Reply to the Editor:

The initial point of our study was to investigate functional protection after myocardial ischemia/reperfusion injury. We mostly focused on the hemodynamic study of the heart. In some aspects, the elevation of high-sensitivity C-reactive protein in serum after myocardial ischemia/reperfusion related to the injury in myocardium, except creatine kinase, myocardial band of creatine kinase, and troponin I. Thus, we mainly discussed inflammation and myocardial injury.

Furthermore, we did evaluate tumor necrosis factor- α and some other cytokines in our later experiment, and we further discussed the high-sensitivity C-reactive protein and acute-phase response in myocardial ischemia-reperfusion. We hope to publish the results soon.

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THE VICTIM OF THORACIC GUNSHOT: ASSESSMENT OF THE PATIENT AND MANAGEMENT OF PULMONARY ARTERY BULLET EMBOLISM

To the Editor:

We read with great interest the article titled "Gunshot Wound of the Main Pulmonary Artery: A Case Report" by Atalay and associates.¹ The authors report a skilled and beautiful operation performed in a young man with a lesion caused by a pistol bullet entering the main pulmonary artery. The patient arrived at the emergency department unconscious and with unstable vital signs, requiring, as stated the authors, urgent surgical intervention. After initial physical examination, a computed tomogram (CT) of the chest was performed, showing the projectile in the cardiac mass. Then the patient was taken to the operating

room and the incision chosen was a median sternotomy.

It is not our routine nor would we recommend performing chest CT in patients with unstable vital signs who have penetrating thoracic trauma. These patients could have an unpredictable course during this radiologic examination or during the mobilization needed for the CT, and their status could rapidly deteriorate. Johnson and colleagues,² in an article reporting 79 consecutive penetrating intrapericardial wounds, concluded that immediate transport to the operating room was an important contributing factor to success when facing these lesions.

Our institution is a university hospital with a level I trauma center, and we have some expertise in managing thoracic gunshot wounds owing to the high rate of civilian conflicts in Rio de Janeiro, Brazil. Although the authors performed a median sternotomy, which was guided by the information provided by chest CT, our approach would be to perform a left anterolateral thoracotomy, given that we would not have performed CT of the chest. The incision could be extended to the right side after we recognized the lesion in the mediastinal structure. This approach can be faster than median sternotomy and better done by a non-thoracic surgeon, which is the reality for most of trauma centers in the world. We have noticed a high rate of complications when sternotomy is performed by a nonthoracic surgeon in an emergency setting. Also, the clamshell incision provides a better operative field for both pleural cavities and the posterior mediastinum when compared with median sternotomy.

Although controversy exists regarding bullet extraction in cases of pulmonary arterial embolism,³ some authors suggest removing the projectile even in asymptomatic patients. Nevertheless, we agree with Atalay and associates that pulmonary bullet embolism must be managed on an individual basis and that initial operation should focus on maintaining the

patient alive. Therefore, no attempt should be made to extract the bullet during an emergency operation in a patient whose condition is unstable.⁴ If one decides to reoperate on the patient to extract the projectile, this second look operation must take into account the risks of the surgery when the patient is asymptomatic.

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Reply to the Editor:

We thank Drs de Andrade, Mourad, and Judice for their interest in our article "Gunshot Wound of the Main Pulmonary Artery."¹ Because no individual center apart from very specialized trauma centers has extensive enough experience with missile emboli, but all thoracic surgeons are one day likely to encounter this pathologic condition with a peculiar presentation, we were stimulated to answer their constructive criticisms in a review-like manner.

Although missile embolism is a rare entity, its manifestations are protean. Three types of missile embolism have been reported: arterial, venous, and paradoxical.² Embolism to the

pulmonary artery is a rare complication of penetrating trauma. The first report of a missile embolus is widely attributed to Thomas Davis, as reported by Agarwal and associates.³ He was probably the unwilling pioneer who had to operate on a 10-year-old boy who had been injured by a wooden missile that had migrated to the right ventricle.

Rareness of bullet emboli causes delays in diagnosis and inappropriate early handling of a potentially mortal surgical challenge. Rich and associates⁴ reported a 0.3% incidence of missile emboli in 7500 cases of vascular injury from the Vietnam war. Lack of success in correctly recognizing and treating these unusual lesions may result in loss of extremities or life. It is not only a diagnostic challenge but also a surgical one, as exemplified in the report by Stephenson and colleagues,⁵ when the missile dislodges during surgery or migrates to the down-side lung.

Degree of suspicion is of paramount importance in diagnosing missile emboli. The hallmark of diagnosis is simple: no exit wound! A missile embolus should be suspected when no exit wound can be found or the bullet is not found at the point of entry. When the position of a missile in the thorax does not conform to the suspected projectile path of the missile, intravascular migration must be suspected.²

Wandering bullets have been the subject of several articles in the past, with reports of excellent simple techniques to prevent migration.⁶

Missile emboli enter the cardiovascular system directly penetrating the heart or via the systemic vasculature.^{2,7} Small caliber bullets, pellets, or parts of shrapnel gain access to the heart or a vessel when they lose part of their kinetic energy during their passage through soft tissues and are able to traverse only one wall of a heart cavity or vessel.⁷

A missile in the heart may be free inside a cavity or partially or totally embedded in the myocardial wall.

Bullet emboli to the heart are frequently observed on the right side, and these usually originate from the head, femoral veins, iliac veins, or the inferior vena cava.⁷ Emboli in the left side may re-embolize into a systemic or coronary artery. Bullets in the right side may migrate into the pulmonary vasculature or may be entrapped permanently in tricuspid valve trabeculations.³ A missile that enters the right side of the heart may embolize against the blood flow and end up in the inferior vena cava or one of its tributaries. Paradoxical embolization through a patent foramen ovale or atrial septal defect may occur, causing peripheral arterial emboli.³ A foreign body in the venous system may move several times as the patient's position is being changed during examination or surgery⁵ or when the surgeon tries to control bleeding from the pulmonary artery manually during surgery.¹ When a bullet enters a blood vessel, bleeding, thrombosis, sepsis, erosion, or vascular occlusion may occur.² Missile emboli may be acute or delayed. In acute cases, if the patient is in unstable condition, emergency surgery done with no radiologic investigations may be lifesaving. We agree with de Andrade, Mourad, and Judice that a preoperative computed tomogram might complicate an unpredictable course in patients who are in unstable condition.

Most bullet emboli follow the direction of blood flow even though about 15% of bullets that enter through the venous route effect embolization in a retrograde manner such that 10% of arterial missiles follow after a right heart or venous injury.⁸ Although arterial missiles are symptomatic in 80% of cases, venous emboli are symptom-free in two-thirds of cases.⁸ Embolization depends on the patient's position, the shape and dimensions of the missile, and the presence of low flow or hypotension when the injury was sustained.⁹

Clinical manifestations of a retained intracardiac or intravascular missile depend on the dimensions, location, and

scale of contamination, especially of bowel contents if the trajectory passes through the abdomen before entering the thorax or vessel. Symptoms may be classified as early symptoms that appear at presentation or delayed symptoms. Late symptoms are usually due to complications, including re-embolization of the missile or missile fragments or its adherent thrombus causing pain, paresthesia, claudications, pericarditis, endocarditis, cerebral infarctions, repeat pleural effusions, pulmonary abscesses or infarctions, gangrene, extremity thrombophlebitis, dilatations, and aneurysms, plus ensuing neurotic states of patients on learning of the presence of a foreign body in their viscera.

Symptomatology determines the indication of surgical intervention. In symptomatic patients, the main indication for surgical intervention is the presence of symptoms such as fever, pericardial effusion or tamponade, pericarditis, endocarditis, arrhythmias, and presence of thrombi. In an asymptomatic patient, knowledge of a retained intravascular or intracardiac foreign body may cause neurosis. Even the presence of anxiety will constitute an indication for surgery in such patients if the risk of mortality or morbidity owing to surgery is not significant.

As has been reported before, asymptomatic emboli in distal pulmonary arteries may be left undisturbed.⁹ Dato and coworkers⁹ have reported on 4 asymptomatic patients with foreign bodies in the heart who were conservatively treated without any complications for a median follow-up of 20 years.

Specifics of penetration including correct location of foreign material is necessary to forfend needless and inappropriate incisions. Rationale for extraction, especially in asymptomatic patients, remains controversial. Weird presentations prevent us from categorizing our management strategies to treatment algorithms. Therefore, management of embolized intracardiac missiles has to be on an individual basis.

Then comes the difficult question: which retained missiles should be extracted and which should be left in place? First, symptomatic retained foreign bodies should be removed regardless of localization. Second, asymptomatic foreign bodies diagnosed at the time of injury with associated risk factors such as risk of infection, presence of incompletely embedded missile in the myocardium, especially on the left side of the heart, risk of re-embolization or erosion, nearness to an artery, sharpness, and irregular contours threatening erosion should be removed. Third, asymptomatic foreign bodies without associated risk factors, especially with late diagnoses, should be conservatively treated, especially if they are completely embedded.

Surgical approaches depend on localization of the missile. If pericardiotomy will be necessary, median sternotomy is the preferred approach.⁹ This is reported by several authors to decrease morbidity and hospital stay

in comparison with thoracotomy.⁹ We agree with de Andrade, Mourad, and Judice about who should perform the sternotomy to decrease possible complications: a thoracic surgeon.

If a second look operation is planned because of a possibility of displacement such as re-embolization, selective angiograms and phlebograms, intraoperatively if possible, should be performed to exactly localize the embolizing missile and provide appropriate guidelines for a suitable incision.⁸

Patients who are managed conservatively should be followed up regularly, and antibiotic prophylaxis or anticoagulation should be administered if needed.

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