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## Clinical Communications: Adults

### CARDIAC INJURY DUE TO ACCIDENTAL DISCHARGE OF NAIL GUN

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**Abstract—Background:** Since 1991, the incidence of injuries associated with pneumatic and explosive powered nail guns has steadily been rising due to increasing use of these devices by the untrained consumer. The vast majority of injuries involve the extremities, but injuries have been reported to occur in virtually every area of the body. **Objective:** Discuss the epidemiology, pathophysiology, and management of penetrating cardiac nail gun injuries. **Case Report:** A 33-year-old man sustained a penetrating cardiac injury from accidental discharge of a nail gun. The patient had successful repair of a laceration to his right ventricle. **Conclusions:** Penetrating cardiac injuries from pneumatic nail guns are rare and have mortality similar to stab wounds. Improved safety mechanisms and training are the keys to prevention. Consideration also should be given to implementing legislation restricting the sale of nail guns. © 2012 Elsevier Inc.

**Keywords—**nail gun; injury; cardiac; penetrating trauma

#### INTRODUCTION

The pneumatic or explosive cartridge-powered nail gun has become an essential tool in modern construction for both professional workers and consumer “do-it-yourselfers” (1,2). As a result, injuries from nail guns are becoming ever more frequent. These devices can be used with minimal training and the consumer can easily

obtain one without any requirements (1,3). Since 1991, the incidence of consumer nail gun injuries has increased by approximately 200%, whereas the incidence of worker nail gun injuries has remained relatively constant (1). The Centers for Disease Control and Prevention (CDC) reported that there were 42,000 nail gun injuries presenting to the emergency department (ED) in 2005 (1). Ninety-seven percent of these injuries were in men and 32% in consumers. The vast majority of injuries occurred in the extremities (69% in upper extremities and 22% in lower extremities), but nail gun injuries have been reported to occur in virtually every part of the body, including the head, orbits, jaw, neck, chest, abdomen, vertebral column, and spinal cord (1–6). Only 6% of nail gun injuries in 2005 required hospitalization secondary to injuries to the head, trunk, joints, and bone (1). Mortality data were not reported by the CDC, nor were any reports of cardiac injury during the surveillance period.

A review of the emergency literature revealed that penetrating nail gun injuries to the heart are relatively rare, though the exact incidence is unknown (7,8). Many of these cardiac injuries are self inflicted, with an incidence of 44% in one case series of 16 patients and the remainder due to accidental discharge (7). Almost all cardiac nail injuries involve the right ventricle due to its anterior location in the thorax, and > 70% are associated with some degree of tamponade (7,8). In this report we describe a case of penetrating cardiac injury from accidental discharge of a nail gun.

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## CASE REPORT

A 33-year-old white man without any known prior medical history presented to the ED after having sustained a penetrating injury to the chest from a pneumatic nail gun. The patient was coming down a ladder at a construction site when he slipped on the lower rung and inadvertently dropped the nail gun. On hitting the ground, the nail gun discharged a 16-penny nail, which struck the patient in the anterior chest wall. The patient was ambulatory immediately after the injury but subsequently collapsed to the ground with decreased responsiveness. Emergency Medical Services (EMS) called to the scene intubated the patient and summoned helicopter EMS for transport to our Level I trauma center.

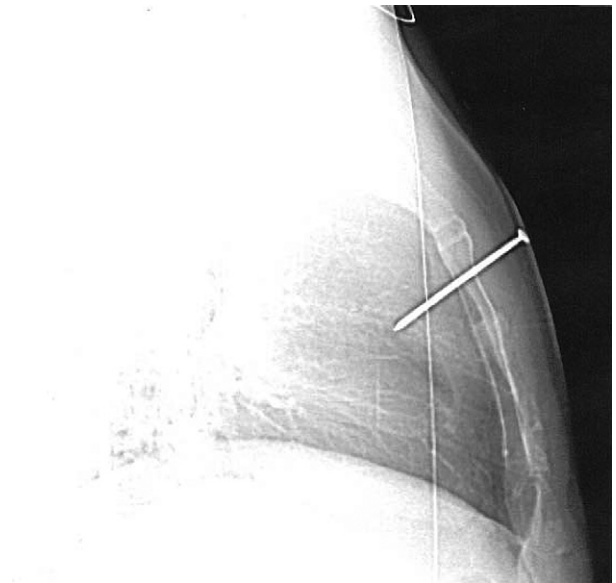
Initial physical examination revealed a pharmacologically paralyzed man on mechanical ventilation. Vital signs were: blood pressure 133/98 mm Hg, pulse 88 beats/min, and respirations 18 breaths/min on mechanical ventilation. Physical examination revealed the head of the nail just right of the sternum in the second intercostal space angled towards the posterior aspect of the diaphragm (Figure 1). Lungs were clear with equal breath sounds bilaterally. Cardiac examination revealed a regular rate and rhythm without rubs, murmurs, or gallops. The patient subsequently was taken for computed tomography (CT) scanning, which revealed a 4-inch nail penetrating into the right ventricle at the pulmonary outlet, with associated pericardial and anterior mediastinal blood (Figure 2).

The patient was taken to surgery, and repair of a laceration to the right ventricle was performed. The patient developed no post-surgical complications and was discharged in good health on hospital day 5.

## DISCUSSION

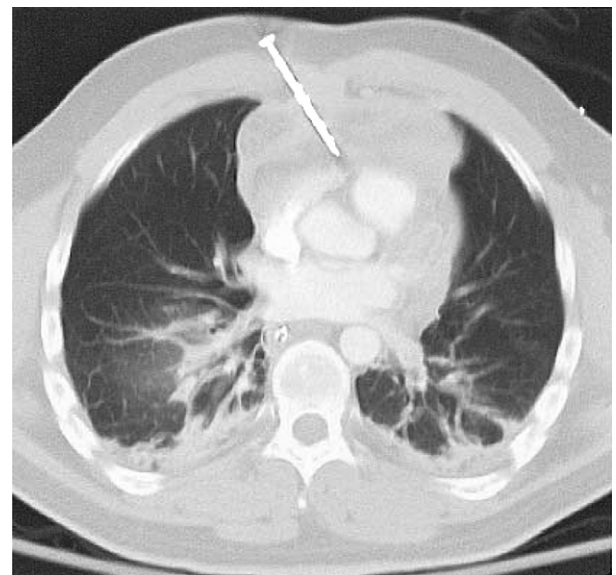
The first nail gun injury was reported in 1959, the year the device became commercially available (2,4). These tools are designed to send nails into high-density materials such as wood, concrete, or steel with minimal damage to the surrounding medium to maintain its retaining ability (4,7). Powered by compressed air (low velocity) or explosive cartridges (high velocity), the nail guns propel fasteners with a velocity of 100 to 150 m/s and distances up to 500 m (2-4).

Penetrating injuries to the non-dominant hand are the most common injuries reported, but can occur in virtually every area of the body (1-6). Over the years, improvements have been made to safety mechanisms for nail guns, but despite these advances, injuries have risen 200% from 1991 to 2005 due to the increasing use of these devices by the untrained consumer (1). Cardiac



**Figure 1. Lateral scout view of computed tomography scan demonstrating 4-inch nail entering second intercostal space and directed towards inferior aspect of posterior diaphragm.**

injuries represent a small portion of the nail gun injuries, but carry a 25% risk of mortality, which is similar to the 35% mortality from stab wounds to the heart (7,9). Self-inflicted injuries from nail guns have mortality as high as 40% (7,10). In contrast, the mortality of penetrating cardiac trauma from gunshot wounds is approximately 80% (9). There are several reasons for the lower mortality of nail gun devices. As mentioned above, the device is



**Figure 2. Computed tomography image of thorax reconstructed on plane parallel to nail demonstrating 4-inch nail penetrating into the right ventricle at the pulmonary outlet with associated pericardial and anterior mediastinal blood.**

designed to fasten objects together, so it will cause less secondary tissue damage than a traditional projectile from a firearm (7). In addition, the nail has a smaller frontal cross section, limiting the area of impact and the direct damage that occurs (7). However, the fasteners used in nail guns may have a plastic collar and washer for maintaining proper orientation and preventing excessive penetration (2,4). These materials may cause additional tissue damage as well as serve as a potential source of infection (4).

Thoracotomy is the accepted treatment for penetrating injuries in the region of the heart (10,11). Two reports have demonstrated utility of transesophageal echocardiography before surgery to assist in determining surgical treatment (10,12). In this report, the patient was taken directly to surgery after the CT scan without echocardiography.

The mechanisms of nail gun injuries have been associated with accidental discharge, carelessness, inadequate training, through-and-through penetration of work-piece, ricochet, and self-infliction (1,2). Prevention of such injuries has been the goal over the past several decades, with multiple safety features being implemented into modern devices such as dual-action contact trigger, which requires that the manual trigger and the nose contact element make contact with the surface before the nail can be discharged (1–3). A shortcoming of this safety feature is that the operator can place a trigger lock that keeps the trigger in the firing position, thus allowing the operator to rapidly fire nails by pressing the nail-gun nose on the work material in a sequential process (1). The alternative sequential trigger mechanism requires that the nose be depressed with force > 25 pounds before trigger activation (1,2,7). Another safety mechanism requires the nail gun to be held at an angle < 6–8 degrees from perpendicular before triggering (2,4,7). The CDC estimates that > 65% of nail gun injuries could be prevented with adequate safety mechanisms and training (1).

At the present time there is no legislation restricting the sale of nail guns, nor are there any requirements by the Consumer Product Safety Commission or the Occupational Safety and Health Administration regarding safety education or demonstrating proficiency in the use of nail guns (13). A recent study of 217 businesses that sell or rent nail guns found that 60% of these businesses failed to provide any information regarding safe use of these devices, and of those that did provide information, it frequently was inaccurate (13). Of interest, Australia

requires individuals to undergo training and obtain a license to utilize high-velocity powder-driven industrial nail guns (14). Consideration should be given to implementing similar legislation in the United States.

## CONCLUSION

Nail gun injuries to the heart, although rare, represent a severe injury that should be treated diligently and expeditiously. Due to the design of this weapon as an industrial tool, and not one engineered for tissue destruction, the survivability is comparable to stab wounds to the heart as opposed to gunshot wounds. Prevention is the key to avoiding nail-gun-associated injuries. Efforts should focus on improved safety mechanisms as well as improved training and safety education, especially for the consumer population. Consideration also should be given to implementing legislation restricting the sale of nail guns to only those who have undergone proper training in the safe utilization of these devices.

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