Introduction

Penetrating cardiac injury is an emergent condition which has a high rate of mortality. Alive patients have a variable clinical presentation at the emergency department with a pericardial tamponade in 70% of survivors and 20% of non-survivors [1]. Firearm and stab wounds are the most common causes of penetrating cardiac injury [2].

Nail guns have been used since 1950s to fire nails into woods, concrete and metal surfaces, with the ability to fire projectiles at a speed of 100-150 meters/second and distances of up to 500 meters [3]. Increasing the use of nail guns, as it requires a minimum training, has been reported to increase the rate of nail gun injuries [4]. Extremities are the most common site susceptible to accidental trauma, while penetrating cardiac injury is much less common injury secondary to discharge of pneumatic nail gun [5].

Nail gun cardiac injuries are fairly rare entity, mostly reported in adult males, due to working related infliction with a nail with a death risk of 25% [6]. Searching Medline on July 2018 determined only 25 published case reports of nail gun cardiac injuries. In most of the reported cases, patients survive as the nail wedges in the soft tissue even when there is a chamber injury. Eleven case reports, described 13 patients presented with stable hemodynamic status or had delayed presentation after cardiac nail gun injuries (Table 1).

Methodology

We reported a rare case with delayed presentation of pericardial tamponade after cardiac nail gun injury. We described clinical features, results of imaging studies, surgical procedure and postoperative outcome. Also, we review the literature by searching MEDLINE for similar cases of cardiac nail gun injuries using keywords of (cardiac injury) and (nail gun).

Results

A 19-years-old male presented at the emergency department 15 hours after nail gun injury during his work as a carpenter. The patient did not notice the entrance of the nail and he thought it hit him and came on the ground. He asked for medical advice
at a primary care center after development of severe chest pain, where he was referred to our university hospital. The physical examination revealed pinpoint skin wound at the right side of the sternum along the intermammary line (Figure 1). The patient was fully conscious and his vital signs were: blood pressure 90/60 mm Hg, heart rate 100 beats/min, and respiratory rate 18 breaths/min. Peripheral venous and arterial lines and urinary catheter were inserted.

![Figure 1: Chest X-ray anterior-posterior view shows previous pneumonectomy with ipsilateral mediastinal shift (indicated by an arrow)](image1)

Computed tomography (CT) scan was performed and revealed right parasternal nail penetrating through the soft tissue, costal cartilage and pericardium associated with pericardial effusion (Figure 2). After CT scanning, the patient became drowsy with deterioration of vital signs: blood pressure 85/50 mm Hg, heart rate 110 beats/min, and respiratory rate 20 breaths/min. Bedside echocardiography revealed tamponading pericardial effusion with collapse of the right ventricle during diastole (Figure 3). Thereafter, the patient was transferred immediately to the operating room. Left anterior thoracotomy revealed penetration of the nail tip into pericardium through a small hole, with hemopericardium and large hematoma over the right side of the heart. After evacuation of the hematoma, a small puncture at the anterior surface of right ventricle was observed and started to re-bleed after removal of the hematoma. The bleeding from the puncture was initially controlled by digital pressure. A 4-cm nail (Figure 4) was removed outward through its track from the pericardium, costal cartilage and soft tissue. The direct repair of the right ventricular injury was performed with two 3/0 Prolene sutures (Figure 5). The patient developed no post-operative complications and he was discharged home at the 5th day after surgery.

![Figure 2: Axial view of chest computed tomography showing a nail passing through the sternum and pericardium with pericardial effusion](image2)
Figure 3: Bedside transthoracic echocardiographic view showing pericardial effusion (arrow) with right ventricular collapse during diastole. RV: right ventricle, RA: right atrium, LV: left ventricle, LA: left atrium

Figure 4: Postoperative image of the extracted nail of 4-cm in length

Figure 5: Intraoperative view of the direct repair of right ventricular injury (arrow) through left anterior thoracotomy
**Discussion**

Cardiac nail gun injury is a rare work-related hazard associated with 25% risk of mortality in male adults [6]. Most of these injuries are a result of accidental discharge of nail gun, commonly involve the right ventricle due to its anterior location, and associated with variable degrees of pericardial tamponade [7].

The clinical presentation of survivors varies in regard to their hemodynamic stability [8]. Most of the reported cases presented few minutes after trauma. Rare cases of delayed presentation or stable hemodynamic status at admission after cardiac nail gun injury were previously reported (Table 1) [5, 8, 17]. There is no standard reason for delayed presentation, but it could be related to stable hemodynamic status and invisible non-bleeding pinpoint skin wound [8,13]. In our case, the delayed presentation of pericardial hematoma. was previously reported (Table 1) [5, 8, 17]. There is no standard reason for delayed presentation, but it could be related to stable hemodynamic status and invisible non-bleeding pinpoint skin wound [8,13]. In our case, the delayed presentation of pericardial hematoma.

### Table 1

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Age (y)</th>
<th>Gender</th>
<th>Cause of injury</th>
<th>Physical examination</th>
<th>Site of injury</th>
<th>Surgical approach</th>
<th>Surgical technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>Georgiou, et al [9]</td>
<td>2003</td>
<td>14 y</td>
<td>F</td>
<td>Blast injury</td>
<td>An entry wound at the level of the 8th IC space</td>
<td>Right ventricular muscular</td>
<td>Median sternotomy with CPB</td>
<td>Removal of the nail and repair of injury with a pledgeted suture</td>
</tr>
<tr>
<td>Nolke, et al. [10]</td>
<td>2005</td>
<td>Case 1: 16 y Case 2: 36 y</td>
<td>Cases 1 and 2: Accidental shot</td>
<td>Case 1 and 2: Puncture (entry point) wound under the left nipple</td>
<td>Case 1: Left ventricular apex Case 2: Right ventricle</td>
<td>Case 1 and 2: Left anterior thoracotomy</td>
<td>Cases 1 and 2: Repair of the defect with pledgeted sutures</td>
<td></td>
</tr>
<tr>
<td>Straus, et al. [11]</td>
<td>2006</td>
<td>62 y</td>
<td>M</td>
<td>Suicidal shot by a pneumatic nail gun</td>
<td>An entry at left anterior chest. Hemodynamic stable</td>
<td>Two nails: One within the left ventricle, and another one in anterior mitral valve leaflet</td>
<td>Median sternotomy with CPB</td>
<td>Extraction of nails. Repair of mitral valve leaflet was not required</td>
</tr>
<tr>
<td>Guo and Myers [12]</td>
<td>2008</td>
<td>25 y</td>
<td>M</td>
<td>Accidental shot</td>
<td>A nail protruding at the sixth left IC space</td>
<td>Anterior wall of the right ventricle</td>
<td>Median sternotomy</td>
<td>Extraction of the nail after tying a purse-string suture around it</td>
</tr>
<tr>
<td>Tuladhar, et al. [13]</td>
<td>2009</td>
<td>49 y</td>
<td>M</td>
<td>Suicidal shot</td>
<td>Two pinpoint blood clots near the xiphisternum</td>
<td>One nail in the rectus insertion. Another one enters right ventricular free margin and exits through the inferior surface of the left ventricle</td>
<td>Median sternotomy with CPB</td>
<td>Removal of both nails. Wounds were repaired and buttressed</td>
</tr>
<tr>
<td>Comoglio, et al. [14]</td>
<td>2010</td>
<td>75 y</td>
<td>M</td>
<td>Accidental shot (unnoticed initially)</td>
<td>A small wound on the left chest wall</td>
<td>Left ventricular wall</td>
<td>Median sternotomy</td>
<td>Gentle removal of the nail. Wounds were repaired</td>
</tr>
<tr>
<td>Madani, et al. [15]</td>
<td>2011</td>
<td>17 y</td>
<td>M</td>
<td>Accidental shot</td>
<td>A punctiform entrance wound at the 2nd left IC space</td>
<td>The trunk of the pulmonary artery without transfixing its posterior wall</td>
<td>Median sternotomy</td>
<td>Extraction of the nail after tying a purse-string suture around it</td>
</tr>
<tr>
<td>Michalsen, et al. [16]</td>
<td>2015</td>
<td>Case 1: 3 y Case 2: 37 y</td>
<td>Cases 1 and 2: Accidental shot Case 1: Punctured wound Case 2: Suicidal shot</td>
<td>Cases 1 and 2: Right ventricular and interventricular septum</td>
<td>Cases 1 and 2: Right ventricular and interventricular septum</td>
<td>Case 1: Median sternotomy with CPB Case 2: Median sternotomy with intravenous adenosing to slow the heart rate</td>
<td>Case 1: Nail extraction through small right ventriculotomy Case 1: Nail extraction and repair of 2 holes in right ventricle</td>
<td>Case 1: Nail extraction through small right ventriculotomy Case 1: Nail extraction and repair of 2 holes in right ventricle</td>
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</tbody>
</table>
Delayed pericardial tamponade after penetrating cardiac injury is a challenging diagnostic and therapeutic entity, with several proposed mechanisms including clot sealing a partial tear associated with slow leak into pericardium or sudden dislodgment followed by rapid accumulation of blood [18]. In stable patients and in those with unclear presentation, imaging modalities particularly echocardiography have a vital role to confirm the presence of pericardial tamponade [13]. Chest computed tomography (CT) scans can be used to confirm the intra-thoracic position of the nail, and to detect pericardial effusion [8]. The stable status of our case at admission gave us the chance to perform preoperative CT and bedside echocardiography [14-17].

A controversy remains regarding the conservative management and pericardiocentesis in patients with no tamponade and stable hemodynamic status. Percardiocentesis can serve as a temporary life-saving measure, particularly as a bridge to definitive therapy [18,19]. The presence of pericardial tamponade indicates an emergent surgical intervention via median sternotomy or thoracotomy according to the location of cardiac injury [20]. Emergency department thoracotomy is favored for the hemodynamically unstable or pulseless patient [19]. In our case with unusual presentation, we preferred anterior thoracotomy in the operating room as the hemodynamic status was query stable and the imaging studies excluded penetration of the nail into cardiac chambers or major blood vessels.

Conclusion

Adequate training and applying of the security systems are essential to prevent accidental nail gun injuries. In addition to firearm and stab wounds, nail gun is an essential cause of penetrating cardiac injury. Cardiac nail gun injury is a rare emergency condition requires early diagnosis and immediate intervention to reduce the rate of mortality. High index of clinical suspicion and use of the best and fastest imaging modalities are useful for successful management of stable patients. Unstable hemodynamic status after penetrating trauma to the cardiac box raises the alert for pericardial tamponade. Aggressive approach with proper resuscitation and avoid of time consuming investigations are crucial for unstable patients with penetrating cardiac injury.

References


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</tr>
</thead>
<tbody>
<tr>
<td>Kulaylat, et al.</td>
<td>2016</td>
<td>29 y</td>
<td>F</td>
<td>Suicidal shot</td>
<td>Bloodless puncture wound at right 4th IC space</td>
<td>Right ventricle</td>
<td>Median sternotomy</td>
<td>Nail extraction and primary repair of torn myocardium</td>
</tr>
<tr>
<td>Ho, et al. [17]</td>
<td>2017</td>
<td>51 y</td>
<td>M</td>
<td>Suicidal shot</td>
<td>One puncture wound at the right sternal border in the 4th IC space</td>
<td>Anterior right ventricular wall and diaphragm</td>
<td>Median sternotomy with CPB</td>
<td>Removal of the nail and closure of the two heart wounds and diaphragm</td>
</tr>
</tbody>
</table>
