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Concomitant Aortic Valve and Internal Mammary Artery Injuries in Blunt Chest Trauma: Report of a Case

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Abstract
We report a case of concomitant injury to the aortic valve and internal mammary artery (IMA) from non-penetrating chest trauma. To our knowledge, this is the first such case to be reported. Transcatheter arterial embolization (TAE) following diagnostic angiography offers an effective and minimally invasive treatment for traumatic IMA injuries. Because there might be an asymptomatic interval after traumatic aortic valve injuries, serial physical examinations and repeated echocardiography should be mandatory for patients with de novo heart failure after blunt chest trauma. Transesophageal echocardiography can provide a clearer image of cardiac injuries than transthoracic echocardiography, particularly if there is extensive anterior mediastinal hematoma resulting from IMA trauma.

Key words Traumatic aortic valve regurgitation · Internal mammary artery injury · Blunt thoracic trauma · Transcatheter arterial embolization · Extracorporeal membrane oxygenator

Introduction

Injury to the internal mammary artery (IMA) after blunt thoracic trauma has rarely been reported; however, its possibility should be emphasized because, without adequate intervention, the consequent rapidly expanding anterior mediastinal hematoma is likely to prove fatal.[1] Angiography is not only a definitive diagnostic tool, but also an effective and mini-invasive treatment of IMA injuries.[2] Traumatic aortic valve injury is another rare complication of blunt chest trauma, the diagnosis of which could be delayed as a result of possible asymptomatic periods. Survival after traumatic aortic valve insufficiency is dependent on early identification and effective surgical repair.[3] We describe our successful management of concomitant traumatic aortic valve rupture and bilateral IMA tear, caused by a strike to the anterior chest during a motorbike collision. We also review and discuss the diagnosis and management of simultaneous traumatic aortic valve and IMA injuries.

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Case Report

A previously healthy 19-year-old man was involved in a high-speed motorbike collision at more than 60 km/h, in which his chest struck the handlebar of his motor scooter. He was taken by ambulance to a nearby hospital, from where he was transferred to a level I trauma center immediately after a focused assessment with sonography for trauma (FAST) showed evidence of intra-abdominal bleeding. The initial trauma assessment revealed an intact airway, decreased breathing sounds on the left, tachypnea (30/min), a Glasgow Coma Scale score of 15, accelerated and palpable pulses in the bilateral extremities, and a 10-cm laceration on the anterior chest wall with marked instability of the sternum. Physical examination revealed neither neurological deficit nor additional external injuries.

In our emergency room, anteroposterior chest radiography showed a widened mediastinum and poor definition of the aortic knob (Fig. 1). Multiple opacities in the bilateral lung fields were considered to represent pulmonary contusion. A widened mediastinum with concomitant severe anterior chest contusion warranted a contrast-enhanced computed tomography (CT) scan of the chest, which showed extensive anterior mediastinal hematoma, with contrast extravasations at both edges of the sternum and a sternum fracture (Fig. 2). Multiple consolidations in the bilateral lung fields suggested pulmonary contusion (Fig. 2). Because of the

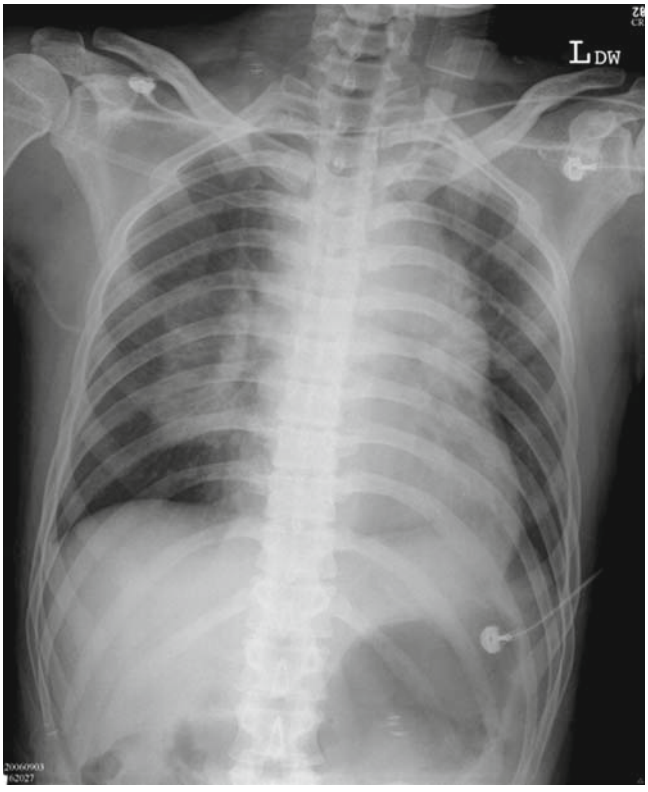


Fig. 1. Anteroposterior chest radiography showed a widened mediastinum, suggesting aortic or thoracic vessel injuries, and multiple pulmonary opacities in the bilateral lung fields indicating pulmonary contusion

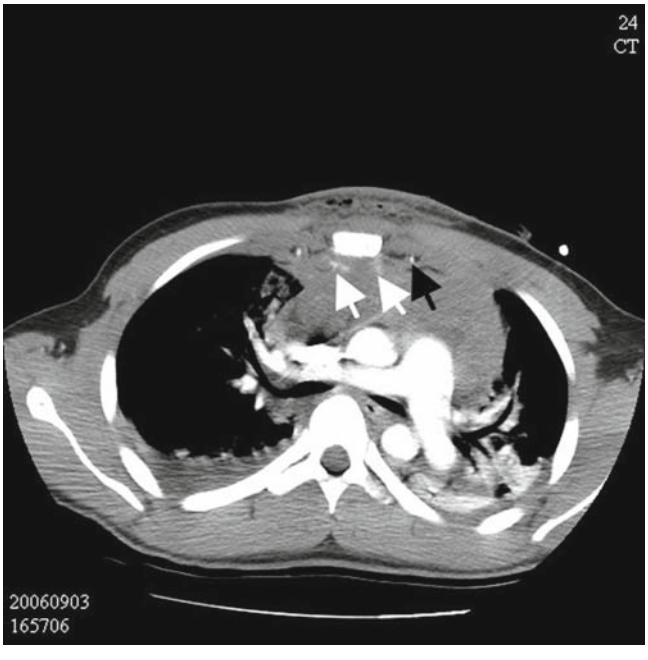
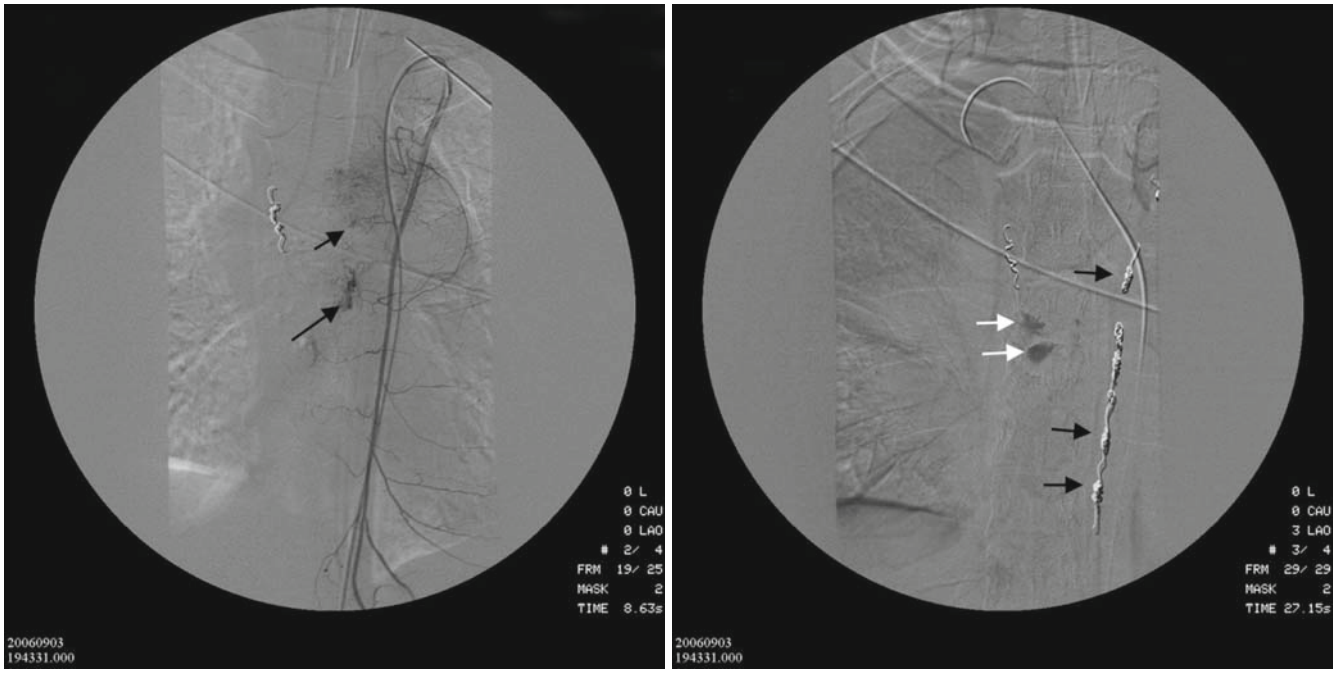


Fig. 2. Extensive anterior mediastinal hematoma resulting from the internal mammary artery (IMA) injuries. Consolidation of the left lung field indicating pulmonary contusion; left IMA (*black arrow*); contrast pooling in the disrupted sternal branches of the bilateral IMAs (*white arrows*)

rising troponin I level (5.64 µg/l), transthoracic echocardiography was performed by a cardiologist. The ultrasonographic image was unclear because of the extensive anterior mediastinal hematoma and persistent tachypnea, but no prominent pericardial effusion or evidence of cardiac valvular dysfunction was detected.

Because of his stable hemodynamic status following resuscitation and suspected active bleeding from the sternal branches of IMA, inferred by contrast pooling at both the edges of the sternum, emergency angiography was performed to confirm if there were aortic or great vessel injuries. This revealed multiple contrast extravasations of the disrupted sternal branches of the bilateral IMA. Transcatheter arterial embolization (TAE) with microcoils (MWCE-18S-4/2-Tornado; Cook, Bloomington, IN, USA) was performed to achieve successful hemostasis (Fig. 3A,B).

The patient was transferred to the trauma intensive care unit and ventilated following the sudden onset of severe hypoxemia, attributed to the combined effects of over-resuscitation and pulmonary contusion (PaO_2, 58 mmHg; $FiO_2 = 1$; O_2 saturation, 92%; central venous pressure, 18 mmHg). He was sedated and given analgesic regimens, muscle relaxants, and diuretics. The status of hypoxemia improved within 3 days (PaO_2, 151 mmHg; $FiO_2 = 0.3$), but when we attempted to wean him off the ventilator and arouse him from heavy sedation, he struggled vigorously and copious pink, frothy sputum was exuded through the endotracheal tube. Because of rapidly deteriorating hypoxemia (PaO_2, 62 mmHg; $FiO_2 = 1$; arterial O_2 saturation, 85%) and failure of all nonsurgical management, a venous–venous mode extracorporeal membrane oxygenator (VV-ECMO) was set up. Because pulmonary contusions generally develop over the first 24 h and resolve in approximately 1 week, the unusual fluctuating course of pulmonary function recovery warranted further investigation. Thus, a second transthoracic echocardiography was performed to recheck and rule out an intracardiac shunt or cardiac valvular disease. However, because the echocardiographic window was still unsatisfactory due to the extensive anterior mediastinal hematoma, we performed transesophageal echocardiography to confirm the diagnosis of severe aortic valve regurgitation combined with diffuse hypokinesis of the left ventricle (ejection fraction of left ventricle, 50%). The following day, a cardiovascular surgeon performed emergency surgical intervention. Intraoperative examination revealed two large tears in the left coronary cusp and the noncoronary cusp (Fig. 4), but the injury was too severe for valvuloplasty. Hence, aortic valve replacement was carried out with a 21-mm bileaflet mechanical valve (St. Jude Medical prosthesis; St. Jude Medical, St. Paul, MN, USA). He was weaned off VV-ECMO immediately after the operation. The patient had an



A B

Fig. 3. A Left internal mammary arteriography revealing multiple disrupted sternal branches with contrast pooling (*black arrows*). **B** Right internal mammary arteriography revealing disrupted sternal branches with contrast extravasation (*white arrows*). Multiple microcoils were used to embolize the main trunk of the left IMA (*black arrows*)

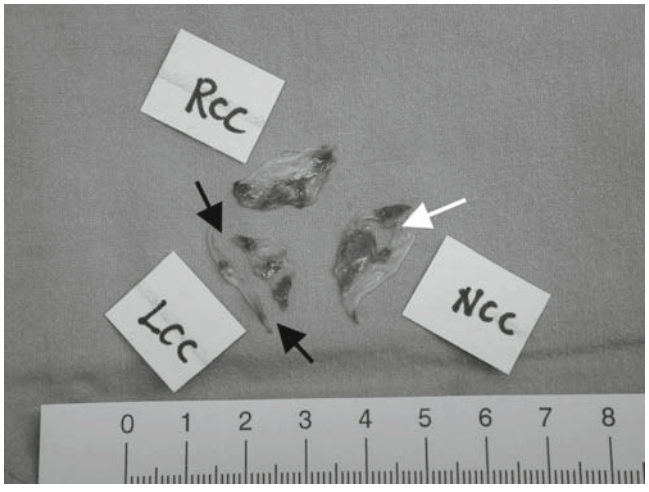


Fig. 4. Ruptured aortic valve cusp. There was a linear laceration parallel to the annulus or left coronary cusp (*LCC*) (*black arrows*), and an irregular perforation in the noncoronary cusp (*NCC*) (*white arrow*)

uneventful postoperative course and was discharged without any sequelae.

Discussion

Traumatic cardiac valve injuries are uncommon, and aortic, mitral, and tricuspid valve injuries have been reported in that decreasing order of frequency.[3,4] A sudden increase in intrathoracic pressure leading to a concomitant increase in the intra-aortic pressure triggered by the compressive or decelerating force applied during the early diastolic phase is the main mechanism of injury to the aortic valve. The noncoronary cusp is the most vulnerable area affected by traumatic aortic valve injuries because drainage of the coronary arterial system during the diastolic phase protects the corresponding cusp against injuries from the rapidly rising hydrostatic pressure.[5]

Unlike penetrating or iatrogenic injury, blunt thoracic trauma has rarely been reported as a cause of traumatic IMA injuries. Most previous cases were diagnosed during thoracotomy or aortography for suspected aortic injuries.[6] Conversely, in our patient a blunt thoracic trauma resulted in concomitant aortic valve rupture and bilateral IMA tears. To our knowledge, this is the first reported case of its kind.

Spiral CT is a useful screening tool when thoracic vascular injuries are suggested by physical examination or radiological findings.[7] Our patient's hemodynamic status was initially stable, but a chest X-ray showed a sternal fracture and a widened mediastinum, which warranted further investigation with contrast-enhanced spiral CT. Traumatic IMA injuries with active bleeding can be diagnosed effectively with the aid of enhanced CT.[8] Angiography helps us to establish the diagnosis of IMA injury, and subsequent TAE offers an effective,

efficient, and minimally invasive alternative to conventional surgical treatment to achieve hemostasis after blunt thoracic trauma in patients who respond to rapid infusion of fluids, at least transiently.[9] However, the threat of cardiac tamponade from an anterior mediastinal hematoma caused by IMA injuries cannot be overemphasized.[1] Pericardiocentesis or pericardiotomy could be futile for a cardiac tamponade that results from a rapidly expanding mediastinal hematoma. Surgeons and an operating room should be on standby during the TAE in case they are needed immediately. If the patient becomes hemodynamically unstable before or during TAE, conversion to thoracotomy is mandatory to drain the anterior mediastinal hematoma and achieve hemostasis.

After severe blunt chest trauma, echocardiography plays a fundamental role in the screening and diagnosis of cardiac injuries. Our patient's persistent tachypnea and extensive anterior mediastinal hematoma obscured the cardiac injuries and their anatomy during the transthoracic echocardiography. Transesophageal echocardiography provided a clearer view of the valvular anatomy, myocardial function, and aortic anatomy.[10] Hence, it is a better choice than transthoracic echocardiography for patients with concomitant traumatic IMA injury and cardiac contusion.

Patients with traumatic aortic regurgitation may have an asymptomatic interval ranging from weeks to years.[3,11,12] The delay between trauma and the onset of symptoms has been speculated to be due to an initially small tear of the cusp that extends progressively with hemodynamic stress. Our patient struggled when we attempted to bring him out of deep sedation, and the severity of aortic regurgitation increased with the rapidly increasing peripheral vascular resistance associated with exertion. Moreover, because there may be an asymptomatic interval before the onset of acute left heart failure, aortic regurgitation must be suspected in every patient with signs or symptoms of de novo heart failure during the post-traumatic period.

Nearly all authors recommend early surgical intervention after traumatic aortic valve injury. The indications for emergency surgery include deterioration of ventricular function, acute pulmonary edema, and a systemic diastolic blood pressure lower than 50 mmHg.[13] However, based on the concept of damage control in polytrauma, if aortic valve regurgitation is tolerated hemodynamically, then surgery can be postponed until the patient recovers from other potentially fatal injuries.[14,15] As we described, VV-ECMO can be an effective bridging tool to help patients endure refractory hypoxemia resulting from acute left heart failure after traumatic aortic valve injuries, prior to definite surgical correction.

If the injured valvular tissue appears to be of adequate quality and the commissures are essentially undamaged, an attempt to repair the injured valve is recommended to avoid the complications of prosthetic valve replacement. Intraoperative control of the repair by transesophageal echocardiography guidance increases the safety and efficiency of valvuloplasty. However, the development of residual aortic regurgitation following aortic valve repair, usually necessitating later valvular replacement surgery, renders aortic valvuloplasty a controversial surgical technique.[11] One of the mechanisms that affects long-term valve function is when the native aortic valve leaflets comes into contact with the artificial vascular graft during systole in patients who have undergone an aortic valve-sparing operation. In an attempt to minimize the problems of post-repair aortic valvular damage, Kawazoe et al. developed a surgical procedure for aortic regurgitation and aortic root pathology.[16] However, valvular replacement is still indicated for complex lesions, or for ineffective primary repair as assessed by intraoperative echocardiography.[17] Aortic valve replacement provides a safer and more reliable long-term outcome than conservative surgical repair for complex traumatic aortic valve injuries.[18,19]

In conclusion, TAE subsequent to diagnostic angiography provides an effective and minimally invasive treatment for traumatic IMA injuries. Repeated investigations are mandatory for blunt chest trauma patients with de novo heart failure. Although transthoracic echocardiography is traditionally performed after severe blunt thoracic trauma patients, if the echocardiographic window is unsatisfactory, transesophageal echocardiography could be a better choice.

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