

# Penetrating Nail-Gun Injury of the Heart

Managed by Adenosine-Induced Asystole in the Absence of a Heart-Lung Machine

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*During his work, an 18-year-old carpenter-in-training overbalanced and shot himself in the left median thorax with a nail gun. The patient was delivered to our thoracic surgery unit with a tentative diagnosis of penetrating lung trauma. An emergent computed tomogram showed a heart-penetrating nail injury. The patient was taken to the operating room, where he underwent emergency surgery that included sternotomy, pericardiotomy, extraction of the nail, and trauma treatment of the heart injury. The surgery was performed in a unit without a heart-lung machine. For that reason, asystole was chemically induced by the intravenous administration of adenosine. The surgery was successful, and the patient was discharged from the hospital on the 10th postoperative day.*

*In cases of penetrating injuries of the heart, especially those with a foreign body retained in situ, we believe that the intravenous administration of adenosine is an elegant solution for the rapid provocation of asystole. In contrast to other methods, adenosine-induced asystole enables relatively safe myocardial manipulation in the absence of a cardiac surgical unit and a heart-lung machine. (Tex Heart Inst J 2014;41(4):429-32)*

**P**neumatic nail-gun injuries occur fairly often and usually involve the hands and the limbs.<sup>1,2</sup> Penetrating injuries of the heart are rare, often performed with suicidal intention.<sup>3-6</sup> We present a case of accidental self injury and discuss the appropriate sequence of evaluation and treatment in the absence of a cardiac surgery unit and a heart-lung machine.

**Key words:** Accidents, occupational; adenosine/ administration & dosage; asystole, induced; cardiac tamponade/therapy; emergency medical services/ standards; foreign bodies; heart arrest, induced; heart injuries/surgery; heart-lung machine; heart ventricles/ injuries; wounds, penetrating/surgery

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## Case Report

During his work in May 2007, an 18-year-old carpenter-in-training overbalanced and shot himself with a nail gun, in the left median thorax. The injury, in appearance, was a small, lightly bleeding inframammary wound (Fig. 1). Because he collapsed, the patient received emergency treatment (perfusion, intubation, and ventilation) by the physician who arrived by ambulance. He was then delivered by helicopter to our thoracic surgery unit with the tentative diagnosis of “penetrating lung trauma.”

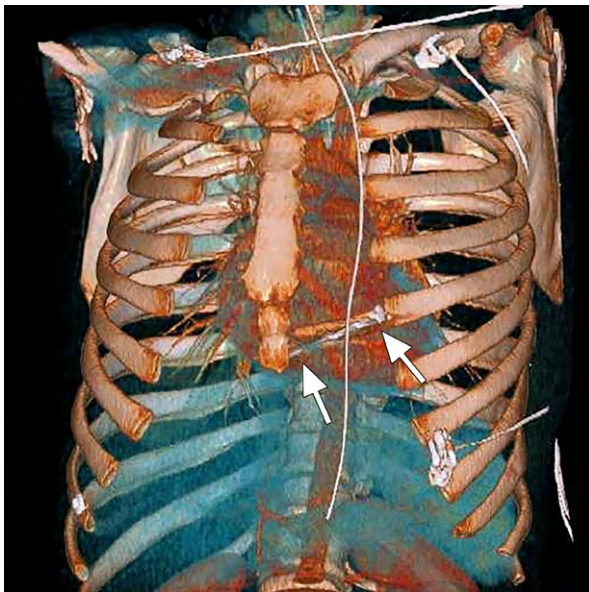
The patient was in stable condition at admission to the emergency ward. This enabled a clarifying computed tomographic scan (Figs. 2 and 3), which showed a penetrating heart injury and cardiac retention of the fired nail. Further, left-sided hemothorax was diagnosed. The abdominal scan showed no injuries. Sudden circulatory failure set in with hypotension, progressive bradycardia, and jugular congestion, so the patient was taken immediately to the operating room.

After sternotomy, a pericardiotomy released a massive amount of blood from the pericardial sac. As a consequence of this maneuver, the circulatory failure was overcome, but sinus tachycardia began. Inspection of the operative site showed a left-sided medial pleural injury and a barbed nail deeply penetrated in the left ventricle (Fig. 4). The computed tomographic scan had not revealed the barbs, because of their small size.

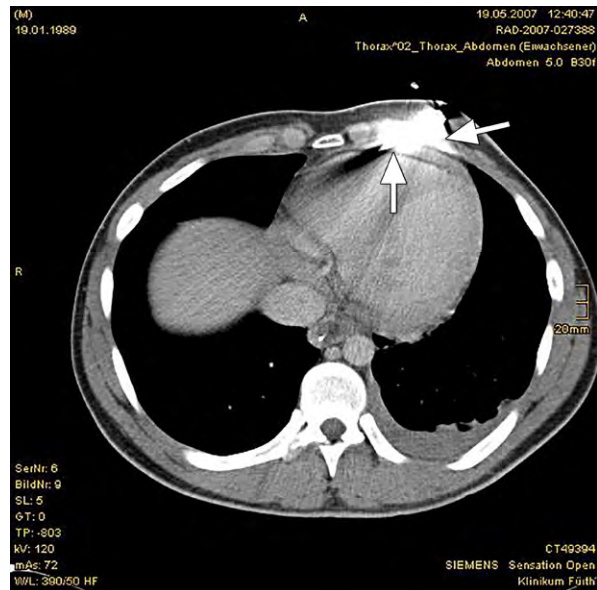
In preparation for extraction of the barbed nail, we induced chemical asystole through intravenous injection of adenosine (12 mg) over a central venous catheter. During this short-term asystole (10–15 s), we removed the nail by carefully twisting it. Simply pulling the nail out of the myocardium could have ruptured the wound margins of the ventricular wall. Inspection of the posterior wall of the heart showed no injury; the entry wound on the anterior ventricular wall was then closed with non-resorbable, felt-sheathed sutures.



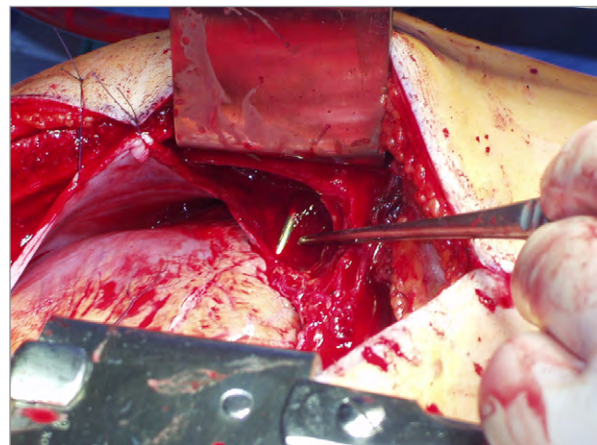
**Fig. 1** Preoperative photograph shows the chest injury as a small, lightly bleeding, inframammary wound.



**Fig. 2** Computed tomogram (3-dimensional reconstruction) shows the chest during the emergency scan. Note cardiac retention of the fired nail (arrows).



**Fig. 3** Computed tomogram (axial view) shows the nail (arrows).



**Fig. 4** Intraoperative photograph shows the nail, having penetrated the left ventricle.

## Discussion

Nail-gun injuries of the heart are potentially fatal<sup>1</sup> for multiple reasons, not least of which is failure of the primary diagnosis.<sup>2,4,7-9</sup> The small penetration wound, the often unrecognizable foreign body, and the absence of classical cardiac tamponade or ECG alteration<sup>2,9-11</sup> lead to an underestimation of the fundamental threat or to a misdiagnosis, such as acute coronary syndrome.<sup>2</sup> At first, the victim is usually in shock, and only symptomatic conditions are treated.

Sufficient blood volume is crucial to the maintenance of adequate cardiac output, because an “empty” ventricle collapses quickly in response to pericardial pressure.<sup>11-15</sup> Although pericardial tamponade is at first life-saving, it leads over time to a fatal outcome, as a result of cardiac

About 15 to 20 seconds after the intravenous administration of adenosine, cardiac function resumed spontaneously. After inserting the chest drain and substernal drains, we ended the procedure by fastening the sternum with wire and closing the wound. The patient was transferred to our intensive care unit and was extubated on the next day.

Repeated echocardiographic and electrocardiographic (ECG) checkups, as well as laboratory tests, showed no indication of other cardiac injuries. Throughout, the ECG showed no disturbance of rhythm. Wound-healing was primary. On the 10th postoperative day, the patient was discharged from the hospital; he still works as a carpenter.

failure.<sup>10,12,13</sup> When a circulatory decompensation (systolic blood pressure, <80 mmHg) sets in after a chest injury, especially when decompensation no longer responds to volume supply, the patient needs to be taken to the nearest appropriate surgical facility.<sup>12,16,17</sup>

Treatment of the impending cardiac arrest (extreme bradycardia, no peripheral pulse) requires at least a temporary discharge of blood through a pericardial window, for the rapid relief of tamponade.<sup>7,9,18,19</sup> A sub-xiphoid relief puncture of the pericardium is rarely successful, because the pericardial blood has coagulated; it can even produce a lesion of the heart.<sup>7,9,11,18,20-22</sup>

In addition to volume substitution,<sup>12-15,22</sup> oral intubation<sup>13,21</sup> is needed to delay the cardiac decompensation. Intubation also enables the administration of a general anesthetic agent, which can suppress the pain-related tachycardia, in this manner preventing more rapid “empty pumping” of the heart. The restlessness caused by pain can move the intracardiac foreign body in such a way as to enlarge the myocardial defect.<sup>6</sup>

Because simultaneous injury of the lung often occurs,<sup>11,13,21</sup> the insertion of a chest tube is indicated at the least suspicion of a pulmonary lesion, especially if helicopter transport has to be arranged. Many patients die of tension pneumothorax, before the penetrating heart injury can kill them.

The cardiovascular situation of the patient determines further therapy. Indications for immediate sternotomy are volume-refractory shock, fluid in the pericardium (as detected by sonography), and a visible wound in the region of the heart.<sup>10,17,18,20,22-25</sup> If all of these conditions are present and severe hypotension sets in or cardiopulmonary resuscitation becomes necessary,<sup>11,19,21</sup> immediate sternotomy becomes obligatory.

If cardiovascular conditions are stable, computed tomography should be performed with the patient under continuous monitoring, in order to precisely capture the location of the foreign body and the extent of additional injury.<sup>2,6,21,24</sup> Prolonged transport to a specialized cardiac clinic<sup>11,16,17,21</sup> is forbidden if cardiovascular shock or clinical signs of pericardial tamponade are present.

During the primary-care period, relief of the tamponade and surgical closure of the penetration wounds should stay in the foreground. In rare cases, a heart-lung machine is needed<sup>2,9,15</sup> for secondary care,<sup>8,25</sup> such as the surgical correction of additional cardiac lesions (septal defects or heart-valve injuries). An intensive cardiologic evaluation must be carried out immediately after the primary operation, in order to detect intracardiac lesions. These would be treated secondarily in a cardiac surgery unit.<sup>3,4,11,21,23</sup>

Adenosine has several times shown its benefits in diagnostic and therapeutic procedures.<sup>21,26,27</sup> Under emergency conditions, the administration of this drug is the fastest way<sup>27,28</sup> to completely immobilize the myocardium and to enable (in contrast to electrical fibrillation

of the ventricle<sup>29</sup>) cardiac manipulation with very little potential for injury.<sup>30</sup> The beating, traumatized heart is highly vulnerable and can, under manipulation, quickly decompensate because of severe rhythm disturbances.<sup>21,25</sup> This is especially the case if the heart must be “lifted” for inspection of the posterior myocardium. Moreover, the wound can rupture further.<sup>21,25</sup> Uncoordinated contractions of the ventricles greatly complicate safe closure of the penetration.<sup>7</sup> These problems are all manageable by the quick central-venous injection of 12 mg of adenosine (0.15–0.3 mg/kg body weight), which leads to short-term asystole (10–15 s) by blocking the sinus and the atrioventricular node.<sup>21,25,28</sup>

Upon total relaxation of the cardiac muscle, sutures can be placed more safely, the posterior myocardium can be inspected (or even sutured) without provocation of rhythm disturbances, and the foreign body can be removed without risk.<sup>5,7,21,25,28</sup>

## Conclusion

In the event of penetrating heart injuries, especially with the foreign body retained in situ, the intravenous administration of adenosine is an elegant way to provoke rapid asystole. In contrast with other methods, this enables relatively safe myocardial manipulation, especially if no cardiac unit with a heart-lung machine is available. This case report describes the successful operative extraction of a barbed nail from a penetrating heart wound with the aid of adenosine-induced asystole, in the absence of a heart-lung machine.

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