Disease and Diagnosis

Dis Diagn. 2024; 13(1):46-51

doi 10.34172/ddj.480

Case Series

Evaluating the Role of a Radiologist in the Firearm Injuries: A Case Series of Important Medico-legal and Health Prospects

Vikash Sharma[1], Rajaram Sharma[1*], Sunil Kast[1], Tapendra Tiwari[1], Saurabh Goyal[1], Kritika[1], Sunil Chugh[2]

[1]Pacific Institute of Medical Sciences, Umarda, Udaipur, Rajasthan, India-313001
[2]Kalpana Nursing Home Pvt Ltd., Sardarpura, Udaipur, Rajasthan, India-313001

***Correspondence to**
Rajaram Sharma,
Email: hemantgalaria13@gmail.com

Abstract
Background: In the emergency department, many cases present with a bullet injury. Bullet injury accidents are highly sensitive cases due to the medico-legal aspect and political issues. Gunshot injuries have increased in the past few years because of the easy availability of guns and firearms. Young male adults are more involved in criminal activity and suicides. Gunshot injuries are high-energy injuries that lead to extensive soft tissue damage and bone fractures.
Materials and Methods: This retrospective descriptive study was performed on eight patients with gunshot injuries between January 2021 and December 31, 2021. After initial first aid, patients underwent an X-ray and computed tomography for further assessment of soft tissue damage, surgical planning, and forensics. SPSS software was used to analyze the collected data and generate descriptive statistics, and the data were plotted in tabular format.
Results: In this article, we discussed the imaging investigation modalities primarily used for firearm injury elaborated on the tissue damage due to firearms and secondary complications. Of eight patients, 87% had single bullet injuries, while 13% had shotgun injuries. In addition, 62% had head and neck injuries, whereas 38% had chest and abdomen injuries.
Conclusion: There are many cases presented in the emergency department with firearm injuries. Radiological investigations are always essential for management or surgical planning to rule out the visceral damage and medico-legal aspects. For an accurate diagnosis, a radiologist must know about the essentials of firearm injuries.
Keywords: Firearm injury, CT scan, Tissue damage

Received: January 6, 2023, **Accepted:** February 14, 2023, **ePublished:** April 24, 2023

Introduction

The assault has been acknowledged as the eighth leading global public health problem worldwide. In developing countries, there is a massive loss of economy and people in the increasing firearm injury cases owing to community and ethnic fighting, political violence, armed robberies, social media, entertainment business (e.g., over-the-top), and suicide cases. These are more common in low- and middle-income societies because low-income sources increase the crime rate for income sources. Most guns are illegal and unlicensed, and these guns are made with poor quality that may blast into the hands, causing injuries. As of 2006 data, India had approximately 40 million civilian firearms, and out of approximately 650 million civilians having firearms, only 15% (approximately 6.3 million) had a license (1). Approximately 300 000 illegal firearms are owned only in India's capital, which is surprising. These rough data underline the firearm trauma problems commonly found in the Indian population, which is a significant cause of injury/death. There are several cases of firearm injuries in which survival rates are high because of the bad quality of the firearm or distance or the patient's condition (2). These rates are higher if a radiological imaging investigation is performed to assess the position of the bullet and damaged organ or bone. If the bullet is left in the body, then it may associate with adverse medical conditions such as infection, lead intoxication, and pain. (3) For ruling out the metal objects, an X-ray or computed tomography (CT) scan is always the first choice of imaging investigation. Magnetic resonance imaging (MRI) is not commonly used in firearm injuries because of a metal object; however, MRI is employed to identify abnormalities in vascular abnormalities, including arteriovenous fistula or aneurysm caused by firearm injury (4,5).

To better understand gunshot injuries, it is necessary to understand the nature of firearms and their projectiles. Ballistics is known as the ordered scientific study of projectile motion that is divided into three major internal, external, and terminal categories (6). Internal ballistics is the projectile within the firearm, while external ballistics is in the air. It is essential that physicians understand the most crucial terminal ballistics; it other words, when the projectile hits its target (7). To assess the wound and its depth, it is mandatory to know about the ballistics and their role. The severity and nature of injuries depend on the type of weapon, projectile, local tissue (hit by ballistics), and the most critical distance between the victim (local tissue) and firearm (weapon) (8).

It is also essential to know the tissue response (behaviour) before and after firearm injuries. These injuries are severe in crumbly solid organs (e.g., in the liver and brain), where damage is more than the actual bullet track due to the formation of temporary cavitation in the organs, while bone and subcutaneous fat tissue are more rigidly reduced or change the bullet course and slow them down. For clinical assessment and forensic evaluation of the incident that happened with a firearm, a radiograph can be helpful in evaluating bone/soft tissue injury and distribution of bullet fragments and tract (direction of travel of the bullet). A CT scan can better reveal the beveling of the bone with the bullet's track, which is of utmost help in medico-legal cases (9, 10). In abdominal wounds, only ruling out any fracture or muscle injuries is insufficient; it is indispensable to assess the bullet tract, peritoneal breach, and gastrointestinal injuries. Hence, a contrast-enhanced CT scan of the whole abdomen is essential to grade the severity of the injury and surgical planning. Peritoneal lavage is also helpful, but it should be after the CT scan because the CT scan is more accurate before the lavage. A laparotomy indicates if peritoneal penetration is suspected (11), and an abdominal CT scan is mandatory in the suspected retroperitoneal path of the bullet. In firearm injury and trauma, oral contrast is contraindicated, thus one must have a high suspicion of the intestinal tract injury; otherwise, it may be missed.

The radiograph is the first imaging investigation of choice in firearm injuries. Two perpendicular views are essential on a radiograph to localize the bullet or the projectile. Few bullet fragments have characteristic patterns, but in some cases, the pattern of bone fragments and bullet fragments may confuse, especially in the deformation of significant lead shotgun pellets after contact with the bone (12). It is always necessary to confirm that the tract from the entrance wound is compatible with the bullet's current position (location), as a bullet always does not follow a straight path in the body; in some cases, the bullet may ricochet off the bone and be found elsewhere in the body where we have not expected. In a few cases, the bullet follows fascial or tissue planes. In literature, the bullet or shotgun pellet movement has been described with an arterial and venous embolization within the spinal canal and subarachnoid space. In the brain, bullets can shift in position because of the development of an abscess or move retrograde along the entry tract (13). The contributions of radiologists include the evaluation of the bullet path (primary and secondary), the extent of the wound, and identification of the sites of emboli and body (organ) damage as a response after the injury (e.g., collection, bone fragments, and free air/fluid). Nowadays, interventional radiology techniques effectively remove a bullet (intravascular and intrarenal). Sometimes, bullets can also be removed from joints with arthroscopy, especially from the knee joint.

Materials and Methods

Study Design

This retrospective hospital-based study aimed to describe the characteristics and outcomes of patients with gunshot injuries.

Study Population

The study population consisted of eight patients who were admitted to a hospital with gunshot injuries between January 2021 and December 31, 2021. The study was conducted in the hospital's medical records department.

Data Collection

The medical records of the eight patients were reviewed to collect demographic and clinical data, including age, gender, type of gunshot injury, anatomical location, time of admission, and outcome (discharge, death, or transfer to another hospital). After the initial analysis, the X-rays and CT scans were reviewed for the bullet's path, position, number of bullet or bullet fragments, and extension of injury.

Data Analysis

The collected data were analyzed using descriptive statistics to determine the frequency, mean, median, standard deviation, and range of the variables.

Statistical Analysis

Statistical software was used to analyze the collected data and generate descriptive statistics. The data were plotted in tabular format, and statistical analysis was performed using SPSS 2022 software.

Results

As mentioned earlier, eight patients with gunshot injuries were included in this retrospective descriptive study. The findings revealed that patients with gunshot injuries often had multiple fractures (Figures 1-5), hemorrhages (Figures 1 and 4), soft tissue injuries (Figures 2, 3, 5-7) and bullet fragments (Figures 1 and 2). CT scans were crucial in the evaluation and surgical planning of these patients. The results also demonstrated that patients had varying outcomes, with some surviving the injury and

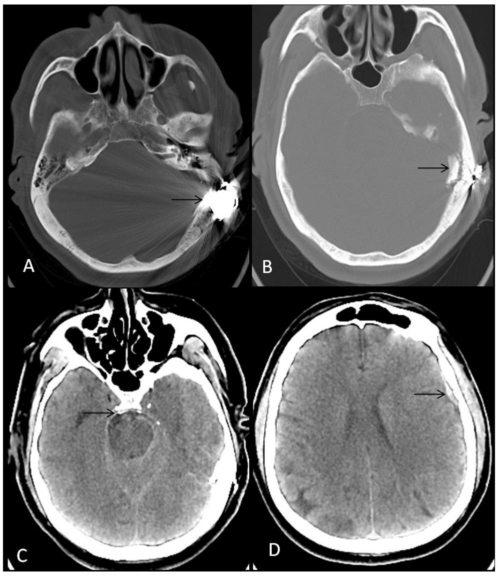

Figure 1. A 27-year-old male was bought to the hospital by relatives after one hour of attempted suicide with a country-made pistol, and for further surgical planning**,** the patient underwent a CT scan. Axial CT scan (A) bone window reveals a hyperdense structure with metallic artifacts (bullet fragments) [black arrow] in the left temporal region. (B)There is a comminuted fracture of the left temporal bone [black arrow] due to high kinetic energy injury. A fracture segment is seen indenting over the brain surface and causing surface contusions, and (C) subdural window demonstrates hyperdensity along the sulci in the left temporal lobe and basal cisterns [black arrow] suggestive of subarachnoid haemorrhage. (D)A thin layer of subdural haemorrhage [black arrow] is also seen at a higher level

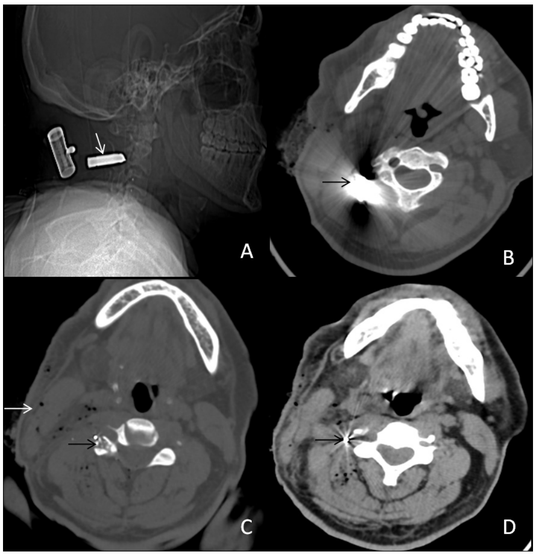

Figure 2. A-39-year old male came to the hospital with complaints of firearm injury in the neck during a communal fight. The patient underwent a CT scan to evaluate the injuries and plan the treatment. (A) Lateral radiograph of the neck showing single bullet [white arrow] at the posterior aspect of the neck. Axial non-contrast CT scan (B) bone window image in axial plane demonstrate a metallic structure [black arrow] adjacent to the right postero-lateral muscular paraspinal space at the level of dens producing metallic artifacts. (C) There is a fracture of the C3 vertebral body [black arrow], possibly due to the direct collision of the bullet with the vertebral body. Air foci are seen in the intermuscular plane as well as the subcutaneous plane on the right side of the neck. Entry wound [white arrow] at the skin can be appreciated on the right side, and (D) soft tissue window demonstrates small metallic fragments [black arrow] adjacent to the right transverse process of the C2 vertebra. The above case signifies a stopping, fragmentation and retention of the high-velocity bullet by body tissue

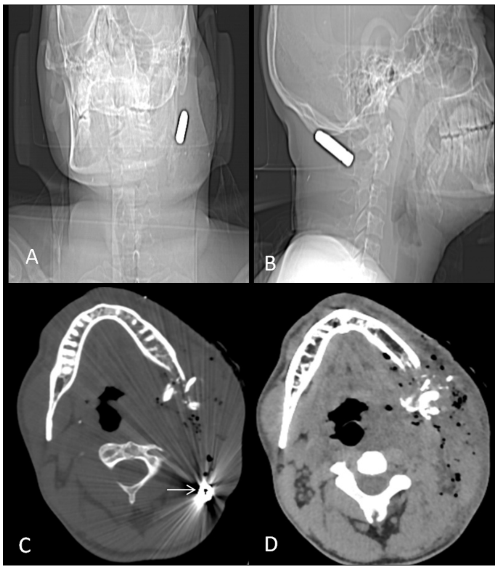

Figure 3. A 35-year-old male was bought to the hospital after a firearm injury to the anterior neck during a police encounter**.** Plain X-ray of neck and mastoid in anteroposterior view (A) and lateral view (B) shows a single large bullet in the left postero-lateral aspect of the neck. (C) Axial CT image in the bone window shows comminuted fractures of left ramus of the mandible with a single bullet [white arrow] in left posterior paraspinal space, which defines the path of the bullet from anterior to posterior. (D) Axial CT image in soft tissue window demonstrates extensive soft tissue injuries in the left side of neck, the floor of the mouth, submandibular space, para pharyngeal space, masticator space and parotid space with few air foci

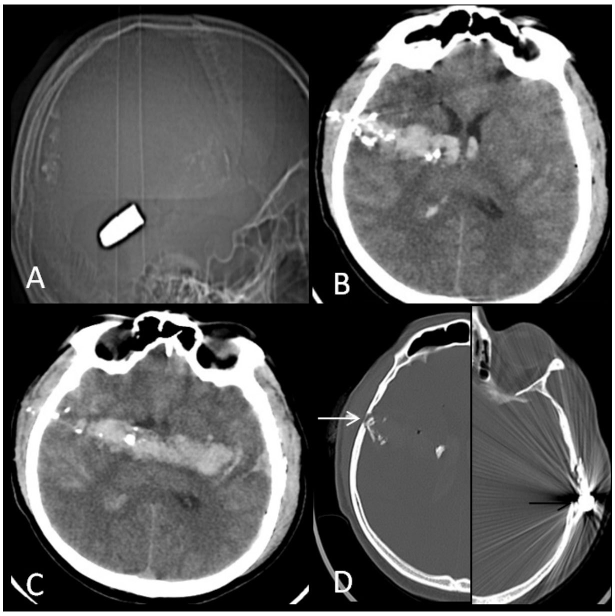

Figure 4. A 34-year-old male was brought to the hospital in the emergency department, followed by a gunshot injury during a personal dispute. (A) Lateral radiograph of the skull shows a single bullet overlying the temporal region. (B) Axial image from unenhanced computed tomography in brain window demonstrates entry point of the bullet causing comminuted fracture of the right temporal bone with linear hemorrhagic tract extending from the right temporal lobe towards the left side. Multiple fragments of the bullets are also seen in the right temporal lobe (C). (D) Bone window image of the same patient demonstrates the bullet's entry [white arrow] and exit [black arrow] sites, causing fracture of the bilateral temporal bones. However, the bullet has stopped and is retained in the subcutaneous region. This is an example of high-velocity bullet injury-causing penetrating skull injuries

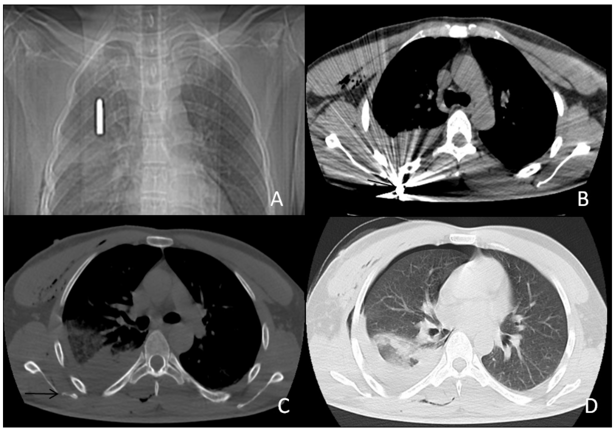

Figure 5. A 29-year-old male was brought to the hospital with a gunshot injury in the neck during criminal activity. (A) Plane radiograph (anteroposterior view) shows a single bullet in the right upper chest. (B) Axial non-enhanced CT scan reveals a single bullet [black arrow] within the right trapezius muscle at the level of the D5 vertebra in a vertical orientation. The bullet travelled obliquely, collided with the scapular body, causing its fractures [black arrow] (C), and stopped in the paraspinal muscles. (D) Axial CT scan of the thorax in lung window demonstrates subcutaneous emphysema, moderate haemo-pneumothorax, lung contusions, and alveolar haemorrhage on the right side due to direct as well as indirect injuries

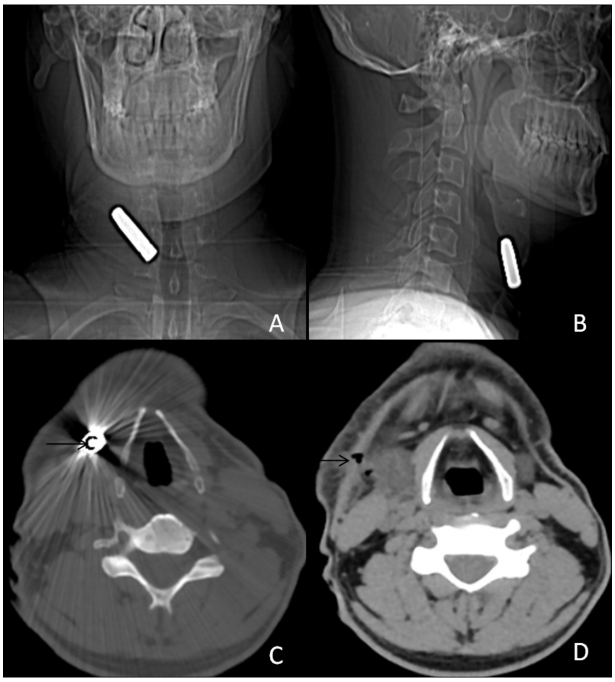

Figure 6. A 55-year-old female sustained a bullet injury during a wedding celebration (also known as ceremonial firing, which is very popular in certain areas and communities in India). She was standing far from the site of the aerial shooting when a bullet hit her in the pelvis. Neither the patient nor anyone in the gathering could find a bullet at the injury site. The patient was suspected to be hit by a ricochet bullet, and there were immense social and political pressures to rule out the bullet inside the body. (A) Antero-posterior lateral radiograph of the neck demonstrates a single bullet in the anterior neck at the C6 and C7 levels. (C) Axial CT scan of the neck in the bone window shows a single bullet [black arrow] in the right anterior neck space lateral of the level thyroid cartilage. Axial non-enhanced CT scan demonstrates few air foci along the bullet path [black arrow]

others succumbing to it. The type of firearm injury and the location of the bullet in the body played a significant role in the outcome of the patients. The findings emphasized the importance of prompt medical attention and surgical intervention in patients with gunshot injuries. The descriptive analysis was conducted using frequencies and percentages of occurrences in the patient population.

We have discussed eight patients with firearm injuries. The firearm type, mechanism, velocities, and shooting subjects help choose an imaging investigation modality and accurate management of the damaged tissue. Male patients are known to sustain a higher number of firearm injuries; seven male patients (87%) and one female case (13%) were included in this study. It was found that most involving head and neck injuries were more common (62%) than thorax and abdomen (38%) in single bullet injuries. In contrast, shotgun injuries were common in the thorax and abdomen (Figures 8 and 9). In India, single-bullet guns are most commonly used because they are easy to handle and procure illegally.

Discussion

Ballistic injuries result from a projectile (i.e., bullet) penetrating or entering the body, which may cause characteristic serious wounds that may be life-threatening due to severe blood loss, contamination of the wound, and respiratory distress. Firearms mainly cause two types of injuries, along the tunnel of attrition and in the peripheral zone. The tunnel of attrition is defined as the direct tissue damage by the projectile's passage, while the surrounding tissues destroyed by the transmission of the energy dissipated by the projectile are included in the peripheral zone (13).

Bullet injury is a correlation between the penetrating subjects, the type of bullet, and the pathway obtained by the bullet in the body. The subject's velocity, shape, size, and mass establish the maximum tissue damage and mortality. Firearm injuries require special care, which depends on the area or mass of the projectile, the clinical picture of the wound, and the suspected secondary complications (14). The role of imaging investigation has recently received more attention in firearm injury care, especially in hemodynamically stable patients who cooperate with imaging investigations. X-ray is a standard and first-line imaging investigation for firearm injury in the extremity (15). The multislice CT scan has improved the care of the firearm-injured patient as it provides meticulous details about the bullet localization, fractures, injured viscera, pleural effusion, organ damage, the severity of the wound, and surgical planning of the wound. Post-contrast imaging after the intravenous administration of a non-ionic contrast agent provides additional details on the penetrating nature of wounds, vascular injury, and trauma grading of the damaged organ (16). Sometimes CT angiography is also needed for

Figure 7. Unenhanced computed tomography image in the axial plane at the pelvis level demonstrating effects of low-velocity gunshot causing superficial injuries in the form of abrasions and shallow wounds. (A) Soft tissue window and (B) bone window demonstrate a single superficial wound with internal air foci in the subcutaneous plane of the right gluteal region [white arrow]. A small calcified right internal iliac group of the lymph node [black arrow] is also seen. No evident metallic/ foreign body was noted in the patient's body. CT scan also rules out internal visceral injury

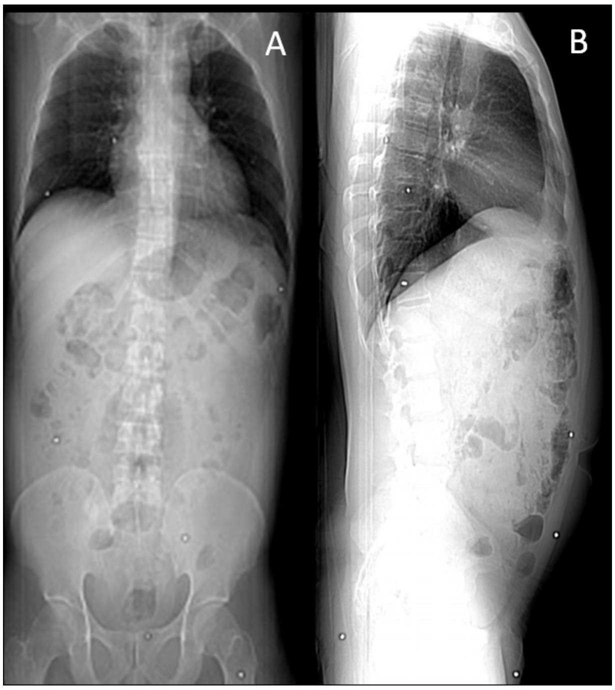

Figure 8. A 21-year-old male presented to the hospital with a far range shotgun injury during a robbery. The patient had injured multiple abrasions on his abdomen but was hemodynamically stable. For localization of shotgun pellets and to diagnose any visceral injury. Images demonstrating the effect of far range shotgun injury. (A & B) Plain radiograph of abdomen and thorax in anteroposterior view and lateral projections demonstrating dispersion of shotgun pellets. Dense well-defined round radio-opacities (pellets) of the shotgun are seen scattered over the various body regions. The anteroposterior image should be correlated with lateral projections to ascertain penetration depth. Radiograph also helps to rule out pneumothorax/ pneumoperitoneum

Figure 9. A 31-year-old male came to the hospital with complaints of a firearm injury. The patient got shot in the anterior chest when he tried to escape from the prison on a bike. Unenhanced computed tomography was done to ascertain and rule out visceral injury. (A) Lung window of CT scan of the thorax in axial plane reveals small shotgun pellet [black arrow] in the right chest wall in the intercostal aspect. The lung window also excludes the development of the pneumothorax. (B) The mediastinal window of CT scan of the thorax in axial plane reveals a single pellet [black arrow] of shoot gun incompletely penetrating the chest wall without any hematoma formation in the chest wall. (C) An unenhanced CT scan of the abdomen just below both kidneys reveals a low-velocity single pellet [black arrow] stopped in the subcutaneous tissue. (D) Unenhanced CT scan of lower abdomen at the level of the neck of the femur showing single intramuscular pellet [black arrow] adjacent to left femur. (E) CT scan in the bone window at the hip joint level reveals a single shotgun pellet [black arrow] at subcutaneous tissue

a suspected vascular injury (17). For accurate mapping of the lesion, a maximum intensity projection and three-dimensional reconstruction images are beneficial as they help in the bullet path reconstruction and localization. Ultrasonography can also be used in an emergency to look for foreign body and liquid or gas effusions; however, it remains a subjective assessment modality, limiting its uses in such medico-legal cases where the evidence may be required in the court of law even after many years.

Conclusion

The radiologist plays an essential role in firearm injury cases for forensic help and accurate management. The plain radiograph is the first choice of imaging investigation in firearm injury, affecting the extremity where it may demonstrate the location of a bullet with tissue disruption and any fracture present or not. CT scan is more helpful in deeper penetrating and visceral injuries and is precise in analyzing the bullet path and surgical planning.

Authors' Contribution

Conceptualization: Rajaram Sharma, Vikash Sharma.
Data curation: Rajaram Sharma, Vikash Sharma, Sunil Kast.
Formal analysis: Rajaram Sharma, Vikash Sharma, Sunil Kast, Tapendra Tiwari.
Funding acquisition: Rajaram Sharma, Vikash Sharma, Sunil Kast, Tapendra Tiwari, Saurabh Goyal.
Investigation: Rajaram Sharma, Vikash Sharma, Sunil Kast, Tapendra Tiwari, Saurabh Goyal, Kritika.
Methodology: Rajaram Sharma, Vikash Sharma, Sunil Kast.
Project administration: Rajaram Sharma, Vikash Sharma, Sunil Kast.
Resources: Rajaram Sharma, Vikash Sharma, Sunil Kast, Tapendra Tiwari, Saurabh Goyal, Kritika.
Software: Saurabh Goyal, Kritika.
Supervision: Rajaram Sharma.
Validation: Rajaram Sharma, Vikash Sharma, Sunil Kast.
Visualization: Rajaram Sharma, Vikash Sharma, Sunil Kast.
Writing–original draft: Rajaram Sharma, Vikash Sharma, Sunil Kast.
Writing–review & editing: Rajaram Sharma, Vikash Sharma, Sunil Kast.

Competing Interests

None to be declared.

Data Availability Statement

All the data is available with the corresponding author.

Ethical Approval

Ethical approval was obtained from the institutional ethical committee prior to the study (Code: STU/IEC/2021/18).

References

1. Gun law in India. Wikipedia website. https://en.wikipedia.org/w/index.php. Updated August 18, 2023
2. Ambrosi PB, Valença MM, Azevedo-Filho H. Prognostic factors in civilian gunshot wounds to the head: a series of 110 surgical patients and brief literature review. Neurosurg Rev. 2012;35(3):429-36. doi: 10.1007/s10143-012-0377-2.
3. Dikshit P. Weaponisation of Indian society through illicit arms proliferation, production and trade. In: Nepram B, ed. India and the Arms Trade Treaty. New Delhi, India: India Research Press; 2009. p. 43-5.
4. Smith RN, Tracy BM, Smith S, Johnson S, Martin ND, Seamon MJ. Retained bullets after firearm injury: a survey on surgeon practice patterns. J Interpers Violence. 2022;37(1-2):NP306-NP26. doi: 10.1177/0886260520914557.
5. Wilson AJ. Gunshot injuries: what does a radiologist need to know? Radiographics. 1999;19(5):1358-68. doi: 10.1148/radiographics.19.5.g99se171358.
6. Reginelli A, Russo A, Maresca D, Martiniello C, Cappabianca S, Brunese L. Imaging assessment of gunshot wounds. Semin Ultrasound CT MR. 2015;36(1):57-67. doi: 10.1053/j.sult.2014.10.005.
7. Kulla M, Maier J, Bieler D, Lefering R, Hentsch S, Lampl L, et al. [Civilian blast injuries: an underestimated problem?: Results of a retrospective analysis of the TraumaRegister DGU®]. Unfallchirurg. 2016;119(10):843-53. doi: 10.1007/s00113-015-0046-3. [German].
8. Swan KG, Swan RC. Principles of ballistics applicable to the treatment of gunshot wounds. Surg Clin North Am. 1991;71(2):221-39. doi: 10.1016/s0039-6109(16)45376-4.
9. Choi CH, Pritchard J, Richard J. Path of bullet and injuries determined by radiography. Am J Forensic Med Pathol. 1990;11(3):244-5. doi: 10.1097/00000433-199009000-00014.
10. Roberts DJ, Bobrovitz N, Zygun DA, Ball CG, Kirkpatrick AW, Faris PD, et al. Indications for use of damage control surgery and damage control interventions in civilian trauma patients: a scoping review. J Trauma Acute Care Surg. 2015;78(6):1187-96. doi: 10.1097/ta.0000000000000647.
11. Hollerman JJ, Fackler ML, Coldwell DM, Ben-Menachem Y. Gunshot wounds: 2. Radiology. AJR Am J Roentgenol. 1990;155(4):691-702. doi: 10.2214/ajr.155.4.2119096.
12. Phillips CD. Emergent radiologic evaluation of the gunshot wound victim. Radiol Clin North Am. 1992;30(2):307-24.
13. Maragkos GA, Papavassiliou E, Stippler M, Filippidis AS. Civilian gunshot wounds to the head: prognostic factors affecting mortality: meta-analysis of 1774 patients. J Neurotrauma. 2018;35(22):2605-14. doi: 10.1089/neu.2018.5682.
14. Duhamel P, Bonnet PM, Pons F, Jourdan P, Jancovici R. [Thoracic ballistic traumatisms. Wounding agents and wound ballistic]. Ann Chir Plast Esthet. 2003;48(2):128-34. doi: 10.1016/s0294-1260(03)00015-3. [French].
15. Franke A, Bieler D, Friemert B, Schwab R, Kollig E, Güsgen C. The first aid and hospital treatment of gunshot and blast injuries. Dtsch Arztebl Int. 2017;114(14):237-43. doi: 10.3238/arztebl.2017.0237.
16. Versier G, Ollat D. Blessures des membres et du rachis par projectiles. EMC-Rhumatologie-Orthopédie. 2005;2(3):262-75. doi: 10.1016/j.emcrho.2005.01.001.
17. Penn-Barwell JG, Brown KV, Fries CA. High velocity gunshot injuries to the extremities: management on and off the battlefield. Curr Rev Musculoskelet Med. 2015;8(3):312-7. doi: 10.1007/s12178-015-9289-4.