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Multiple Shotgun Pellet Embolization to the Pulmonary Artery

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Abstract

Pellet embolization to the pulmonary artery from a shotgun injury is a rare event. Our current experience with this entity is described. We reviewed the literature of Bullet Embolization with emphasis on management. We believe that shotgun pellet **pulmonary artery embolism should be regarded as a separate entity from** bullet **embolism. The mechanism of injury and its sequelae, leading to complication is very much subtle compared to bullet embolism per se. After entry into the venous system, smaller sized pellets can easily lodge into the distal segments of pulmonary artery but tend to have less deleterious effect as compared to bigger sized bullet. We therefore recommend non-surgical management of pellet pulmonary embolism with clinical follow up to determine emergence of complications.**

Keywords: Pulmonary artery, embolism, pellet/bullet, shotgun.

Introduction

Embolization to the pulmonary artery from shotgun wounds is a rare event. Gunshot wounds without an exit should incite a high index of suspicion for this process. The kinetic energy of shotgun pellets is highly variable, depending on the barrel length, choke, gauge, cartridge type, size and number of pellets. The small size and the large number of pellets make shotgun injuries more likely to result in intravascular pellet location.

There are three types of bullet embolization described in the literature: arterial, venous, and paradoxical. Incidence of arterial embolization is higher than venous embolization [1]. When embolization is suspected, work-up should include plain x- rays, CT scans and the addition of echocardiography (transthoracic and transesophageal) if indicated. Management is variable and should be individualized depending on the presenting signs and symptoms, pellet location and its complications. Open surgical, percutaneous or endovascular techniques for removal are valid options versus non-operative management. We describe a case of a shotgun injury with pellet embolization to the pulmonary artery.

Case report

A 24-year-old female was evaluated in the Emergency Department after a shotgun injury. She was a victim of assault and was shot with a shotgun at close range. The patient was clinically stable on arrival to the Emergency Department. On initial evaluation, there was bleeding from a single 5-centimeter irregular wound in the left lower quadrant over the iliac crest. She had associated cutaneous powder burns. Vital signs upon admission to Emergency Department showed a blood pressure of 110/60 mmHg, heart rate of 99 beats/min in sinus rhythm, respiratory rate of 20 breaths/min and a temperature of 36.9 °C. Pulse oximetry on room air showed an oxygen saturation of 99%.

Initial assessment and management were performed based on standard ATLS protocol. Neurologic examination was normal with a Glasgow coma scale of 15. Head and neck showed no signs of injury. Chest examination revealed no signs of any contusion or laceration. There was no tenderness or crepitation on palpation. Chest auscultation showed symmetric and equal vesicular breath sounds and normal heart sounds. Abdomen was flat with a 5 cm irregular wound in the left lower quadrant close to

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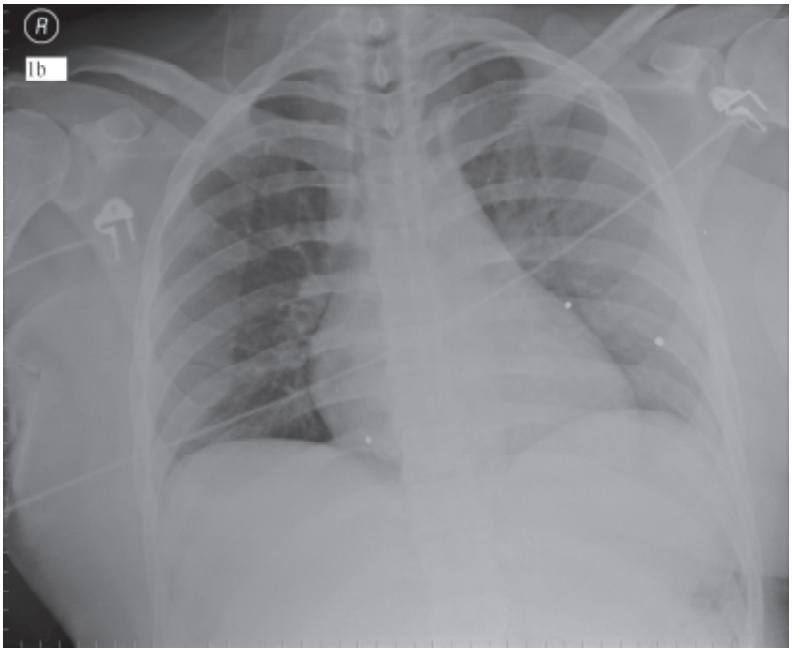
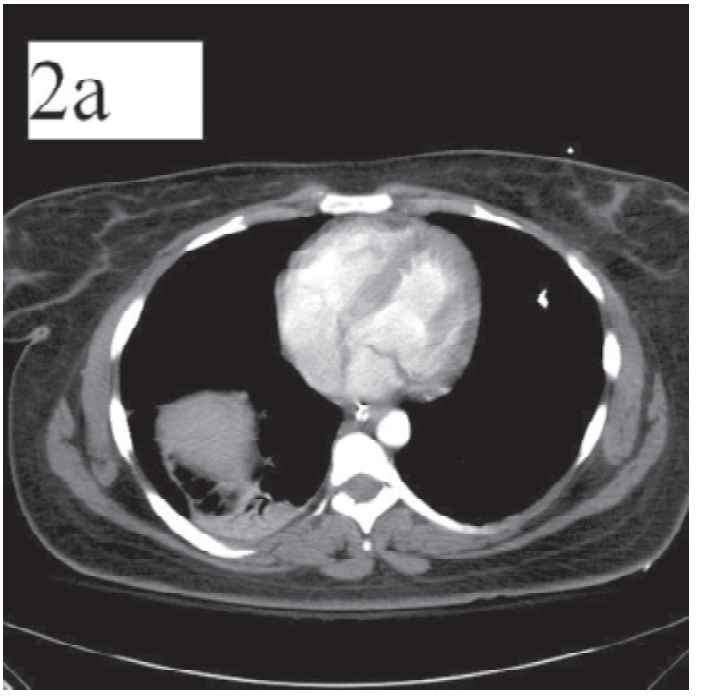
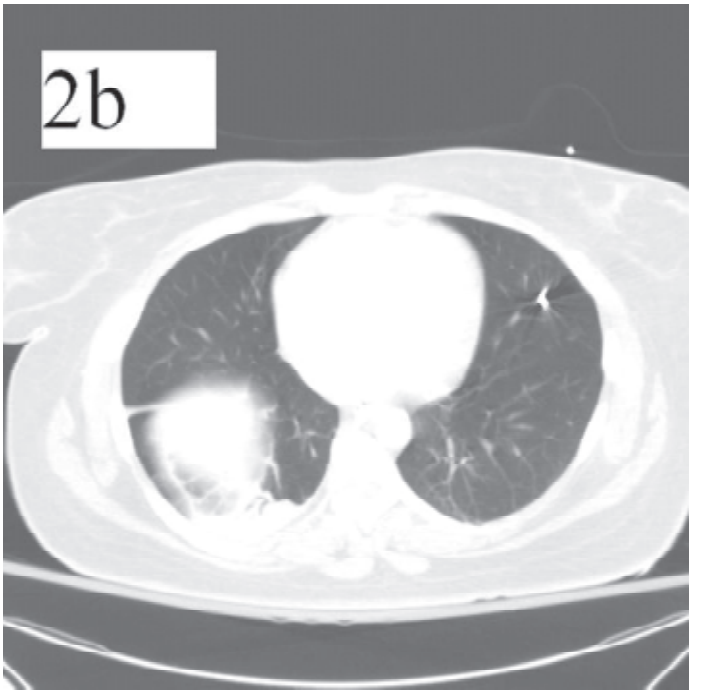
the iliac crest. There were hypoactive bowel sounds; the abdomen was soft to palpation with left lower quadrant tenderness. Back, flanks and axillae showed no injuries. Rectal examination was normal with no gross or occult blood. A foley was placed draining clear and yellow urine. Pulses on both lower extremities were bounding and equal. All four extremities showed no neurologic deficit. Radiologic evaluation followed. The chest x-ray showed no pneumohemothorax, no cardiac enlargement and multiple radiopaque densities (pellets) within the lung fields. There were multiple shotgun pellets projecting over the left hemipelvis with a multi-fragmentary fracture of the left ilium extending to the acetabulum (**Figure 1a** and **Figure 1b**). FAST examination did not demonstrate pericardial or peritoneal fluid collection.

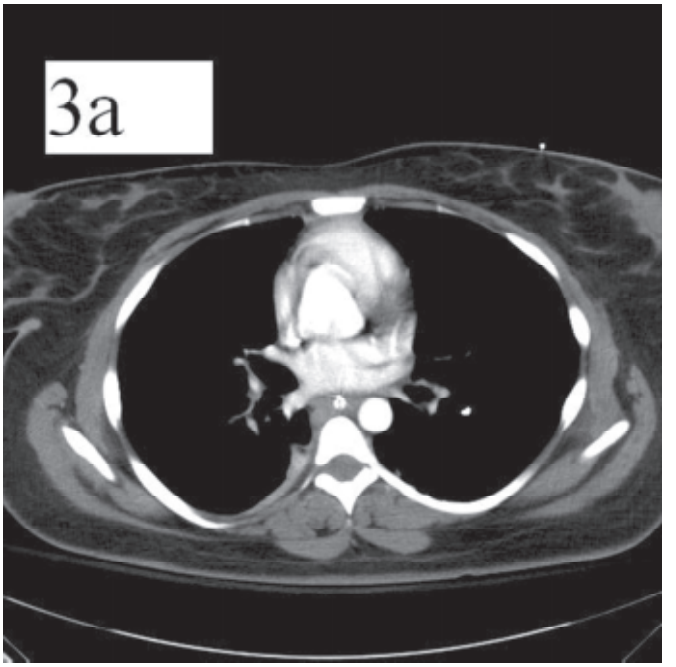
Given the patient's examination findings, the patient was brought to the operating room for emergency exploration. Exploratory laparotomy revealed no intra-peritoneal injury. A left pelvic hematoma was found directly under the wound site. Exploration of the hematoma with proximal and distal vascular control showed a small left external iliac vein injury approximately 5 mm, which was

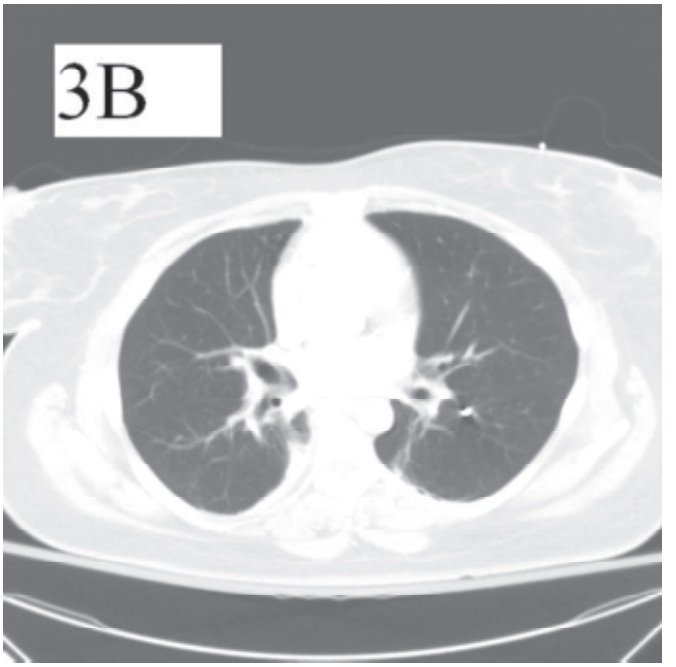


repaired with a single figure of eight technique using 4-0 prolene suture. The iliac arterial vessels were grossly intact. Subsequent exploration did not demonstrate any additional injuries. The patient underwent primary abdominal closure and packing of groin wound with saline gauze. She remained hemodynamically stable and was transferred to Trauma Intensive Care Unit, intubated and supported by mechanical ventilation. A postoperative CT scan of the chest was performed to evaluate the three thoracic radiopaque particles (assumed to be pellet embolization at that time). It revealed that the three pellets were lodged in the pulmonary artery (**Figure 2a**, **Figure 2b** and **Figure 3a**, **Figure 3b**). A transesophageal echocardiogram was done to exclude the possibility of intracardiac localization. It showed that the pellets were located outside the heart.









The finding of multiple pellets in the pulmonary vasculature raised several concerns: 1. lung infarction 2. thrombosis proximal to the pellet and 3. thrombus formation at or around the repaired iliac vein injury. To address these concerns, we followed up the patient with repeat chest spiral CT scan with intravenous contrast and showed no radiographic signs of infarction or thrombosis. Deep vein thrombosis (DVT) prophylaxis was started on admission and was given once daily thereafter. We held giving therapeutic heparinization because there was no evidence of thrombosis on CT scan combined with the recent surgery. The patient did well with no clinical evidence of pelvic or lower extremity venous thrombosis and a negative lower extremity doppler study.

CT scan of the pelvis revealed an anterior column acetabulum fracture with no displacement of the articu-

lar surface, but with multiple displaced fragments of the ilium. Additionally, multiple lead particles were located posterior to the ilium. On hospital day 2, the orthopedic team performed a second debridement of the wound through an iliac incision. Multiple loose fragments of bone, shotgun wadding and lead pellets were removed from the deep confines of the wound. Copious irrigation and debridement of devitalized muscle was then performed. A vacuum assisted closure (VAC®) dressing was applied.

The patient was subsequently extubated on hospital day 3 without respiratory compromise. She was transferred to the floor on hospital day 5 and remained stable from a cardiopulmonary standpoint, so a decision was made to leave the intra-thoracic fragments in place. She was then transferred from the hospital to a rehabilitation center seven days after injury.

Discussion

Thomas Davis reported in 1834 the first case of bullet embolization in a 10 y/o boy. A wooden missile fragment had moved to his right ventricle [2]. Sir Arthur Keith in 1917 stressed the rarity in the pathology literature of bullet embolization to the pulmonary artery [2]. Modern era reports of bullet embolization to the pulmonary artery started in 1975 with Stephenson's report of two patients and a review of the literature [3]. When a bullet enters a vessel, it may cause: 1. hemorrhage, 2. thrombosis, 3. sepsis, 4. erosion or vascular occlusion, 5. ischemia, infarction leading to gangrene and 6. severe sometimes incapacitating cardiac necrosis [3]. He also suggested that operative removal of a bullet in the pulmonary artery is necessary. However, this was a report of large caliber bullets and there was no mention of shotgun pellets.

Michelassi in 1988 reviewed 153 cases of bullet embolism. Fifty-three out of 153 were venous and 8 out of 53 venous cases lodged into the pulmonary circulation [4]. Rich, *et al*, reported 22 cases of bullet emboli out of 7500 (0.3%) vascular trauma cases during the Vietnam War [5]. Mattox reported 28 cases of civilian bullet emboli at the Ben Taub General Hospital, Houston, Texas (12 yr review of cases from 1965 to 1977). Seven of the 28 cases were lodged to the pulmonary artery. Five out of seven were left in place [6]. The article did not mention the bullet caliber. There was no mention of shotgun injury.

Several case reports of bullet that entered the venous circulation embolized and stayed within the right ventricle but never went to the pulmonary artery [7-11].

Bullet embolism should be suspected in any victim who has sustained a penetrating gunshot injury without an exit wound [12,13], when the signs and symptoms do not correlate with those expected from the suspected course of the missile, and when radiologic investigation shows that the missile location deviates from the supposed path of penetration [4].

The laws of ballistics play an important role in this process. Bullet emboli are usually associated with small caliber, low velocity missiles [13]. The factors affecting tissue penetration and eventual missile destination are as follows: 1. kinetic energy, 2. bullet or pellet diameter, 3. vascular anatomy, 4. gravity, 5. position of patient, and 6. flow dynamics [1]. Shotgun pellet injury can be predisposing to the process of embolization due to the small size and large number of pellets [14], and due to the relatively low kinetic energy upon entry to the blood vessel.

Multiple approaches to treating missile embolization have been reported. One of the most controversial is the removal of the missile from the pulmonary artery [6,15,16]. Management should be individualized based on the degree of symptoms, size and location of the pellet embolism and its presenting or anticipated complications. Symbas and Harlaftis [16] noted that patients not undergoing bullet embolectomy had a higher mortality, and they recommended that all missile emboli to the lung be removed. Other authors have concluded that small emboli can be left in place in the pulmonary artery without untoward sequelae. There is general consensus that management should be individualized based on the degree of symptoms, size and location of the pellet embolism and presenting or anticipated complications. Conservative management in these patients necessitates continued surveillance for anticipated complications especially wedge infarction, which may lead to gangrene, infection and sepsis or thrombosis of the pulmonary artery proximal to the pellet leading to pulmonary artery hypertension.

We believe that shotgun **pellet** pulmonary artery embolism should be regarded as a separate entity from **bullet** embolism. The mechanism of injury and its sequelae, leading to complication is very much subtle compared to bullet embolism per se.

Conservative management with surveillance monitoring is highly recommended due to the small size of the pellets. We also recommend clinical and radiological evaluation for pellet embolization in extremities at risk during the secondary survey. Pulmonary embolism may lead to respiratory failure and ventilator management [17]. Rarely, depending on the severity of the presenting signs and symptoms and the degree of infarction and pulmonary hypertension, acute operation may be required. Patients with a main or secondary pulmonary artery bullet

should have localization determined using intra-operative fluoroscopy [18,19] because bullet may re-embolized to the opposite pulmonary artery during operation [2,19,20]. Segmentectomy or lobectomy was recommended in patients with delayed discovery of bullet embolus to the lung [21].

Close range (< 14 ft) shotgun wounds should be treated as high-velocity gunshot wounds due to the tissue damage caused by the multiple fragments, and the potential for foreign body (wadding and cloth) in the wound. Thus, tetanus prophylaxis, broad-spectrum antibiotics, operative exploration, aggressive debridement of devitalized tissue, and open wound management are the standard.

In general, the potential for plumbism with retained lead fragments is small [22], but is most likely to occur with lead fragments which remain in a bone, a bursa, or a joint [13,23,24]. In this case, there was no lead inside the hip joint. The few lead fragments in the ilium that could not be removed at the time of surgery were left in place, as it was decided that the risks of removal outweighed the benefit.

This case illustrates several important principles in the treatment of shotgun injuries: embolization of bullet or pellet fragments can occur and can be life threatening. Thorough and ongoing clinical and radiographic analysis is necessary to recognize and treat the potential complications of embolization. Clinical judgment should guide the team in deciding when surgery is indicated. Close-range shotgun wounds cause extensive injuries, necessitating thorough debridement. CT scans will help to localize the region of tissue destruction and foreign body location. Close-range shotgun wounds must be inspected for shotgun wadding. Multiple specialists working in close coordination will provide optimal treatment to patients with these potentially devastating injuries.

References

1. Demirkilic U, Yilmaz AT, Tatar H, Ozturk OY (2004) Bullet Embolism to the Pulmonary Artery. Interactive Cardiovascular and Thoracic Surgery 3:356-358
2. Barrett NR (1950) Foreign bodies in the cardiovascular system. Br J Surg 37:416-445
3. Stephenson LW, Workman RB, Aldrete JS, Karp RB (1976) Bullet emboli to the pulmonary artery: a report of 2 patients and review of the literature. Ann Thorac Surg 21:333-336
4. Michelassi F, Pietrabissa A, Ferrari M, Mosca F, Vargish T, Moosa HH (1990) Bullet emboli to the systemic and venous circulation. Surgery 107:239-245
5. Rich NM, Collins GJ Jr, Andersen CA, McDonald PT, Kozloff L, Ricotta JJ (1978) Missile emboli. J Trauma 18:236-239
6. Mattox KL, Beall AC Jr, Ennix CL, DeBakey ME (1979) Intravascular migratory bullets. Am J Surg 137:192-195
7. Gandhi SK, Marts BC, Mistry BM, Brown JW, Durham RM, Mazuski JE (1996) Selective management of embolized intracardiac missiles. Ann Thorac Surg 62:290-292
8. Marti V, Auge JM, Carreras F, Camara ML, Caralps JM (1992) [Bullet embolism of the right ventricle following gunshot wound]. Rev Esp Cardiol 45:489-491
9. Morton JR, Reul GJ, Arbegast NR, Okies JE, Beall AC Jr. (1971) Bullet embolus to the right ventricle. Report of three cases. Am J Surg 122:584-590
10. Nagy KK, Massad M, Fildes J, Reyes H (1994) Missile embolization revisited: a rationale for selective management. Am Surg 60:975-979
11. Nazir Z, Esufali ST, Rao NS, Rizvi I (1992) Venous bullet embolism: a case report and review of the literature. Injury 23:561-563
12. Chapman AJ, McClain J (1984) Wandering missiles: autopsy study. J Trauma 24:634-637
13. DiMaio VJ, DiMaio DJ (1972) Bullet embolism: six cases and a review of the literature. J Forensic Sci 17:394-398
14. Patel KR, Cortes LE, Semel L, Sharma PV, Clauss RH (1989) Bullet embolism. J Cardiovasc Surg (Torino) 30:584-590
15. Ledgerwood AM (1977) The wandering bullet. Surg Clin North Am 57:97-109
16. Symbas PN, Harlaftis N (1977) Bullet emboli in the pulmonary and systemic arteries. Ann Surg 185:318-320
17. Papadakos PJ, Lachmann B (2002) The open lung concept of alveolar recruitment can improve outcome in respiratory failure and ARDS. Mt Sinai J Med 69:73-77
18. Padula RT, Sandler SC, Camishion RC (1969) Delayed bullet embolization to the heart following abdominal gunshot wound. Ann Surg 169:599-602
19. Petsas AA, Ghahramani AR, Green R (1975) A wandering bullet. Successful removal and a simple technique to prevent its migration. J Thorac Cardiovasc Surg 69:954-956
20. Bland EF, Beebe GW (1966) Missiles in the heart. A twenty-year follow-up report of World War II cases. N Engl J Med 274:1039-1046
21. Saylam A, Bozer AY, Kadioglu Y (1972) Migration of a bullet from the inferior vena cava to the right pulmonary artery: case report. Jpn Heart J 13:572-577
22. Pollak S, Ropohl D, Bohnert M (1999) Pellet embolization to the right atrium following double shotgun injury. Forensic Sci Int 99:61-69
23. Bolanos AA, Demizio JP, Jr., Vigorita VJ, Bryk E (1996) Lead poisoning from an intra-articular shotgun pellet in the knee treated with arthroscopic extraction and chelation therapy. A case report. J Bone Joint Surg Am 78:422-426
24. Meggs WJ, Gerr F, Aly MH, Kierena T, Roberts DL, Shih R, Kim HC, Hoffman R (1994) The treatment of lead poisoning from gunshot wounds with succimer (DMSA). J Toxicol Clin Toxicol 32:377-385