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Remembering a critical triad in severe deceleration injuries to the chest: report of a traumatic aortic rupture case

Göğüs bölgesindeki ciddi deselerasyon yaralanmalarında son derece önemli bir triadın hatırlanması: Travmatik bir aortik rüptür olgusu

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We aimed to present herein the case of a potentially preventable death involving traumatic aortic rupture and to develop a critical pathway for the management of isthmic aortic ruptures consistent with the available resources. A retrospective record review by a multidisciplinary panel of experts was done, and the probability of survival was estimated based on the Revised Trauma Score and Injury Severity Scale score. Literature review and expert consensus were used in a quality and safety analysis to develop a critical care pathway for future cases. A 32-year-old man, injured in a motorcycle accident, was referred to a trauma center in a state of shock. Thoracic aortic rupture was highly suspected. For educational purposes, the classic signs of a widened mediastinum, right tracheal deviation, and left-sided hemothorax (in a context of significant deceleration injury) are incorporated into an acute care triad for traumatic aortic rupture. In such cases, in the absence of poor access to aortography, we suggest (serial - if needed) contrast-enhanced chest computed tomography scanning for diagnosis confirmation and operative planning. Assumption of hemodynamic stability can be catastrophic, and transferring the patient to a second facility may endanger survival, when operative capacity exists at the initial trauma facility.

Key Words: Traumatic aortic rupture; preventable death; Revised Trauma Score; Injury Severity Scale score; patient transportation; over-resuscitation; critical pathway.

Travmatik aortik rüptürü içeren potansiyel olarak önlenebilir bir ölüm olgusunu sunmayı ve mevcut bilgilerle uyumlu istmik aortik rüptürlerinin tedavisine yönelik kritik bir yöntem geliştirmeyi amaçladık. Uzmanlardan oluşan multidisipliner bir panelde geriye dönük kayıt incelemesi yapıldı ve Revize Travma Skoru ile Yaralanma Ciddiyet Ölçeği skoru esas alınarak sağkalım olasılığı tahmin edildi. Daha sonra ortaya çıkabilecek olgulara yönelik önemli bir tedavi algoritması geliştirmek için, kalite ve güvenlik incelemesi yapılırken, literatür gözden geçirmesi ile uzman konsensüsünden yararlanılmıştır. Motosiklet kazasında yaralanan 32 yaşındaki erkek hasta, şok tablosu içinde bir travma merkezine sevk edildi. Hastada ciddi olarak torasik aortik rüptürden kuşkulanıldı. Eğitim için, genişlemiş bir mediastene ilişkin klasik belirtiler, sağ trakeal deviasyon ve sağ hemotoraks (önemli bir deselerasyon yaralanması açısından) travmatik aort rüptürüne yönelik akut bir bakım triadına dahil edilmiştir. Bu tür olgularda, aortografi işleminin yapılamayacağı durumlarda, tanı doğrulama ve operatif planlamaya yönelik olarak (seri gerektirirse) kontrastlı bilgisayarlı göğüs tomografi taraması yapılmasını öneriyoruz. İlk başvurulan travma merkezinde ameliyat kapasitesi mevcutken hastanın hemodinamik stabilite gerekçesiyle ikinci bir merkeze transferi katastrofik sonuçlar doğurabilir.

Anahtar Sözcükler: Travmatik aortik rüptür; önlenebilir ölüm; Revize Travma Skoru; Yaralanma Ciddiyeti Ölçeği skoru; hasta transportu; aşırı resüsitasyon; kritik yol.

Traumatic rupture of the thoracic aorta is a major cause of death in injuries,[1] and accounts for up to 15% of all deaths following motor vehicle deceleration injury.[2] Nearly 90% of patients with such injuries die before they reach the hospital.[3] In those who survive, extravasated blood is contained by mediastinal tissues. They usually have small tears or partial-thickness tears of the aortic wall with pseudoaneurysm formation.[2] The challenge is rapid stabilization and definitive treatment before an all-out rupture develops;[4] 70-90% of such cases could be saved if diagnosed early and treated in a timely manner.[4,5]

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The purpose of this study is to present a case of potentially preventable death involving traumatic aortic rupture (TAR), and to suggest a critical pathway for the management of TAR consistent with resources available at trauma hospitals. We will illustrate how an in-depth quality and safety analysis can be applied to learn from a poor outcome.

An independent multidisciplinary panel of experts, covering medical disciplines of general surgery, radiology, heart surgery, and healthcare quality, assessed the adequacy of care and judged whether the outcome was frankly preventable, potentially preventable, or non-preventable. The probability of survival was calculated according to the Revised Trauma Score and Injury Severity Scale (ISS) score.[6] Based on the lessons learned and the available literature, a critical pathway for the management of TAR was developed.

CASE REPORT

A 32-year-old male injured in a motorcycle accident was brought to the Emergency Department of a university hospital (trauma center) by the city Emergency Medical Services (EMS) personnel late at night (22:00) on a Thursday. He was in respiratory distress and in a state of shock with a respiratory rate of 25 breaths/minute and a systolic blood pressure of 70 mmHg. He was resuscitated with crystalloids (2000 mL of Ringer's solution), after which his Glasgow Coma Scale was 11 and his blood pressure rose to 100/80 mmHg (22:30). As the chest exam and chest X-ray were suggestive of hemothorax, a chest tube was inserted; the tube drained 700 mL of blood upon placement (23:00).

A head contusion was evident on the right frontal region. Lateral neck X-ray, brain and abdominal computed tomography (CT) scan, and an orthopedic survey for significant musculoskeletal injuries were all negative (23:30-00:30).

The chest X-ray had also revealed widening of the mediastinum and right tracheal deviation. Transthoracic echocardiography was normal (23:30). The working diagnosis, TAR, was substantiated by a non-contrast chest CT scan. The radiologist recommended aortography to better define the injury and the imaging study was approved by the hospital's on-call Fellow of heart surgery (00:30). Aortography could not be arranged in-house (it was a weekend midnight and this imaging service was unavailable). The on-call attending general surgeon recommended transferring the patient to another trauma center of the university for emergency aortography. At that time point, 950 mL of blood had drained through the chest tube, the patient had received 1.5 units of packed cells and some 400 mL of dextrose-saline solution intravenously, and his blood pressure was 120/75 mmHg (01:30).

The patient was transferred by ground EMS vehicle to the other trauma center (3:00). While he was being moved from the ambulance onto the stretcher, tachypnea developed and the pulses vanished. Resuscitation commenced. Thoracotomy was performed and the aortic rupture was clamped. Internal massage and other measures failed to save the patient and he was declared dead (04:00).

Multidisciplinary Review

The probability of survival according to the Revised Trauma Scale and ISS score was estimated at 74% and the death was judged potentially preventable. The panel of experts agreed on the following process factors:

1. For this case with a left-sided hemothorax, urgent vascular intervention was indicated; arrangements for aortography delayed this. The decision to transport the patient to the other trauma center for aortography seemed ill-advised and plausibly the patient's movements or hemodynamic changes along the way precipitated the free rupture.

2. Given the high suspicion for large vessel(s) injury and lack of contraindications (including adequate urinary output), chest CT scanning should have been performed with contrast to better define the injury and stage operative intervention. Serial CT scanning of contrast-enhanced images may have complemented the initial CT scan, if needed.

3. The patient's hemodynamic management merited special attention. He received about 3500 mL of crystalloids and packed cells during the first 4 hours. His output during this time was estimated at 2150 mL total: 950 mL through the chest tube and 1200 mL urine. The patient's 'polyuria' can be indicative of over-resuscitation, although post-traumatic diabetes insipidus cannot be ruled out. His pre-hospital systolic blood pressure was 70 mmHg. Following stabilization, readings of 110-120 mmHg were recorded. It was prudent that the patient receive analgesia, sedation, and beta-blockers while under evaluation preoperatively, especially during the stress of transfers (to and from radiology and between facilities). The factors contributing to free rupture are outlined in Table 1.

Some experts argue against the appropriateness of placing a chest tube drainage in a patient with hypovolemic shock and suspicion of TAR, as it may induce free rupture of a self-contained pseudoaneurysm.

DISCUSSION

This case report serves as a reminder of important clinical issues. It is true that not all TARs need emergency surgical intervention. If the injured aorta is not a source of active hemorrhage, surgery can be deferred and other management priorities, e.g., hem-

Table 1. Factors with probable contribution to free rupture

Factor	Observation	Factor details
Elapsed time	6 hours + evacuation time	CT scan was done without contrast; unavailability of emergency aortography in-house; the trauma team's decision not to perform urgent thoracotomy and to transfer the patient to a second facility for aortography
Patient's movement	Precipitation of the second cycle of shock	Moving the patient from the ambulance on to the stretcher
Over-resuscitation	High intravenous intake and polyuria	'High normal' blood pressure (and coagulopathy?)
Not using beta-blockers		Unable to blunt elevations in heart rate or blood pressure

orrhage control and neurological stabilization, can be arranged.[2,7-9] If operative and critical care facilities exist at the initial facility, it is prudent to accomplish the necessary imaging studies at the initial facility and avoid transfer to a second facility for aortography.

Following traumatic thoracic injury, mediastinal hemorrhage and widening may be caused by processes other than TAR, including fractures of the spine and other vascular lesions.[4,10] CT -with contrast- has a 83-99% specificity for the diagnosis of TAR.[2] If CT results are (highly) suggestive, confirmatory angiography is generally desired for operative staging in our community. Aortography is used to rule out the diagnosis in equivocal cases and is needed for optimal operative planning. Later generation (spiral or multislice) CT scanners may ultimately obviate the need for aortography in these situations.[2,4,11]

Traumatic aortic rupture should be regarded as an unstable injury, and the trauma team should not be deceived by the patient's apparent hemodynamic stability. With a variable course of time, a clinically silent contained rupture may evolve into a free, uncontained pseudoaneurysm rupture, resulting in exsanguination and death. The fact that 15-30% of TAR patients who survive the prehospital phase die in the first six hours (and up to 50% by 24 hours) underscores the need for rapid diagnosis and treatment.[3,4,12,13]

Acute care has its own peculiarities and needs highly structured and consistent approaches; thus, trauma centers are defined wherein trauma coordinators assure integrated consistent case management.[14-16] Application of this formal approach is especially challenging in the university hospital settings.

A left-sided hemothorax has been classically recognized as a major prognostic sign and risk for rupture and death. Some of these patients are described 'meta-stable' - i.e. they respond to fluid resuscitation and then their blood pressure drops in a cyclical manner.[2,7,17,18] The well-described typical findings of widened mediastinum, right tracheal deviation, and left-sided hemothorax yielding bright red blood in the thoracic aortic rupture serve as a 'TAR triad'. This triad, in a context of significant deceleration injury, should activate an alarm calling for urgent intervention (see the Appendix).

Deaths related to exsanguinations are generally considered preventable.[19] It seems that in this case, the criticality of the injury process was under-estimated. Although thoracotomy entails a significant risk it should be performed after convincing radiological evidence, the risk of a missed TAR clearly outweighs that of the surgery.[2,4] Thus, in the case of limited access to aortography (i.e., not available in the initially receiving hospital in a timely manner), we suggest that (serial) contrast-enhanced CT scanning of the chest would suffice for management planning, given operative capacity at the initial hospital.

It is noteworthy that TAR management is changing diagnostically and therapeutically; aortography is not considered the gold standard anymore, as magnetic resonance (MR) aortography and CT angiography might be preferred (they provide details on aortic tissue).[20,21] Dynamic CT angiography even allows intraoperative control of the operative procedure. Endovascular aneurysm repair is a highly efficient technique for multiple trauma cases.[22]

Deterioration occurred while the patient was being transferred. Procedures that strain the patient or cause gagging (such as nasogastric tube insertion) can open a contained pseudoaneurysm and must be avoided. Moreover, resuscitation has to be managed with extreme care as elevated blood pressure can increase the likelihood of rupture. Therefore, the patient should be kept as comfortable and calm as possible. Once hemodynamic stability is achieved, the management priority is blood pressure reduction; beta-blockers have been shown to reduce the incidence of rupture. Analgesics are also beneficial.[2,3,12,23] We suspect that sudden movements (either through the transmission of direct physical forces or through secondary elevations in heart rate or blood pressure) in a case with pseudoaneurysm may result in free rupture.

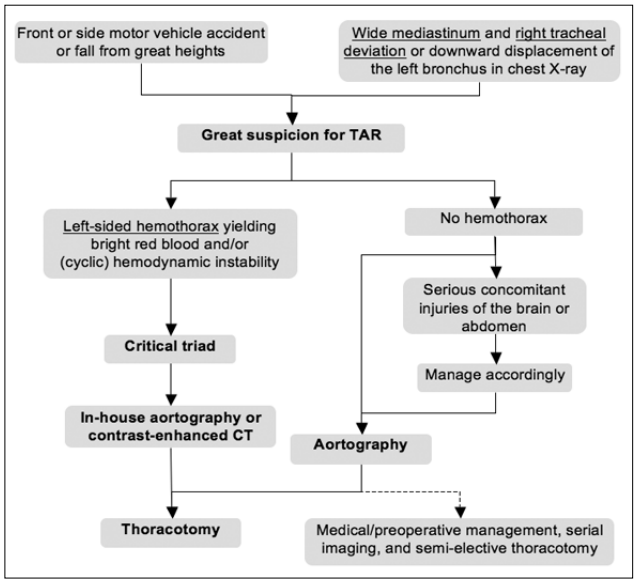

Fig. 1. A preliminary critical pathway for the management of traumatic aortic rupture (TAR).

Appendix

Isthmic Traumatic Aortic Rupture

A Preliminary Critical Pathway (Fig. 1)

- Cases with the critical triad (underlined text in the diagram) are highly unstable and their movement should be kept to a minimum.

- Vascular imaging can be in different forms, i.e. (dynamic) CT aortography, MR aortography, etc.

- In the absence of access to aortography at the initial hospital, contrast-enhanced CT scanning of the chest should suffice for diagnosis confirmation and operative planning; transferring the patient to a second facility may endanger survival when operative and critical care capacity are available at the initial hospital.

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