

Management of Concomitant Traumatic Anterior Mitral Valve Papillary Muscle and Ascending Aortic Rupture

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Abstract

Blunt cardiac injury can cause a spectrum of life-threatening complications. A 26-year-old male suffered blunt chest trauma after a heavy object fell onto his head and chest. Computed tomography demonstrated multiple facial fractures and an aortic pseudoaneurysm. Subsequent multi-modality imaging revealed a concomitant rupture of the mitral valve papillary muscle. We describe the challenging initial diagnosis and management of this rare combination of blunt cardiac injuries.

Keywords

Papillary Muscle Rupture, Aortic Rupture, Blunt Traumatic Injury, Blunt Cardiac Injury, Mitral Valve Rupture, Mitral Regurgitation, Blunt Chest Trauma

1. Background

Mitral Valve Papillary Muscle Rupture

Blunt chest trauma can result in a spectrum of life-threatening conditions, including blunt cardiac injury (BCI) [1] [2]. BCI represents a spectrum of injuries, ranging from asymptomatic myocardial contusion, to rupture of the cardiac chambers or pericardium, papillary muscles, valves, and coronary artery injuries [3]. The aortic and mitral valves are the most likely valves to suffer injury, likely due to the higher pressures of the left side of the heart [4]. Mitral valve injury is thought to occur when traumatic forces cause high intracardiac pressure during early systole between closure of mitral valve and opening of aortic valve (isovolu-

metric contraction) [1] [5]. When papillary muscle injury occurs, it can rupture immediately or in a delayed fashion [6]-[8]. The proposed mechanism of delayed onset papillary muscle rupture is an initial cardiac contusion leading to hemorrhage and ischemic induced necrosis, usually within 7 days after the incident [6] [8]. An alternative explanation could be a small tear in the papillary muscle not identified on initial imaging, eventually leading to papillary muscle rupture in the absence of ischemic induced necrosis [7]. If the entire trunk of one mitral valve papillary muscle ruptures, loss of function of both leaflets can occur since chordae from each papillary muscle are attached to both the anterior and posterior leaflets. This results in severe mitral regurgitation and acute heart failure. However, symptoms may be less severe if rupture only involves one or two apical heads of the papillary muscle [9].

In patients requiring intensive care treatment for blunt chest trauma, the incidence of cardiac contusion is estimated to be in the range of 20% [10], and mitral valve injury may be present in up to 1.25% of patients with BCI [11]. However, autopsy data suggest that 4.4% of patients with BCI have a ruptured papillary muscle, the vast majority of which (96%) had concomitant myocardial rupture [4].

Timely diagnosis and management of BCI are important [12]. Mortality rates are high, with estimates approaching 90% in cases of cardiac rupture, with death at the scene of the incident being common [13]-[15]. Of the patients who make it to hospital, mortality rates remain high (~50%) [13] [15]. Mitral valve papillary muscle rupture may result in the rapid development of left-sided heart failure requiring urgent surgical intervention to ensure patient survival. Mitral valve repair, and papillary muscle reimplantation have been described previously; however, mitral valve replacement is often required [7] [16] [17]. Early diagnosis of papillary muscle rupture is essential to ensure timely surgical intervention. Despite the widespread availability of transthoracic echocardiography (TTE), diagnosis can be challenging [14]. Patients presenting with blunt cardiac injury are likely to have sustained significant trauma to the chest such as chest wall deformities, pneumo-mediastinum, pneumothorax, wounds, and dressings [7]. Those factors may impact the acoustic window to such a degree that TTE may be inaccurate in as many as 50% of cases for the diagnosis of papillary muscle rupture following blunt chest trauma [8]. In those cases, transesophageal echocardiography (TEE) or cardiac catheterization may be required to achieve an accurate diagnosis [3] [7] [8].

Aortic Root Rupture

Traumatic aortic rupture is also rare, estimated to occur in less than 1% of all patients sustaining blunt chest trauma, with 70% - 80% of patients not surviving to hospital [3]. For hemodynamically unstable patients who make it to the hospital, mortality rates are above 90%, and patients who are initially hemodynamically stable still experience mortality rates up to 25% [3]. Traumatic aortic injury is often located at the isthmus, as this represents a transition point between the more mobile aortic arch and the fixed descending aorta [18]. Traumatic rupture of the

aortic root or ascending aorta is more rare and comprises approximately 3% of thoracic aortic injuries [19]. A variety of proposed mechanisms for traumatic aortic root rupture are reported; for example, compression causing displacement of the heart downward and into the left posterior chest can create a shearing force just above the aortic valve, and deceleration forces of the cranial, caudal, and horizontal planes [20]. Current evidence favours computed tomography of the chest with intravenous contrast to diagnose blunt thoracic aortic injury [21] [22], and it is managed with surgical repair [23] [24].

We report an extremely rare case of blunt chest trauma resulting in mitral valve papillary muscle rupture and concomitant ascending aortic root rupture.

2. Case Presentation

2.1. Initial Presentation

A 26-year-old male suffered blunt trauma after a heavy object fell onto his head and chest. A CT scan following aortic dissection protocol was performed upon his arrival at the local hospital. He was found to have multiple injuries including facial fractures, a tension pneumothorax, hemothorax, T12 and L2 vertebrae fractures, left subclavian artery injury, hemopericardium, vertebral artery dissection and a pseudoaneurysm of his aortic root. The patient was stabilized at a local hospital before being transferred to our tertiary care centre, 14 hours after the injury.

The patient was found to be in a shock state upon arrival, requiring norepinephrine 0.14 mcg/kg/min and vasopressin 0.03 units/min in order to maintain a mean arterial pressure of 60 mmHg. He received adequate fluid resuscitation, and the etiology of his shock state was not clear. A bedside point of care ultrasound, performed at the time of admission, appeared to show good left ventricle (LV) function, with only trivial mitral regurgitation (MR), and no signs of pericardial tamponade. On admission, his laboratory investigations revealed a peak high-sensitivity troponin of 1070 ng/L. Around 8 hours post admission, the patient was then evaluated by otolaryngology, and he underwent an urgent percutaneous tracheotomy due to the severity of the patient's head and neck trauma. Later that day the patient developed bilateral pulmonary infiltrates and hypoxemic respiratory failure that was initially thought to represent pulmonary contusion. A TTE performed within 12 hours after admission to the tertiary care center found moderate-severe mitral regurgitation with prolapse of leaflets. Those findings prompted a TEE, which was performed 14 hours after admission, and revealed severe mitral valve regurgitation with partial dehiscence of the anterolateral papillary muscle. The patient then underwent emergent mitral valve replacement and repair of the aortic root rupture; the operation was completed within 24 hours of the patient's admission to the hospital.

2.2. Operation

A median sternotomy was performed, and significant pericardial adhesions were

encountered. Central aortic and bicaval venous cannulation was performed. An aortic cross-clamp was applied, and the heart was arrested in an antegrade fashion. The mitral valve was approached through Sondergaard's groove, and the anterolateral papillary muscle was found to be hemorrhagic and avulsed from the ventricular free wall with a significant hematoma in the atrioventricular groove and the mitral annulus. The anterior leaflet and anterolateral papillary muscle were excised (**Figure 1**), and a 25 mm Magna Mitral Ease (Carpentier-Edwards) bioprosthetic valve was inserted.

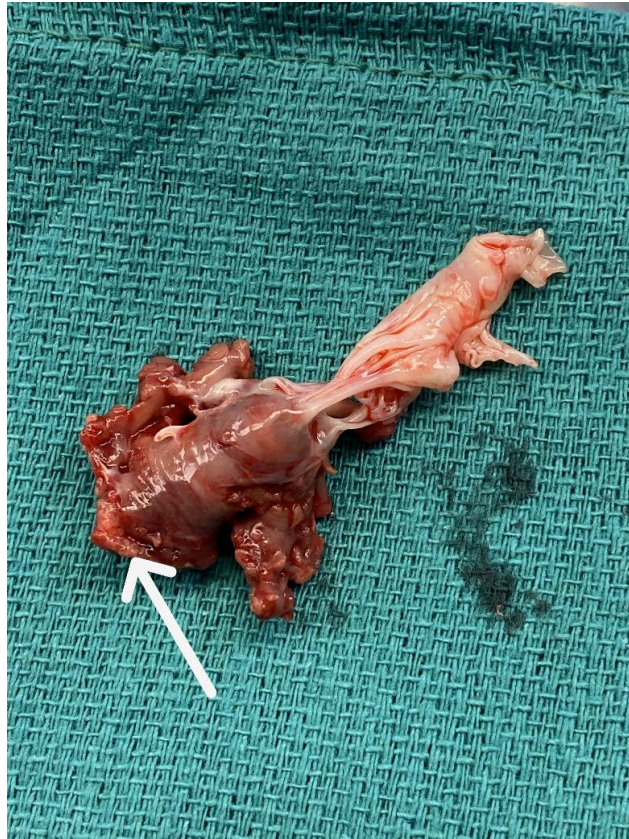


Figure 1. Ruptured and hemorrhagic anterolateral papillary muscle, with arrow demonstrating area of excision from left ventricular free wall.

The mid ascending aorta was then transected, and the site of rupture was identified 4 mm above the ostium of the left main coronary artery (**Figure 2**). The rupture was excised circumferentially, and a size 20 Vascutek graft was used to replace a short segment of the ascending aorta (**Figure 3**). The site of aortic rupture was incorporated into the proximal suture line, while maintaining the integrity of the left main coronary orifice. The intraoperative TEE showed mild-moderate right ventricle dysfunction, a competent mitral valve prosthesis, and good left ventricular function. The patient subsequently underwent facial reconstruction surgery on post-operative day 8 for his bilateral maxilla, zygoma, orbital floor, nasal, and mandible fractures. He continued to recover and was eventually discharged from hospital neurologically intact.

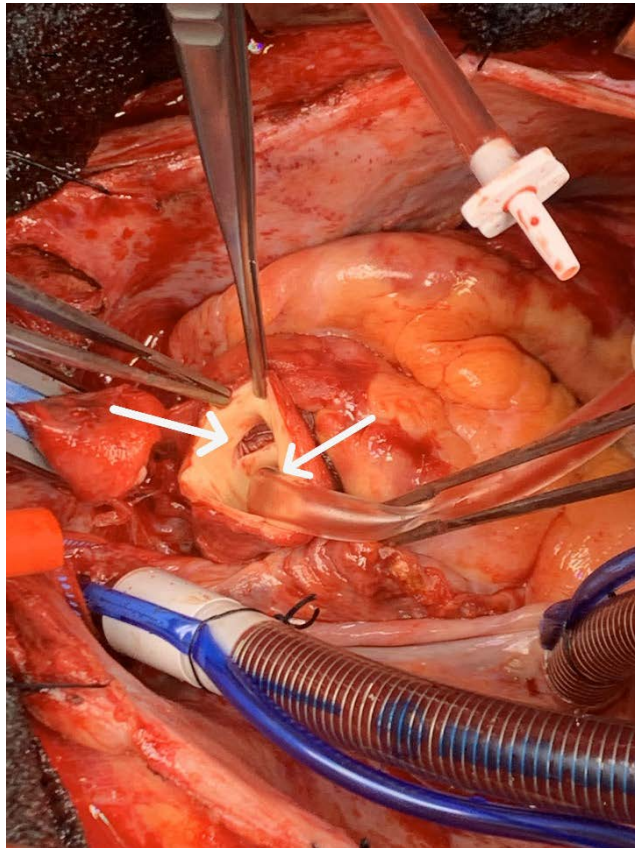


Figure 2. Ascending aortic rupture (arrow on the left), 4 mm above left main coronary ostium (arrow on the right), contained by pulmonary artery.

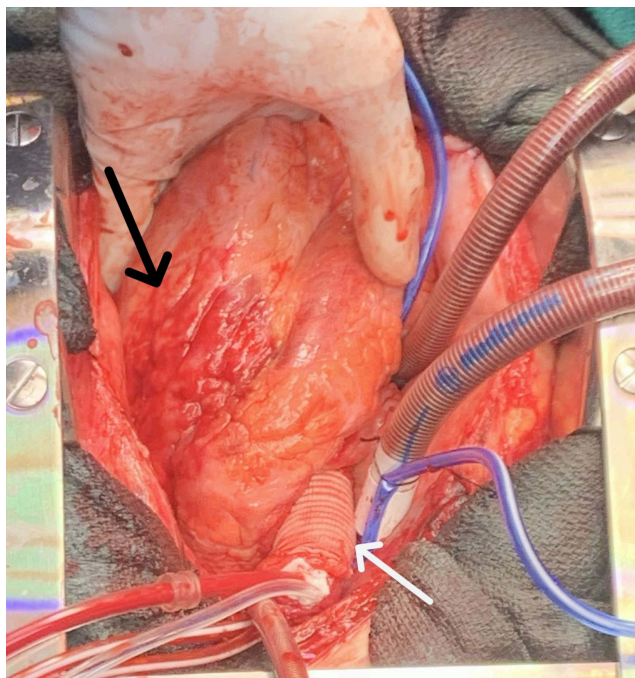


Figure 3. White arrow shows the ascending aortic graft. Black arrow shows an area of hemorrhage on the anterior aspect of the heart extending posteriorly into hematoma in the left atrioventricular groove.

2.3. Follow-Up

Imaging 3 years following discharge revealed stable post-surgical appearance of the ascending aortic graft on CT scan, and an intact mitral valve prosthesis on echocardiogram.

3. Discussion

The only previously documented report of concomitant mitral valve papillary muscle rupture with ascending aortic injury from blunt chest trauma was in 1984 [24]. They documented a case of a woman in an automotive accident who initially appeared stable with a grade 2/6 holosystolic murmur radiating to the axilla and a pulmonary capillary wedge pressure of 15 mmHg with a large V wave on the pressure tracing. TTE at presentation was inconclusive, suggesting the possibility of mitral valve prolapses or flail mitral leaflet. Simultaneously, an aortogram demonstrated a deformity of the aortic root above the noncoronary sinus, with no signs of aortic regurgitation. The following day, however, the murmur increased to a grade 4/6 and ventriculogram demonstrated moderate mitral regurgitation. By day 5, TTE revealed a prolapse of both mitral leaflets and near-total dehiscence of the posteromedial papillary muscle from the left ventricular free wall. Surgical exploration revealed a completely circumferential tear of the intima and media, roughly 1 - 2 cm above the coronary ostia. Histology of the papillary muscle was consistent with 7-day-old infarction [24]. The papillary muscle, along with the chordae tendineae and leaflets, was excised, and a Bjork-Shirley prosthesis was inserted. The aortic root rupture was repaired using internal and external buttressed sutures to approximate the intima and media to the adventitia.

In another case [25], a 32-year-old man suffered an injury due to a partially unopened parachute. Initial CT revealed aortic transection around the level of the isthmus, which was surrounded by a large hematoma. An initial TEE showed a grade 1 - 2/4 mitral regurgitation, with ongoing respiratory failure requiring initiation of veno-arterial extracorporeal membrane oxygenation (VA-ECMO). When they struggled to wean off VA-EMCO 3 days later (recurring pulmonary edema), a repeat TEE showed progression to severe mitral regurgitation (grade 3/4) and prolapse of anterior leaflet due to ruptured anterior papillary muscle. The mitral valve was replaced with a 31-mm St. Jude mechanical valve. An interposition, 18-mm diameter Vascutek Gelsoft graft was used to repair the descending aortic rupture.

This report describes a unique case of blunt chest trauma resulting in anterolateral papillary muscle rupture and concomitant aortic root rupture, treated with surgical management. Mitral valve replacement was selected over mitral valve repair in accordance with guidelines published by the American College of Cardiology and American Heart Association [26]. In keeping with the guidelines, factors such as the patient's heavy burden of concomitant injuries, young age, and complex injury informed the decision of the heart team that mitral valve replacement was the appropriate operation for this patient [26]. The requirement of open aor-

tic repair further favoured open mitral valve surgery as opposed to endovascular repair techniques.

Review of all three cases highlights the potential for a delay in the rupture or diagnosis of rupture of the mitral valve papillary muscle following blunt chest trauma, with progression of clinical symptoms over the first hours to days following the injury. A comparable progression was seen in both previously reported cases, who reported worsening of mitral regurgitation over time. A delayed rupture of the papillary muscle from blunt chest trauma is extremely rare, and is likely a result of contusion induced necrosis at the insertion site of the papillary muscle [6]. In our case, it is difficult to decipher if the rupture of the papillary muscle was delayed, or if the diagnosis was delayed, as it was not identified by bedside ultrasound, but rather the following day via TEE.

Diagnosis of these potentially lethal concomitant injuries is difficult, as they require strong clinical suspicion and proper choice of diagnostic imaging, since no one type of imaging could make both diagnoses. Furthermore, the potential of the delayed nature of papillary muscle rupture requires the physician to be persistent in monitoring for complications of blunt cardiac injury even after initial stabilization of the patient and reassurance of an initial bedside echocardiography.

4. Conclusion

The first case of an ascending aortic rupture and concomitant anterior mitral valve papillary muscle rupture resulting from blunt cardiac injury has been described. This case emphasizes the need for strong clinical suspicion, multimodality imaging and a wide differential in blunt cardiac injury.

Declaration of Ethics

Due to the nature and design of this paper, ethics review was not required.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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