CASE REPORT

Pulmonary Artery Bullet Emboli: To Retrieve or Not? A Contemporary Reassessment

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ABSTRACT

Aim: We present two patients with bullet emboli to the pulmonary artery and discuss their management based on a review of the literature.

Background: Bullet emboli to the pulmonary arteries from abdominal gunshot wounds are rare. It is unclear whether these bullets should be removed in stable, asymptomatic patients.

Case description: We discuss the management of two cases of bullet emboli to the pulmonary arteries and the associated morbidity and mortality, based on a thorough review of the relevant literature.

Conclusion: We recommend elective removal of the asymptomatic bullet to the pulmonary artery once patients have been appropriately resuscitated or on a close follow-up of the compliant patient.

Clinical significance: The complex management of these patients necessitates an individualized management with a collaborative approach between cardiothoracic and trauma surgeons.

Keywords: Bullet, Chest, Embolus, Penetrating trauma, Pulmonary artery.

RESUMO

Objetivo: Apresentamos dois pacientes com êmbolo de projétil de arma de fogo (bala) na artéria pulmonar e discutimos seu manejo com base em uma revisão da literatura.

Antecedentes: Os êmbolos de bala nas artérias pulmonares decorrentes de ferimentos por arma de fogo abdominais são raros. Não está claro se essas balas devem ser removidas em pacientes estáveis e assintomáticos.

Descrição do caso: Discutimos o tratamento de dois casos de êmbolos de projétil de arma de fogo (bala) nas artérias pulmonares e a morbimortalidade associada, com base em uma revisão minuciosa da literatura relevante.

Conclusão: Recomendamos a remoção eletiva do projétil de arma de fogo assintomático na artéria pulmonar, uma vez que os pacientes tenham sido adequadamente ressuscitados ou após acompanhamento de perto destes pacientes.

Significado clínico: O manejo complexo desses pacientes requer planejamento e condução individualizados, com uma abordagem colaborativa entre os cirurgiões de trauma e os cardiótorácicos.

Palavras clave: Artéria Pulmonar, Bala, Embolia, Projétil de Arma de Fogo, Tórax, Trauma penetrante.

BACKGROUND

Bullet emboli to the pulmonary arteries resulting from distant gunshot wounds are exceedingly rare. It remains unclear if asymptomatic patients should preemptively undergo bullet removal. We present two patients with bullet emboli to the pulmonary artery and review the reported cases in the literature to optimize their management.

CASE 1

A 40-year-old male was shot from close range to his extremities and abdomen. He was alert and oriented with a blood pressure of 80/40 mm Hg with a heart rate of 130’s in the field. At the trauma center, he had a blood pressure of 140/80 mm Hg and a pulse rate of 123 beats per minute. He was noted to have a gunshot wound to the epigastrium and a through-and-through injury to both the left forearm and the thigh. Lateral and upright chest X-rays demonstrated a foreign body, consistent with a bullet, posterior to the heart. At laparotomy, he was noted to have >2 L hemoperitoneum with injuries to the transverse colon, jejunum, third portion of the duodenum, and a non-expanding zone-I retroperitoneal hematoma. Intraoperatively, he was hypothermic to 34° and acidic to a pH of 7.22. Upon medial visceral rotation, a through-and-through injury to the inferior vena cava below the level of the renal veins was identified and repaired primarily. A damage control laparotomy was performed with the rapid repair of the colon, resection of the jejuna m, and repair of the third portion of the duodenum. The abdomen was packed, leaving the bowel in discontinuity. The abdomen was left open. He was returned to the
operating room after resuscitation. The segments of the jejunum were anastomosed and the colon was re-anastomosed as a colocolostomy. The patient did well postoperatively until day 22, when he became febrile with an elevated white blood cell count of 22 K. He had scattered rales and rhonchi at the left base. Computerized tomography (CT) scan of the chest and the abdomen were obtained and showed evidence of a left lower lobe pneumonitis, a foreign body (bullet) in the left lower lobe and an insignificant abdominal CT. Even though a bronchoscopy and brochoalveolar lavage were negative for organisms, he was started on antibiotics. He became increasingly septic, however, and subsequently developed septic shock. A thoracotomy and lower lobectomy were emergently scheduled, but he expired from sepsis before he could be taken to the operating room. An autopsy confirmed a necrotizing pneumonia of the left lower lobe adjacent to the retained bullet.

**Case 2**

A 21-year-old male sustained a gunshot wound to the right upper quadrant. Prior to abdominal exploration, anterior–posterior and lateral chest X-rays demonstrated a single bullet posterior to the heart with no evidence of pneumothorax or hemothorax (Fig. 1). A focused assessment with sonography in trauma (FAST) exam was negative for pericardial fluid. Abdomen/pelvis CT showed a complex liver injury with fluid surrounding the duodenum (Fig. 2). Chest CT scan demonstrated a single bullet lodged in the left pulmonary artery (Fig. 3). At the time of laparotomy, he was noted to have a complex liver laceration, duodenal injury, and laceration of the anterior wall of the inferior vena cava at the level of the right renal vein. These injuries were managed with primary repair. Subxiphoid pericardial window performed was negative for blood. A missile embolus was diagnosed but was left in situ. He improved postoperatively and was discharged home without bullet removal. An echocardiogram (ECHO) was planned for 6 months later to evaluate his right heart function. Seven weeks later, the patient presented with chest pain and shortness of breath with oxygen saturations of 97% on 100% oxygen non-rebreather. A chest CT scan showed evidence of a large left pneumothorax with concern for broncho-pleural fistula and empyema. Following chest tube placement, he was taken emergently to the operating room for exploration. There was 300 cc of purulent material in the chest and over 50% of the left lower lung was necrotic. A left lobectomy was performed through a thoracotomy incision. Pathology was consistent with subpleural hematoma and infarction with adjacent acute pneumonia and acute fibrinous pleuritis. Microbiology was positive for **Streptococcus milleri** and mixed anaerobic bacteria. He completed a 4-week course of Zosyn which was converted to Augmentin for an additional 2 weeks of coverage. He did well on follow-up.

**Discussion**

The optimal management in arterial missile emboli is agreed upon uniformly. It is, however, not as clear on the venous side, because of the need for a major procedure of thoracotomy and the “presumed” absence of clear-cut threat for complications. “Presumed” because a careful review of the reported experience raises some questions whether non-interventional observation is always a good option in pulmonary missile emboli. Further, recent innovations in minimally invasive surgical techniques and interventional radiological and hybrid procedures provide a less severe alternative option to thoracotomy.

To reevaluate the management in this era of technologic advances, we have rereviewed the existing literature, adding two cases of pulmonary artery bullet emboli. Literature search revealed three significant reports of the phenomenon: Shannon et al. (126 cases, 1929–1987) and Miller et al. (45 cases, 1987–2011). We found an additional 17 cases to date including the two reported here. These are summarized in Tables 1 and 2.
Table 1: Venous missile embolism—literature summary 1900–1929; 1930–1987, Reproduced with permission, Shannon et al.1

| Origin                | Dale of report |
|-----------------------|----------------|
| Below diaphragm        | 1900–1929      |
| Above diaphragm        | 1930–1987      |
| Final destination      | 1900–1929      |
|                       | 1930–1987      |
| Right heart            | 13             | 48             |
| Missile removed        | 1 (8%)         | 32 (67%)       |
| Embolus morbidity      | 0              | 3 (6%)         |
| Embolus mortality      | 5 (62%)        | 1 (4%)         |
| Pulmonary artery       | 7              | 38             |
| Missile removed        | 7 (66%)        | 7 (58%)        |
| Embolus morbidity      | 0              | 2 (17%)        |
| Embolus mortality      | 0              | 0              |
| Peripheral/central vein| 3              | 12             |
| Missile removed        | 2 (66%)        | 7 (58%)        |
| Embolus morbidity      | 0              | 4 (50%)        |
| Embolus mortality      | 0              | 0              |
| Paradoxic systemic artery| 1              | 4              |
| Missile removed        | 0              | 4 (100%)       |
| Embolus morbidity      | 0              | 4 (50%)        |
| Embolus mortality      | 1 (100%)       | 0              |
| Total                  | 51             | 25             |
| Missile removed        | 4 (17%)        | 64 (64%)       |
| Embolus morbidity      | 0              | 14 (14%)       |
| Embolus mortality      | 11 (46%)       | 4 (4%)         |

Table 2: Reported cases of venous embolism (1987–2016)

| S. no. | Author (year)        | Site of primary injury | Visceral injuries                  | Treatment                                |
|--------|----------------------|------------------------|-----------------------------------|------------------------------------------|
| 1      | Rehm et al. (1988)   | Chest                  | Rt hepatic vein                   | Endovascular                            |
| 2      | Patel et al. (1989)  | Abdomen                | PA 1                              | Observation                              |
| 3      | Patel et al. (1989)  | Abdomen                | PA 2                              | Observation                              |
| 4      | Patel et al. (1989)  | Abdomen                | Right atrium                      | Open removal                             |
| 5      | Schmelzer et al. (1989) | Chest             | L SC vein popliteal vein               | Observed                               |
| 6      | Vázquez-Valdés et al. (1989) | Chest        | PA PL                             | Thoracotomy                             |
| 7      | Michelassi et al. (1990) | Abdomen          | Right atrium                      | Sternotomy/cardio pulmonary (CP) bypass |
| 8      | John and Edmondson (1991) | Abdomen          | Pulmonary artery (PA)             | Unknown                                 |
| 9      | Van Arsdell et al. (1991) | Head              | Right ventricle                   | Open                                    |
| 10     | Colquhoun et al. (1991) | Neck              | Right ventricle                   | Sternotomy/CP bypass                    |
| 11     | Colquhoun et al. (1991) | Inguinal            | Rt atrium                         | Sternotomy/CP bypass                    |
| 12     | Kortbeek et al. (1992) | Abdomen             | PA                                | Observation                              |
| 13     | Martí et al. (1991)   | Chest                | Superior vena cava (SVC) right ventricle | Unknown                                |
| 14     | Nazir et al. (1992)   | Chest                | Right ventricle                   | Open/failed endovascular                |
| 15     | Nagy et al. (1994)    | Lower extremity      | Iliac right ventricle             | Observation                              |
| 16     | O’Neill et al. (1996) | Abdomen             | RV inferior vena cava (IVC) RA     | Transjugalial                            |
| 17     | Panichabhongse et al. (1996) | Abdomen            | Right (Rt) PA                     | Observation                              |
| 18     | Schurr et al. (1996)  | L external iliac vein | Ex Lap, open removal w/ arteriotomy |                                         |
| 19     | Headrick et al. (1997) | Abdomen             | IVC right ventricle               | Sternotomy/CP bypass                    |
| 20     | Lodder (1997)         | Lower extremity      | PA                                | Observation                              |
| 21     | Schöpf et al. (1998)  | Head                 | PA                                | Unknown                                 |
| 22     | Kaushik and Mandal (1999) | Lower extremity    | Iliac vein RA                    | Endovascular                            |
| 23     | Pollak et al. (1999)  | Inguinal             | Right atrium                      | Observation                              |
| 24     | Obermeyer et al. (2000) | Buttock             | Right ventricle                   | Observation                              |

Contd...
Bullet embolism is a rare, potentially life-threatening complication of penetrating missile trauma. It occurs when a small-caliber bullet enters the bloodstream with enough velocity to penetrate one wall of a vessel. It loses momentum once inside the lumen, as might happen with BBs, 0.22 caliber bullets, airgun pellets, or shotguns ammunition. The free-floating foreign body may then be carried by the bloodstream or if free within a body cavity, by gravity or a change in body position. Migrating venous bullets lodge in the right ventricle more often than the pulmonary arterial tree since they tend to be trapped beneath the tricuspid valve or the chordae tendineae. Arterial missile emboli are carried downstream in the arterial tree after the bullet is lodged in the left side of the heart or the major arterial branches. Paradoxical emboli cross over from the venous system to the arterial system, either through a large...
A–V fistula, or, as is more usual, through a patent foramen ovale.1,2,17 Rarely, a double play is to blame: Corbett18 described a case where a bullet to the flank and groin embolized to the common femoral artery, via retrohepatic cava, right heart, patent foramen ovale, and then the arterial circulation.

The first reported venous embolus was by Davis in 1834 as a case of a wooden fragment embolizing from the venous circulation to the right ventricle in a 10-year-old boy.19,20 Bullet embolism should be suspected by an odd number of missile wounds or a bullet lies outside the established trajectory, or suggested by changing position of a missile on radiographs. In the majority of cases, the initial wounding site is the chest or the abdomen. Rarely the head and the neck or extremity embolization was the primary site of entry. The emboli may be discovered both at the time of presentation and as late as 59 years after the initial injury.20

There is no consensus on whether aggressive retrieval is necessary for asymptomatic patients.1,2,7,11,14,18,45–51 Reasons for removal of bullet emboli to the pulmonary artery include complications of bullet erosion, local hemorrhage, and pulmonary infarction with the risk of infection.1–5 Studies supporting the removal of venous bullet emboli stem from data showing a 13% complication rate from retained right heart missiles often month to years following the initial injury.1,2 Similarly, in a review of 102 cases reported since 1930, Shannon et al.1 demonstrated a retrieval rate of 64% and an embolus-related mortality of 4%, Table 1. These authors advocated bullet extraction given the high morbidity and considerable mortality rate. In the reported cases since 1987, more than 50% of emboli underwent intervention.2 The majority of them were extracted through open operation (24/61), endovascular (11/45), or hybrid open/endovascular (2/61) approaches. Four cases were at autopsy. In three cases, the management was unclear. Five open procedures were performed following failed endovascular retrieval (Table 2).

Eighteen of the 61 cases were managed by careful observation, with most of these restings within the pulmonary artery in asymptomatic patients. In a couple of patients, initial attempts at endovascular attempts failed and the patients were observed without further treatment. Conservative management was advocated by Kortbeek et al.,11 who in 1992 reviewed 32 cases of pulmonary artery bullet emboli that were observed without complication. Observation is apparently appropriate when bullets lodged in the pulmonary tree do not cause a pulmonary infarction, pulmonary abscess, or erosion in the bronchus or when the emboli were detected late after the primary event.1

More than 50% (10/16) of the interventions for bullet emboli reported since 2007 underwent either an endovascular or a hybrid retrieval. The series of Miller et al.2 reported in 2011 documented a 100% endovascular retrieval in the reported four cases. A recent report emphasized the use of endovascular retrieval of bullet embolism.43 These techniques have reduced the morbidity and the mortality of intracardiac bullet retrieval, and have favored prophylactic retrieval of bullet emboli to prevent complications. Endovascular bullet retrieval still requires surgical bullet extraction through arteriotomy and venotomy.1,2 Whether the advent of newer techniques or the decreased morbidity from avoiding a thoracotomy should influence the decision to proceed with bullet retrieval in the hemodynamically stable patient remains unknown. The question becomes even more pertinent for embolized bullets that became contaminated by trans-enteric migration.

Traditional surgical dogma would suggest that bullet penetration of the gastrointestinal tract and subsequent embolization would present the chance for infection around the embolization site, perhaps augmented by adjacent tissue necrosis. This may explain the not-too-infrequent finding of associated pulmonary infarction. It is conceivable that bullets undergoing trans-colonic penetration with higher bacterial counts may lead to higher associated infection rates around these embolized bullets than those without associated enteric penetration. Shannon et al.1 strongly support this concept as a reason to extract such embolized bullets. Similarly, whether the source of infection arose from a bullet contaminated with enteric contents bathed in the blood or from the infarcted lung tissue remains unknown. Both patients presented in this series, however, developed bullet-associated lung infection and sepsis after their migration through the duodenum and the colon. It is also sobering to realize that this resulted in a septic death of one of our two cases.

The cases reported in the literature also provide fascinating operative facts. In four of nine patients who underwent thoracotomy for retrieval, the missile was dislodged during manipulation and a second thoracotomy was required in three of them.50 In one recent report of a bullet embolus to the inferior branch of the pulmonary artery,51 interventional radiology was unsuccessful in attempts at endovascular bullet retrieval necessitating operative retrieval through a left posterolateral thoracotomy. During dissection and mobilization of the left pulmonary artery, the bullet became dislodged and was no longer palpable. Intraoperative chest radiograph revealed that the bullet had traveled into the right PA! The left thoracotomy incision was closed with a towel clip closure and the patient placed the right side up in the decubitus position. Vigorous percussion of the right chest relocated the missile to the left side as confirmed by a chest X-ray. The bullet was extracted through a pulmonary arteriotomy. The authors commented on the intraoperative use of an inflated Swan-Ganz catheter to prevent bullet migration during patient positioning and operative manipulation.52

CONCLUSION

Based on a review of the reported experience on pulmonary missile emboli, we recommend elective removal even in the asymptomatic patient when the bullets are potentially contaminated by trans-colonic migration.

CLINICAL SIGNIFICANCE

The complex management of these patients necessitates a collaborative approach between cardiothoracic and trauma surgeons to decrease morbidity and mortality among this very rare group of patients.

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