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Case Report

Indirect ballistic injury to the liver: Case report and review of literature

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ABSTRACT

Introduction: Penetrating injury due to gunshot wounds is a common problem seen in trauma centres around South Africa. Gunshot wounds can injure organs directly or may cause indirect injury. The temporary cavity is responsible for injury to organs distant to the wound tract. Organs with higher density such as bone or liver are more prone to injury due to the temporary cavity.

Presentation of case: A 25 year old male patient sustained a gunshot wound to the right lower chest from a handgun. He was haemodynamically and metabolically stable with no evidence of peritonitis. CT scan of the abdomen revealed a Grade 2 injury of the liver. There was subcutaneous emphysema along the tract of the bullet. No injury to the lung or pleura was reported. The patient was explored laparoscopically to rule out diaphragmatic injury. At exploration the peritoneum was not breeched but the liver had a grade two laceration caused by an indirect ballistic injury

Discussion: Penetrating trauma to the right lower chest can potentially injure multiple organs. CT scan can reliably diagnose the bullet tract as well as solid organ injuries. In this case the diaphragm was contused and the liver was lacerated by energy created by the temporary cavity. The difference in severity of the injury of these organs is related to the pliability of the tissue.

Conclusion: Gunshot wounds can injure organs directly as well as those located close to the bullet tract. These injuries may be found in adjacent cavities not traversed by the bullet. A high index of suspicion, as well as imaging, is important to diagnose and grade these injuries. The possibility of indirect ballistic injury should always be kept in mind when managing patients with gunshot wound even in the lower velocity handgun injuries.

1. Introduction

Penetrating injury remains a common mechanism of injury in South Africa. Penetrating trauma constituted 30% of the trauma load with gunshots contributing 5% in Pietermaritzburg [1]. There are two distinct mechanisms of injury caused by gunshot wounds. These are related to "crush" and "stretch" of the tissues (Diagram 1). The crush mechanism is related to passage of the bullet through the tissues, the tissues are pushed away centrifugally and this results in the permanent cavity. The stretch mechanism applies to the adjacent tissues and can be equated to the temporary cavity formed as the bullet passes through the tissues. The temporary cavity reaches a pressure of four atmospheres, lasting about 4–5 milliseconds. The temporary cavity can injure blood vessels and fracture bones not directly passed through by the bullet, the higher the energy transfer of the bullet the larger the temporary cavity produced [2,3]. Elastic tissues with more pliability such as lung and bowel wall, tolerate this stretch much better. Inelastic solid organs such as the liver do not [4].

There have only been a handful of cases published in the literature to date. These cases have been both high and low velocity injuries. The majority of injures documented have been to the small bowel. In World War 1 Fraser and Bates reported on an extraperitoneal injury that caused a bladder rupture [5]. Since this original report there have been reports to injury of various parts of the small bowel, spleen and colon, however no one has objectively reported significant injury to liver from indirect ballistic injury. We present the unique case of an indirect ballistic injury to liver caused purely by the temporary cavity of a passing bullet [6–8].

Abbreviations: CT, computed tomography; ATLS, advanced trauma life support; CO2, carbon dioxide.

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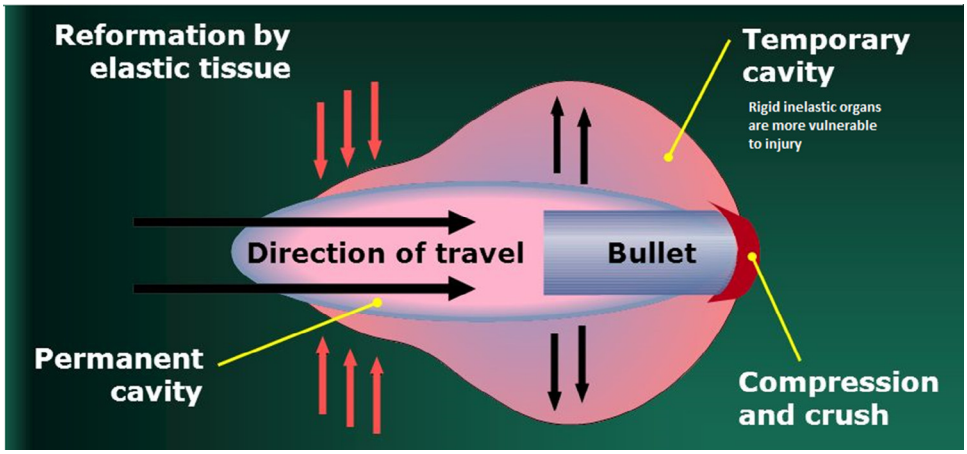

Diagram 1. A schematic representation of the mechanism of injury caused by bullet.

2. Patient information

A 25 year old male patient presented to Doctor George Mukhari Academic Hospital Trauma Unit with a gunshot wound to the right lower chest in an attempted house robbery. The patient sustained a gunshot with a handgun. He was managed according to ATLS principles. The patient was haemodynamically stable. Secondary survey revealed a wound over the 7th intercostal space anteriorly in the midclavicular line and a second wound in the 8th intercostal space midaxillarly line. Chest x-ray revealed no haemopneumothorax. The abdomen was clinically soft with no peritonitis. Initial blood gas revealed a metabolically normal patient. Connecting the trajectory of the bullet the liver as well as the diaphragm was likely to be injured (Figs. 1 and 2). A contrasted computed tomography scan of the abdomen was performed. A grade 2 (2 cm laceration) of the liver with surgical emphysema in the soft tissues was noted. There was no free air or intra-abdominal fluid. Due to trajectory of the bullet diaphragmatic injury was strongly suspected. The patient was taken to theatre for a laparoscopic exploration. Under general anaesthesia with the patient positioned supine pneumoperitoneum of 12 mmHg of CO2 was established by open Hasson technique infraumbilically. There was evidence of contusion (Grade 1) injury to the diaphragm but no peritoneal penetration (Fig. 3). The liver was lacerated (Grade 2) but not bleeding (Fig. 4). This did not require therapeutic intervention. The rest of the exam was normal. Chest x-ray on day 1 post operation revealed no delayed pneumothorax. The patient made an uneventful recovery and was discharged on postoperative day 2 tolerating a full diet and full mobilization. The patient was advised to avoid contact sport for six weeks.

Fig. 1. Picture of bullet trajectory a lateral view.

Fig. 2. Picture of bullet trajectory anterior view.

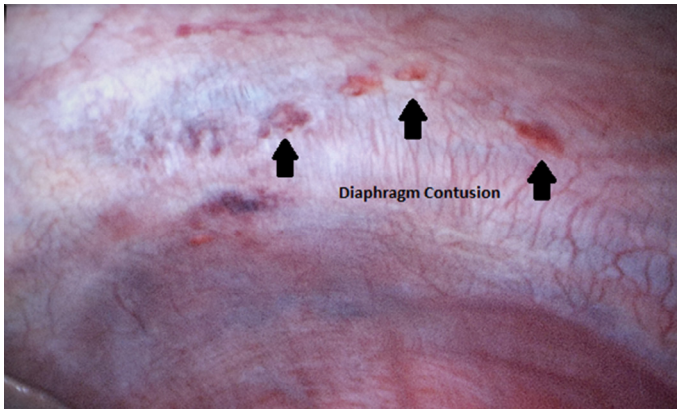

Fig. 3. Contusion of diaphragm at laparoscopy.

3. Discussion

Penetrating trauma injuries can injure a wide variety of organs. This depends on the location of the injury. In the right upper quadrant the liver, diaphragm, lung and colon are the predominant organs at risk. The option to perform non-operative management in carefully selected cases of gunshot wounds is well described [9].

The ready access and use of computed tomography (CT) has caused a paradigm shift in managing penetrating trauma. CT provides a preoperative diagnosis. This provides the surgeon with valuable information in planning the treatment approach. CT has vastly improved over time and it provides information on the trajectory of the projectile. CT reliably shows the presence of solid visceral injury and allows for grading of these injuries [10]. It should however always be remembered that there is the possibility of an indirect injury especially with a gunshot.

In reviewing the literature with regards to intrabdominal injury from missiles without peritoneal or diaphragmatic breech there are mainly case reports. A review of the literature revealed 19 cases of indirect injury [8]. These cases spanned the period from World War 1 to present day. All cases were managed by open surgery and laparotomy revealed no penetration of the peritoneal cavity or diaphragm. In contrast with this approach our patient was managed with minimal access techniques. This allowed the patient to benefit from minimal trauma as well as quicker post operative recovery. The wounding potential due to energy transfer of the bullet is well described. The high energy transfer wounds (rifle or shotgun injuries) result in significant cavitation which injures hollow viscera as well as solid organs. This is clearly seen as the nine cases in the literature identified as high energy transfer injuries. Eight cases involved perforation of the bowel (six involving portions of the colon and two involving small bowel). The other case involved solid organ injury with splenic laceration [11–17].

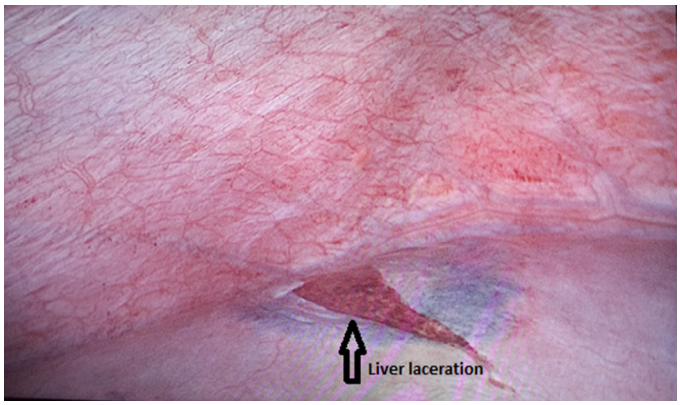

Fig. 4. Laceration found on liver at laparoscopy.

In contrast to this the six cases with confirmed low energy transfer injury involved injury to the spleen in two cases, the mesentery of the terminal ileum in one case, two cases of small bowel injury and one colonic injury [7,18–20]. Low energy transfer injuries do not produce as significant a temporary cavity as with high energy transfer wounds [18]. The cases in the literature including our case where solid organ injury has occurred may be explained by the presence of shear wave which is similar to that occurring with blunt abdominal trauma. This mechanism however does not explain the injuries to the hollow viscera and there must be injury to some extent from temporary cavitation caused by the passing bullet [8].

Concerning the indication for laparoscopy in this patient there is some controversy as to whether there is a need to repair right-sided diaphragmatic hernias. The natural evolution of these injures has not been defined. The patient may develop complications related to strangulation of bowel [21,22]. This can result in severe morbidity as well as mortality.

We believe that all diaphragmatic injuries must be repaired by minimal access techniques. In this case the bullet had not violated the peritoneum. There was a laceration on the liver (in keeping with that seen on CT) that was not bleeding. The most likely explanation for this would be related to the temporary cavity created by the passing bullet. The diaphragm is pliable and tolerated the shockwave better and was only contused, the liver however which is relatively inelastic was lacerated. As the current case shows it is possible to have injury to an organ without the bullet injuring that organ directly. This should be kept in mind whenever the clinician views a scan of a patient with a gunshot wound whether it is low or high velocity.

This case objectively demonstrates indirect injury to the liver caused by the passing bullet. To the authors knowledge it is the first time such an injury to liver has been objectively documented using minimal access techniques.

4. Conclusion

Gunshot wounds may cause significant injuries. Organs located close to the tract of the projectile can be injured. These injuries may be found even in an adjacent cavity not directly traversed by the bullet. The surgeon must have a high index of suspicion for the possibility of indirect ballistic injury away from the bullet tract. This should be maintained with all gunshot wounds irrespective of velocity. Imaging of the patient is vital to diagnose and grade these potentially significant injuries.

Ethical approval

There is no need for ethical approval as this is a case report. Informed consent for publication of this article was obtained from the patient and is available for review by the editor.

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Author contribution

All authors contributed to the writing of the draft as well as reviewing the literature and the final publication. The case was managed by the corresponding author.

Conflict of interest statement

No competing interests to be declared by any of the authors.

Guarantor

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Research registration UIN

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Appendix: Supplementary material

Supplementary data to this article can be found online at doi:10.1016/j.ijso.2016.09.006.

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Further Reading

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