active body warming was initiated. Another central venous port was placed in the subclavian vein and blood was collected for analyses (10:00 p.m. – RBC 3.11 × 106/μL, hemoglobin 9.7 g/dL, hematocrit 27%, PLT 88 × 103/μL, coagulation parameters within normal limits).

As relative stabilization of patient's condition was achieved, decision was made to acquire a whole body computed tomography (CT) scan using the multi-organ trauma protocol. The scan, performed between 11:40 p.m. and 00:10 a.m., revealed dissection of the descending aorta (just downstream of left subclavian artery origin) and downstream rupture at the tracheal bifurcation level. Extensive periaortic hematoma was observed, segmentally constricting the arterial lumen. Massive, active bleeding into the mediastinum, periaortic space and left pleural cavity was observed.

This periaortic hematoma extended down to the level of celiac trunk origin; maximum width of the hematoma was 23 mm. Otherwise, fractures of 10 left ribs, including 4 comminuted fractures, were noted.

Immediately after the CT scan (0:10 a.m.), the physician on duty at the Department of Vascular Surgery of the other University Hospital in Szczecin was contacted and CD media with patient scans were sent to that department after being prepared at a local CT lab. Treatment was continued as previously with systolic pressure maintained within the range of 100–120 mmHg.

At 00:40 a.m., patient's condition rapidly deteriorated: patient required markedly higher doses of noradrenalin (1.25 μg/kg/min), a total of 600 mL of blood was collected from the left pleural drain, signs of centralized circulation developed (no pulse at radial or ulnar arteries, positive pulse at carotid arteries, ultrasound of femoral arteries revealing slow, barely noticeable pulse amplitude). In light of the above, pleural drain was clamped in hope to achieve at least temporary hemostasis from the bleeding site being compressed by the hematoma. Hematology performed at 00:57 a.m. revealed signs of anemization (RBC 2.04 × 106/μL, hemoglobin 6.3 g/dL, hematocrit 18%, PLT 48 × 103/μL), and transfer of 4 units of pRBC with 900 mL of FFP was commenced. In addition, patient received hydroxyethyl starch (HES) 60 mg/mL (Tetraspan) 1000 mL, multi-electrolyte solution (Sterofundin) 1000 mL, 4 g $CaCl_2$ i.v., 1g tranexamic acid (Exacyl) i.v.

At 01:30 a.m., a response from the Department of Vascular Surgery's physician on duty arrived stating that patient was preliminarily qualified for thoracic stent graft deployment. Decision was made to complete an operating team; in the meantime, attempts were to be made to prepare patient for transport as transporting the patient to the other University Hospital would take less time than bringing a vascular surgery team to the Center). At 04:20 a.m. the patient, in shock and under continuous infusion of large doses of catecholamines, was transferred to the "S" ambulance team (including a physician) to be transported to the Vascular Surgery Clinic. The procedure was performed immediately, with patient receiving additional 2 units of pRBC, 900 mL of FFP, 2 packed units of platelets and 2 g of fibrinogen.

No pulse was observed at common femoral arteries due to aortic dissection and compression by mediastinal hematoma. As introduction of guidewire into the true aortic lumen was impossible from inguinal access, the guidewire was inserted via the right brachial artery. As a result, it was possible to reach the true lumen of descending and abdominal aorta down to the right groin. After the stent graft expansion, circulation to both inguina was restored. Pulse was still palpable at left upper limb arteries (left subclavian vein not affected). Intraoperative arterography was performed to reveal no infiltration or migration of the stentgraft.

Patient was transported back for further treatment at the Multiorgan Trauma Treatment Center; he was readmitted at 11:26 a.m. Due to the respiratory insufficiency caused by the fractures of 10 ribs on the left, patient remained at the Center for a total of 6 weeks. He remained under life support with controlled ventilation; improvement was observed following stent graft treatment. Lung function, which initially ensured good systemic oxygenation, started to decrease gradually. After one-week, high frequency oscillatory ventilation was used to deliver air to patient's lungs in a pulsed pattern. HFOV treatment was continued for 10 days until improved lung oxygenation was achieved. Then, conventional ventilation was provided. Patient continued to improve while remaining under ventilation; a phonation tube was installed so that he could speak.

Fig. 2. Traumatic aneurysm in CT imaging scan.

Fig. 3. Stent graft deployed within the thoracic aorta.

On 7 March, 2017, after disconnection of ventilation, rehabilitation was intensified so that patient could stand up and make several steps. On the next day, he was transferred to the Department of General and Hand Surgery for continued rehabilitation. On 10 March 2017 the patient, capable of assisted ambulation, was discharged home in good overall condition. On 23 March 2017, patient reported at the Department of Rehabilitation in Choszczno to commence rehabilitation treatment.

DISCUSSION

The authors wish to highlight the severe and sometimes deceitful nature of trauma resulting from lateral crash [1, 2] occurring on the driver's side of a passenger car moving at a speed of above 40 kph. [3]. An inward dent of the depth of 26–30 cm in the driver's door as observed by medical rescuers [2] is in most cases suggestive of severe, life-threatening internal trauma of the chest as well as the abdominal cavity [4], even though the victim may sometimes get out of the car on their own and appear conscious and oriented. Changes due to exsanguination following traumatic spleen rupture may in short time lead to fatigue, loss of consciousness, and circulatory arrest. If these general signs are ignored, the patient has no chance to survive despite proper resuscitation, since all maneuvers result in all remaining blood being pumped out of the circulatory system. In such cases, the only routine management should follow the load-and-go model, i.e. the patient should be promptly transferred to ER after all necessary actions are completed at the accident site. In the reported case, these actions had been performed as medical rescuers following the assessment of patient's condition made an additional decision to secure the airways by means of endotracheal intubation and as well as to deliver analgosedation and active oxygen therapy at accident site, thus ensuring appropriate oxygenation of blood in the critical period of internal bleeding into the thorax and abdominal cavity.

The second moment requiring reasonable actions being taken is the assessment of patient's conditions and other measures performed at the ER. In the course of a thoracic FAST scan being performed in the patient at borderline hemodynamic stability, an ER physician identified a hematoma within the left pleural cavity and made a decision to drain the hematoma and decompress the lung in accordance with medical art. Removal of blood from the pleural cavity resulted in escalation of bleeding from the ruptured aorta and circulatory arrest, leading to the patient being immediately transferred to an operating room where the thoracotomy procedure performed to carry out seton drainage of the pleural cavity with simultaneous massive blood transfusion succeeded in keeping the patient alive yet failed to identify the cause of pleural bleeding. During a period of transient improvement in hemodynamic parameters following the procedure, a trauma center physician made a decision to perform an angio-CT imaging examination. The scan revealed the cause of the bleeding, namely a rupture and dissection of the aorta. Despite another worsening in patient's condition, a decision was made to transfer him to the Department of Vascular Surgery located at another clinical hospital ca. 3 km away. Such procedures cannot be performed without risk by specialists arriving from another hospital due to the lack of experience in medical staff (radiology technician, operating room nurse), appropriate operating room and tools, and access to appropriate types and sizes of stent grafts. On the other hand, the number of aortic injuries requiring such a management in our area is estimated at about 10 per year. This may affect the decisions of authorities responsible for health care funds, and hence this article is a voice in a dispute regarding the need for a vascular surgery unit being located in a hospital running a trauma treatment center.

Despite his grave condition, the patient was delivered by ambulance to the Department of Vascular Surgery for thoracic stent graft implantation. Although the transport was associated with a high risk of patient's death, it was the only opportunity to safe his life at that moment. The ISS score of patient's injuries was 54. Aortic injury was classified as SVS type III (traumatic pseudoaneurysm) or Stanford type B thoracic aorta dissection.

Aortic isthmus injury is second most common cause of death following blunt bodily trauma [5]. About 75% of patients die at the site or during transport while 50% of those arriving at the hospital die within 24 hours from the moment first medical actions have been taken [5]. Previously, all cases of aortic injuries were treated immediately after detection; currently, however, a watchful waiting approach is preferred with focus on radiological scans, appropriate medication, and arterial blood pressure control [5]. However, taking into that failure to treat aortic isthmus injuries results in death of as many as 45% of patients, the Society for Vascular Surgery recommends stent graft implantation within 24 hours from the trauma and not later than before the discharge [5].

The procedure performed in this case is referred to as thoracic endovascular aortic repair (TEVAR) and is characterized by very good three-year outcomes. Annual angiographic follow-up is recommended [6]. The first report of the efficacy of TEVAR was published by Semba et al. in 1997 [7].

The largest incidence of these types of trauma is observed in males at the average age of 40 years [5] as the result of traffic accidents, car crashes and pedestrian hits [8]; rarely injuries of these types occur as the result of falling down from heights, including cases of suicide attempts. Concomitant head injuries are frequently observed. Aortic injury is detected in whole body computed tomography angiography (angio-CT, CTA) acquired in a multi-organ trauma mode. The surgeon performing the TEVAR procedure should be aware of the angio-CT results prior to the procedure so that they may determine the feasibility and conditions of the procedure, identify any anomalies within the target aortic segment, and select the type and size of the stent graft [5]. In the reported case difficulty was encountered with regard to guidewire insertion into the true lumen of the aorta as it was constricted by mediastinal hematoma and dissected within the thoracic segment. The access to the true aortic lumen was achieved via the right brachial artery and then thoracic stent graft was introduced from inguinal access into the thoracic aorta; following deployment, the stent did not block the left subclavian artery. Another angiographic scan is performed to ensure the proper position, patency, and tightness of the stent graft. Early complications may include partial or complete closure of the left subclavian artery, arterial leak along the prosthesis, or brain stroke with paraplegia. Late complications are usually prosthesis-related (graft fracture, shield material wear, recurrent leaks, pseudoaneurysm, stent migration, stent collapse, stenosis, thrombosis). Spilotopulos et al. tracked a total of 76 cases within their study material of 11 years. Patients consisted mostly of young males (average age of 40 years), with women accounting for only 11% of the population (8 cases). The three-year follow-up outcomes of TEVAR procedures performed due to traumatic aneurysm were evaluated as good [6] as also confirmed by other authors [5, 9]. In a ca. 6-year follow-up of patients having undergone TEVAR procedure for blunt aortic trauma (most involving the development of pseudoaneurysm), Pifaretti et al. observed neither stent leaks nor patient deaths. Traumatic aneurysms resorbed spontaneously in 42 patients. In one patient (2.3%) a complication consisting in stent collapse was observed; however, it was asymptomatic and subjected to conservative treatment [10].

At the moment, TEVAR is the gold standard for the treatment of blunt aortic trauma. It has replaced the open vascular prosthesis placement procedure performed using left thoracotomy with extracorporeal circulation [11] which was associated with potential complications such as graft infection, spinal cord ischemia, renal insufficiency, and increased mortality rate [5]. Evidence for lower complication and mortality rates of endovascular procedures was presented [5]. However, patients with traumatic aortic injuries constitute a population different from that of post-TEVAR patients as degenerative processes lead to the number of vascular resurgeries in the latter group being much higher than that of 5.8% in trauma patients [10]. Determination of the time frame for follow-up checkups following the TEVAR procedure appears to be somewhat problematic. The authors postulate extending the follow-up period to more than 1 year while presenting evidence on the harmful impact of CT scans and nephrotoxicity of contrast media used [6]. The problem was also raised by other authors [12]. However, follow-up may reveal potentially fatal complications (such as leaks) requiring lifesaving resurgeries. Since distant outcomes of TEVAR procedures remain unknown [10], numerous authors are inclined to review indications for follow-up examinations on a case-by-case basis [12].

Watchful waiting is another procedure which may be taken into account in type I trauma patients who have already survived several hours within the hospital provided that the rupture is of minute length [11]. According to other authors, the risk associated with conservative treatment of small aortic pseudoaneurysms is about 10% [13]. When identifying aortic rupture risk factors and indications for prompt stent graft implantation, attention should be drawn to the following parameters: the quantity of lactates being delivered (>4 mM), the aortic pseudoaneurysm to aorta diameter ratio (>1.4) and the diameter of the aneurysm along the ascending (>10 mm). Notably, the aneurysm is at risk of rupture when 2 out of 3 aforementioned criteria are met [11]. When such a risk is identified, it may constitute an indication for appropriate treatment where priority should be placed on the management of the remaining severe injuries with a low risk of aneurysmal rupture. Usually, this type of aortic trauma occurs together with other serious concomitant trauma and patient survival is determined by the overall ISS score of all injuries. The lower the score, the higher the patient's chances for survival [8]. Thus, with the ISS score of 54, our reported case can be classified among the most severe injuries. A separate problem is that of further treatment after aortic repair when hematomas remain within the peritoneum and mediastinal tissues posing risk of respiratory insufficiency which may further impact patient's survival and making the outcomes of TEVAR procedures in trauma patients comparable to those observed in patients undergoing the procedure due to degenerative lesions [14]. Timely evacuation of pleural hematoma following endovascular treatment and control of coagulation parameters contribute to increased patient survival [14].

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