ANNALI ITALIANI DI CHIRURGIA

Digital Edition
e-publish on-line
ISSN 2239-253X
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Ann Ital Chir, Digital Edition 2018, 7
pii: S2239253X1802830X - Epub, April 20
free reading: www.annitalchir.com

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Blunt abdominal trauma following gunshot wound. Case report and literature review

INTRODUCTION: *Similarly to blast weapons, every firearm produces explosion at the moment of shooting, which can cause injuries in every region of the body. The aim of this paper is to present the mechanism of blunt abdominal injury following gunshot wounds, bringing this uncommon disease to the clinicians' attention and to review the literature available.*
CASE REPORT: *A patient developed a delayed bowel perforation following a gunshot injury of the abdomen without breaking of the peritoneum. It was clinically suspected eight hours later and confirmed with contrast-enhanced computed tomography scan. The patient underwent immediate laparotomy. Resection, end-to-end anastomosis, and large lavage of the peritoneal cavity was performed. The patient was discharged ten days after operation in good condition.*
CONCLUSION: *Failure to recognize blunt trauma mechanism following firearm wounds increases the risk of missed injuries. Distant injuries should be suspected in all cases after blast wave and firearms exposure and a follow up should be done for many days to make sure such injuries are excluded. CT scan total body is recommended in all such cases.*

KEY WORDS: Blunt trauma, Distant Injuries, Firearm injuries, Pressure Waves

Introduction

Usually, penetrating injuries are caused by firearms and sharp objects, while blunt injuries by motor vehicle collisions, assaults, recreational accidents, or falls. Blast weapons might cause both penetrating and/or blunt trauma [1]. Despite the increased number of terrorist attacks over the last 15 years, blunt abdominal injuries following blast wave are very rare. Most clinicians are not familiar in their daily practice with this disease even in the busiest urban trauma centers and especially after gunshot wounds [2-5].

Similarly to blast weapons, every firearm produces explosion at the moment of shooting, which can cause blunt injuries in every region of the body. Blast injuries are a result of the body exposure to sudden changes in pressure produced by the explosion. Such injuries are described since the First World War and are commonly encountered in the battlefield [6]. Blast injuries are divided into five categories: Primary blast injury that is caused by the exposure to a blast wave itself; Secondary blast injury that is caused by material propelled by a blast that strikes the body; Tertiary blast injury is caused by setting the body in motion from the blast wave and striking the ground, a structure, or some other object; Quaternary blast injury is attributed to explosions such as crush injuries, burns, chemicals, toxins; Quinary is the systemic inflammatory response provoked in the host [7].
Blast wave changes its intensity under certain circumstances. Thus, in water and confined spaces, it is more devastating than in open air. The pressure wave travels

Pervenuto in Redazione Gennaio 2018. Accettato per la pubblicazione Aprile 2018
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three times faster in water than in the air for a comparable size of explosion [8]. The underwater equivalent of the blast wind is a mass movement of water as a "ram" effect, which can potentially cause a significant blunt trauma [9]. In confined spaces the increase of the focal blast pressure and the long time exposure increase the risk of primary blast injury [7].

Blast weapons and every firearm can cause blast injuries in every region of the body as a result of an externally imposed pressure wave or an internal pressure created by the interaction of a bullet and tissue respectively [10,11]. In addition to local effects in tissue caused by direct impact, blast weapons and firearms produce distant injury due to indirect impact [12]. A penetrating high velocity missile (usually bullets) transfers a destructive energy called shock wave to the surrounding tissues, which can extend in distance, transferring physical shock to tissues whose physiologic function may be disrupted by it (especially in the circulatory or nervous systems). Bellamy RF and Zajtchuk R described three mechanisms of distant injury due to transient pressure wave: 1) stress waves 2) shear waves and 3) a vascular pressure impulse. Stress waves refer to tissue damage due to primary waves that is in contact with the wound channel (for example a lung contusion from a hit to the shoulder). Shear waves reflect a possible mechanism of indirect injuries (for example bones fractured by the bullet passing close to the bone without a direct impact). The same Authors wrote, "The abdomen is one body region in which damage from indirect effects may be common" [13].

Dr. Cernak explains that neurotrauma following blast injury is associated with pressure transients propagating via blood vessels (for example, pressure transients arising from an abdominal gunshot wound might propagate through the vena cava and jugular venous system into the cranial cavity and cause a precipitous rise in intracranial pressure with consequent transient neurological dysfunction) [14].

The tissue damage from bullet blast effect is related to the shooting distance, whereas the distance up to which serious wounding can occur depends on the type of firearms. The range of fire is determined by the characteristic of the entrance wound, burning, singeing and blackening, tattooing and metallic particles. The symptoms of primary blast injury are sometimes similar to other blunt trauma, but the absence of visible trauma is consistent with primary blast injury being a unique type [15]. Unlike with primary blast injury, trauma caused by firearms is visible and distant injury way back to the wound channel should be suspected until they have been excluded. The major clinical problem with blast injury is delayed presentation due to the slow evolving of the damage [16]. Although most blast injuries can be managed in a similar manner with those applied in traumatized patients, injuries caused by the blast pressure wave itself cannot [7,17].

The aim of this paper is to report a case of blunt abdominal injury following gunshot wound, bringing this uncommon disease into clinicians' attention and to review the literature available.

Case Report

A 32-year-old man from a suburban area was admitted to our Level I trauma center one hour after he sustained a gunshot wound to the abdomen. He was hemodynamically stable and complained of abdominal pain at the level of wound channel. A penetrating gunshot wound of the anterior abdominal wall, from the right periumbilical region towards the right iliac crest, was ascertained (Fig. 1). On physical examination, the patient had no signs of peritoneal irritation and no prior medical history. Focused abdominal sonography for trauma,

Fig. 1: Penetrating gunshot wound of the anterior abdominal wall, from the right periumbilical region towards the right iliac crest.

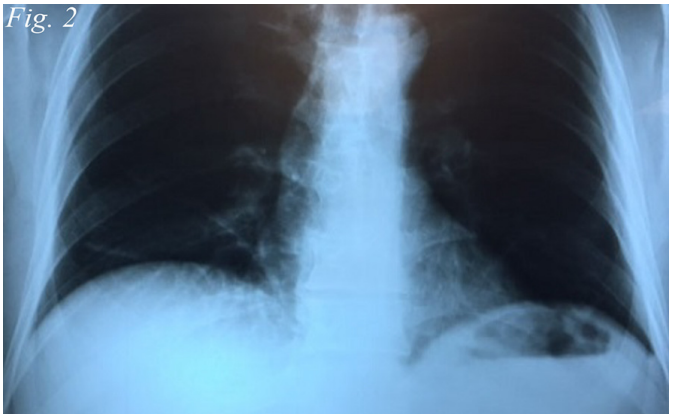

Fig. 2: Plain chest radiograph on admission showed no presence of pneumoperitoneum.

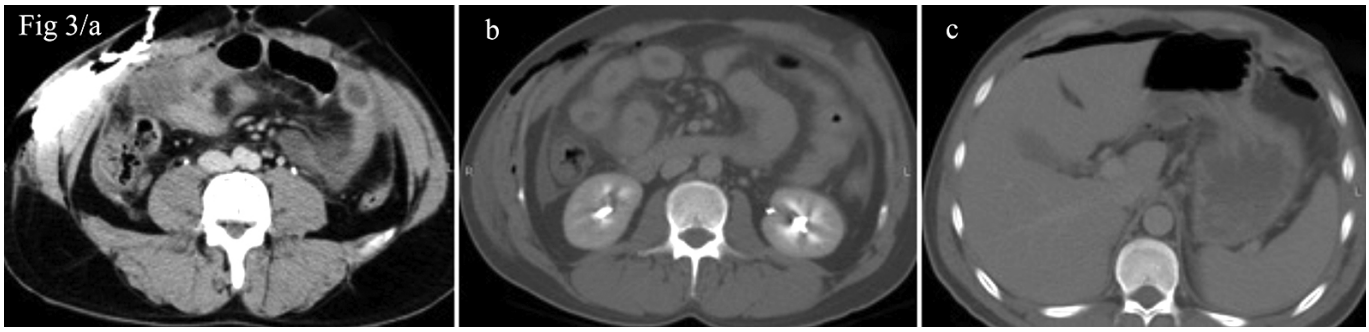

Fig. 3: (A, B, C): Abdominal CT scan showed pneumoperitoneum, free fluids, and thickening of the bowel walls.

laboratory parameters, chest, abdomen, and pelvis x-rays were normal (Fig. 2). A sterile polyethylene tube passed through the wound channel freely. Under such circumsances, the patient was selected for non-operative management. Eight hours later the patient showed abdominal pain, fever, nausea, vomiting, peritoneal signs and leukocytosis. The abdominal CT scan revealed pneumoperitoneum, free fluids and thickening of the bowel wall, but did not detect any perforation in the peritoneum or the presence of the contrast media into the peritoneal cavity, which was instilled through the periumbilical hole wound channel during CT scan examination (Fig. 3 a, b, c). The patient underwent immediate laparotomy, and a terminal ileum perforation was found but not the breaking of the peritoneum. Resection, end-to-end anastomosis, and large lavage of peritoneal cavity were performed, and two drains were placed. Intravenous fluids, analgesic, PPI, anticoagulant, and broad-spectrum antibiotics therapy were given. The patient displayed infection of the gunshot wound channel, which was healed per secundum. He was discharged ten days after operation in good condition.

Discussion

The extent of damage from the blast wave mainly depends on five factors: (1) the peak of the initial positive-pressure wave; (2) the duration of overpressure; (3) the medium of explosion; and (4) the distance from the incident blast wave [18].

Blast injuries should be considered for any person exposed to an explosive force. In spite of claims that shock waves cannot result from bullet impacts with tissue, many evidences support the theory that high velocity missile causes almost always distant injuries away from the main track [14,19,20].

In ballistics, energy is a function of mass and the square of velocity [21] When a high velocity missile (exceeding 2,500 feet or 800 metres per second) passes through the tissue, it sends a shock wave of compression away back from the main track [22]. This wave increases the tissue pressure up to thousands of kilopascals that can cause severe damage into fluid and gas containing tissues like vessels, respiratory, gastrointestinal, bladder and auditory systems. Blast wave can cause unique patterns of injury seldom seen in civil life.

Actually, it is well established that blast wave induces traumatic brain injury. Primary biomechanical mechanisms which contribute this type of injury are translational and rotational head accelerations, direct cranial transmission, and thoracic mechanism where a pressure transient reaches the brain via the thoracic vessels. The neural damage is hypothesized to result from the exposure to extravasated blood products, edema, and hypoxia [23]. Lu et al in their non-human experimental study have found that ultrastructural changes after blast wave exposure are present in the brain tissue, and Purkinje neurons in the cerebellum and pyramidal neurons in the hippocampus were most vulnerable. These findings correlated with behavioral changes and changes in motor coordination and working memory of the affected monkeys, but cellular level changes were mostly undetectable using MRI [24].

The clinical diagnosis of blast injury to the lung is based on anamnesis, clinical symptoms and radiology examination. Symptoms may vary from chest pain and dyspnoea up to haemoptysis, associated with cyanosis, respiratory distress hypoxemia. Radiology findings may include focal opacities, loss of lung translucency, pneumothorax, pneumomediastinum, pneumopericardium, interstitial emphysema and haemothorax. CT scan shows anatomical structures in respect of location and extent of damage. When distant injuries due to transmitted blast wave are suspected, total body CT scan is necessary to detect them and follow up. Pulmonary contusion and rib fractures can occur in case of thoracic gunshot wound without pleural breach [25]. Arterial air emboli due to severe pulmonary injury can cause ischaemic complications, especially in the brain, heart, and intestinal tract [7].

The typical injury after blast abdominal trauma is gastrointestinal mural hematoma, which may perforate up to 14 days after injury [6]. The concept of evolving transmural damage explains the delayed presentation of gastrointestinal blast injury [26]. Consequently, a delayed treatment of blunt abdominal trauma due to untimely diag-

nosis, can be a life threatening complication [27,28]. Some authors have reported mural hematomas of sufficient size to obstruct the lumen of the bowel, however, as the natural history of hematoma is resolution, a conservative approach would be appropriate [29]. Blast abdominal injury should be suspected in any exposed patient with abdominal pain, nausea, vomiting, hematemesis, rectal pain, and tenesmus. Not all small bowel contusions detected during laparotomy require excision. Bowel contusions smaller than 15 mm in diameter and colonic contusions of less than 20 mm can be managed conservatively [26]. However, the treatment of such injuries is complex and depends on the mechanism of injury, affected organ(s), grade of injury, and individual circumstances (individual or mass casualty).

Conclusion

Failure to recognize blunt trauma mechanism following firearm wounds increases the risk of missed injuries. Distant injuries should be suspected in all cases after blast wave and firearms exposure and should be followed up for many days before excluding them. CT scan total body is recommended in all of such cases.

Riassunto

Presentiamo il caso di un paziente che ha sviluppato una perforazione dell'ileo terminale a distanza di 8 ore dopo aver subito una ferita d'arma da fuoco superficiale dell'addome, in assenza di soluzioni di continuo del peritoneo. In questo paziente, l'arma da fuoco ha prodotto l'esplosione del viscere da improvviso ed intenso aumento della pressione endoluminale che ha causato la tipica lesione da "scoppio". Il mancato riconoscimento di questo meccanismo di trauma da onda d'urto, come conseguenza di una ferita d'arma da fuoco interessante la parete addominale espone al rischio di una tardiva identificazione della lesione viscerale. Lesioni remote dovrebbero dunque essere sempre sospettate, in presenza di esplosioni di qualunque tipo. È consigliabile, l'attento monitoraggio del paziente, per poter escludere lesioni secondarie di questo tipo. Il controllo TC total body è raccomandabile in tutti i casi.

References

1. Turégano-Fuentes F, Pérez-Diaz D, Sanz-Sánchez M, et al.: *Abdominal blast injuries: Different patterns, severity, management, and prognosis according to the main mechanism of injury*. Eur J Trauma Emerg Surg, 2014; 40: 451-60.

2. Gregory TM, Bihel T, Guigui P, et al.: *Terrorist attacks in Paris: Surgical trauma experience in a referral center*. Injury, 2016; 47: 2122-126.

3. Ceballos JP, Turégano-Fuentes F, Perez-Diaz D, et al.: *11 March 2004: The terrorist bomb explosions in Madrid, Spain-an analysis of the logistics, injuries sustained and clinical management of casualties treated at the closest hospital*. Crit Care, 2005; 9: 104-11.

4. Golan R, Soffer D, Givon A; Israel Trauma Group, Peleg K: *The ins and outs of terrorist bus explosions: Injury profiles of on-board explosions versus explosions occurring adjacent to a bus. Injury,* 2014; 45: 39-43.

5. Khan MS, Waheed S, Ali A, et al.: *Terrorist attacks in the largest metropolitan city of Pakistan: Profile of soft tissue and skeletal injuries from a single trauma center*. World J Emerg Med, 2015; 6: 217-20.

6. Owers C, Morgan JL, Garner JP: *Abdominal trauma in primary blast injury*. Br J Surg, 2011; 98:168-79.

7. Wolf SJ, Bebarta VS, Bonnett CJ, et al.: *Blast injuries*. Lancet, 2009; 374: 405-15.

8. Ripple GR, Phillips Y: *Military explosions.* In Cooper GJ, Dudley HAF, Gann DS, Little RA, Maynard RL(eds): *Scientific Foundations of Trauma.* Butterworth-Heinemann: Oxford, 1997; 247-57.

9. Cudahy E, Parvin S: *The Effects of Underwater Blast on Divers.* NSMRL Report 1218-2001. Naval Submarine Medical Research Laboratory: New Groton, 2001.

10. Cernak I, Wang Z, Jiang J, et al.: *Ultrastructural and functional characteristics of blast injury-induced neurotrauma*. J Trauma, 2001; 50: 695-706.

11. Courtney M: *The ballistic pressure wave theory of handgun bullet incapacitation*. 2008. Ballistics Testing Group, P.O. Box 24, West Point, NY 10996.

12. Kahaner L:AK-47: *The Weapon that Changed the Face of War*. Hoboken, NJ: John Wiley & Sons, 2007; 32.

13. Bellamy RF, Zajtchuk R: *The physics and biophysics of wound ballistics*. In: Zajtchuk R, ed. Textbook of Military Medicine, Part I: Warfare, Weaponry, and the Casualty, Vol. 5, Conventional Warfare: Ballistic, Blast, and Burn Injuries. Washington, DC: Office of the Surgeon General, Department of the Army, United States of America; 1990: 107-162.

14. Cernak I: *Brain Neurotrauma: Molecular, Neuropsychological, and Rehabilitation Aspects*. Chapter 45; 2015.

15. Bala M, Rivkind AI, Zamir G, et al.: *Abdominal trauma after terrorist bombing attacks exhibits a unique pattern of injury*. Ann Surg, 2008; 248: 303-09.

16. Paran H, Neufeld D, Shwartz I, et al.: *Perforation of the terminal ileum induced by blast injury: Delayed diagnosis or delayed perforation?* J Trauma, 1996; 40: 472-75.

17. Argyros GJ: *Management of primary blast injury.* Toxicology, 1997; 121: 105-15.

18. Cernak I: *Blast injuries and blast-induced neurotrauma: Overview of pathophysiology and experimental knowledge models and findings*. In: Kobeissy FH(ed): *Brain Neurotrauma: Molecular, Neuropsychological, and Rehabilitation Aspects*. Boca Raton (FL): CRC Press/Taylor & Francis; 2015. Chapter 45.

19. MacPherson D: *Bullet penetration: Modeling the dynamics and the incapacitation resulting from wound trauma*. Ballistics Publications, El Segundo, CA, 1994.

20. Suneson A, Hansson HA, Seeman T: *Pressure wave injuries to the nervous system caused by high-energy missile extremity impact: Part I. Local and distant effects on the peripheral nervous system. A light and electron microscopic study on pigs*. J Trauma, 1990; 30: 281-94.

21. Denton JS, Segovia A, Filkins JA: *Practical pathology of gunshot wounds*. Arch Pathol Lab Med, 2006; 130: 1283-89.

22. Max W, Rice DP: *Shooting in the dark: Estimating the cost of firearm injuries.* Health Aff (Millwood), 1993; 12: 171-85.

Courtney A, Courtney M: *Brain Injury: A Review of Potential Mechanisms*. Front Neurol, 2015; 6: 221.

23. Lu J, Ng KC, Ling G, et al.: *Effect of blast exposure on the brain structure and cognition in Macaca fascicularis*. J Neurotrauma, 2012; 29:1434-454.

24. Mackenzie IM, Tunnicliffe B: *Blast injuries to the lung: epidemiology and management*. Philos Trans R Soc Lond B Biol Sci, 2011; 366: 295-99.

25. Cripps NP, Cooper GJ: *Risk of late perforation in intestinal contusions caused by explosive blast*. Br J Surg, 1997; 84: 1298-303.

26. Stagnitti F, Salvi P, Corelli S, et al.: *Colon lesion for blunt trauma in the abdomen*. Ann Ital Chir, 2005; 76: 543-48.

27. Costa G, Fransvea P, Frezza B, et al.: *Hollow viscus injury due to blunt trauma. Epidemiology and outcome in a large urban area*. Ann Ital Chir, 2016; 87: 230-63.

28. Chien JH, Ho TY, Shih-Peng L, et al.: *Acquired duodenal obstruction in children*. Pediatr Neonatol, 2008; 49: 193-6.