Delayed presentation of a pneumatic nail gun injury to the right ventricle without circulatory compromise

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ABSTRACT

Delayed presentation of penetrating cardiac injuries is exceedingly rare due to the observed near 100% pre-hospital mortality. We describe a case of a patient who presented for evaluation nearly 24 h after sustaining a self-inflicted pneumatic nail gun injury to the right ventricular outflow tract. Remarkably, the patient had no evidence of hemodynamic compromise. This case highlights the importance of maintaining a high index of suspicion for cardiac injury with penetrating trauma to the cardiac box regardless of presenting signs and symptoms, and the value of adhering to advanced trauma life support principles.

Introduction

The prevalence of pneumatic nail gun injuries is alarmingly high. Although a minority of these injuries are localized to the thorax or abdomen, they are associated with a high mortality rate. Of those individuals who sustain a penetrating cardiac injury, the majority exhibit signs of cardiac tamponade or active hemorrhage resulting in an observed near 100% pre-hospital mortality rate. Given the lethality of penetrating cardiac injuries, delayed presentation has been rarely documented.

Herein we report an unusual case of a self-inflicted penetrating cardiac injury by pneumatic nail gun that came to medical attention after approximately one day following the event. Remarkably, the patient did not exhibit any signs of hemodynamic compromise on arrival despite injury to the right ventricular outflow tract. The absence of classic signs or symptoms of injury to the heart secondary to penetrating trauma to the cardiac box as in the present case illustrates the critical importance of maintaining a high index of suspicion for lethal injuries.

Case

A 49-year-old male with a medical history notable for depression, social anxiety disorder, delusions, methamphetamine use, and prior suicide attempts sustained a self-inflicted penetrating thoracic injury by pneumatic nail gun. He called police for help...
approximately 20 h later. Upon arrival to the hospital, the patient was evaluated following Advanced Trauma Life Support (ATLS) protocol. He was conscious, speaking easily with equal bilateral breath sounds, and hemodynamically sufficient. On secondary survey, a nail head was identified at the left parasternal border above the fifth rib. On focused assessment with sonography in trauma (FAST) examination, the cardiac window was negative for effusion as were the abdominal windows. Chest x-ray demonstrated a nail at the left parasternal border without evidence of pneumothorax or pleural effusion. An electrocardiogram revealed ST-segment elevations in the pre-cordial leads. Computed tomographic angiography (CTA) was performed which revealed the nail traversing the left border of the sternum and penetrating the right ventricular outflow tract (RVOT). (Fig. 1) Involvement of the posterior wall of the RVOT could not be clearly determined due to beam hardening artifact. Laboratory findings were notable for a white blood cell count of 13,500, hemoglobin of 12.6 g/dL, international normalized ratio of 0.98, and a PTT of 11.0 s. Urine toxicology was positive for amphetamines and benzodiazepines.

The patient was brought emergently to the operating theater for exploration. Following induction of general anesthesia, cardiopulmonary bypass (CPB) was initiated via right femoral arterial and venous cannulation. A median sternotomy was performed, and the right ventricle was found to be transfixed approximately 1 cm posterior to the sternum by an annular ribbed nail. The nail was cut adjacent to the posterior table of the sternum to liberate the heart and facilitate placement of a Finochietto retractor for exposure (Fig. 2) after which a pericardiotomy was performed and a small amount of hemorrhagic effusion was identified. The area of penetration in the RVOT was hemostatic, and the posterior aspect of the heart did not appear to be injured on manual palpation. A double row purse-string with Teflon pledgets was fashioned around the injury with 3-0 polypropylene suture, and subsequently closed around the defect as the nail was removed. The pulmonic valve was found to be without injury on evaluation by intra-operative trans-esophageal echocardiography and no evidence of right ventricular or pulmonic valve dysfunction was identified during a subsequent transthoracic echocardiography performed on post-operative day 3. The post-operative course was unremarkable, and the patient was discharged to an inpatient psychiatric facility on post-operative day ten.

Discussion

There are several reported cases of pneumatic nail gun associated cardiac injuries in the literature [1–10]. Ventricular, valvular and aortic injuries have been described and these are most commonly associated with hemodynamic insufficiency on presentation [1,3,4,6,7,10]. The majority of described cases were evaluated shortly after injury, however 3 cases were evaluated after more than sixteen hours [2,8,9]. One report described circulatory collapse on induction of general anesthesia [2]. In the remaining two cases, one patient sustained a pulmonary artery injury, while the other sustained a left ventricular wall and interventricular septal injury. Remarkably, neither patient exhibited signs of circulatory compromise. In the present case, this patient did not demonstrate signs of hemodynamic insufficiency or respiratory distress despite the 20-hour delay in presentation. We hypothesize that the annular ribbed design of the nail allowed for rapid development of a platelet rich plug (Fig. 3) which was sufficient to prevent hemorrhage and tamponade from the relatively low pressure RVOT. Notably, of the cases previously described in the literature, 2 report injury with an annular ribbed nail; one patient experienced circulatory collapse while the other did not [1,5].

The present case demonstrates the importance of maintaining a high index of suspicion for cardiac injury in the presence of penetrating trauma to the “cardiac box” even in the asymptomatic individual. On the anterior chest wall, the cardiac box is bounded by the sternum medially, the left nipple laterally, the clavicle superiorly, and the costal margin inferiorly. There is a five-fold increase in the incidence of cardiac injury with penetrating trauma occurring within the cardiac box. When hemodynamic insufficiency is present, the patient should be transported immediately to the operating theater for resuscitation and surgical intervention. If available, a cardiac surgeon and cardiothoracic anesthesiologist should be intimately involved. Availability of intra-operative trans-esophageal

Fig. 1. Axial (a) and sagittal (b) views from chest CTA revealing the trajectory of the nail entering the chest through the sternum and piercing the RVOT (red arrow) just proximal to the pulmonic valve (blue arrow).
Echocardiography for evaluation of the valves and septa can be invaluable. Empiric femoral cannulation for cardiopulmonary bypass may be considered prior to opening of the chest to facilitate cardiac decompression for repair of complex injuries. Should cardiac arrest occur on arrival or immediately prior to arrival with signs of life present, resuscitative thoracotomy may be considered as per the Western Trauma Association practice management guidelines. However, judicious manipulation of the heart should be undertaken as it may be transfixed to the chest wall as in the present case; aggressive maneuvers to deliver the heart from the pericardium may result in worsening of a puncture wound into a laceration, or injury to the surgeon.

In the hemodynamically sufficient patient, an expeditious and complete evaluation should be performed guided by ATLS protocol to assess for occult injury and to precisely define any cardiac injury present to facilitate operative planning. CTA in particular can be extremely helpful in such cases. While FAST should be performed to evaluate for hemopericardium during initial evaluation, in the presence of a hemothorax, results should be interpreted with caution as hemopericardium may not be detected if a through and through injury is present with decompression of hemorrhage occurring into the pleural space.

Regardless of mechanism, penetrating cardiac injuries are highly lethal. Absence of overt signs of hemodynamic compromise should not be misconstrued as absence of a life-threatening injury. Adherence to ATLS principles is critical for survival.

**Declaration of competing interest**

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**References**

[1] H. Rupprecht, M. Ghidau, Penetrating nail-gun injury of the heart managed by adenosine-induced asystole in the absence of a heart-lung machine, Tex. Heart Inst. J. 41 (4) (2014) 429-432.

[2] S. Tuladhar, A. Eltayeb, S. Lakshmanan, P. Yiu, Delayed presentation of right and left ventricle perforation due to suicidal nail gun injury, Ann. Card. Anaesth. 12 (2) (2009) 136-139.
A. Yamamoto, Y. Umeda, Y. Kamei, H. Suzuki, C. Kondo, H. Tashiro, Penetrating nail-gun injury of the thoracic descending aorta, Acute Med. Surg. 7 (1) (2020), e530.

G.P. Georgiou, E. Birk, M. Nili, M. Stein, B.A. Vidne, E. Erez, Images in cardiovascular medicine. Direct nail injury to the heart without functional or hemodynamic compromise, Circulation 107 (14) (2003) e92–e93.

L. Nolke, P. Naughton, C. Shaw, J. Hurley, A.F. Wood, Accidental nail gun injuries to the heart: diagnostic, treatment, and epidemiological considerations, J. Trauma 58 (1) (2005) 172–174.

A.C. Beaver, M.L. Cheatham, Life-threatening nail gun injuries, Am. Surg. 65 (12) (1999) 1113–1116.

J.M. Felner, Images in clinical medicine. Nail in the aorta, N. Engl. J. Med. 334 (4) (1996) 239.

M. Madani, M. Drissi, M.R. Ajaja, et al., Nail gun may cause heart injury: a young adult's misadventure, Int. Emerg. Nurs. 20 (2) (2012) 98–101.

B.C. Prokesch, J.E. Mangino, Nail gun attempted suicide and traumatic ventricular perforations, QJM 107 (7) (2014) 589.

E. Eren, C. Keles, B. Sareyyupoglu, N. Bozbuga, M. Balkanay, C. Yakut, Penetrating injury of the heart by a nail gun, J. Thorac. Cardiovasc. Surg. 127 (2) (2004) 598.