THE USE OF IMPROVISED BULLET MARKERS WITH 3D CT RECONSTRUCTION IN THE EVALUATION OF PENETRATING TRAUMA

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Abstract

Radio-opaque markers placed over entry and exit wounds, have been used to help evaluate penetrating injuries and provide a permanent record of wound location on plain radiographs. To date there are no published reports of the application of improvised bullet markers in the evaluation of penetrating injuries using computed tomography (CT). We report a series of 4 cases where bullet markers were used in combination with three-dimensional (3D) computerised tomography (CT) to ascertain the path of the bullets and to assess damage to vital structures. We believe that the use of bullet markers in penetrating trauma casualties undergoing CT is valuable in the surgical decision making process and allows planning of surgical approaches.

Introduction

Evaluating the path of a bullet or fragment as it passes through the body can be difficult. As they pass through body tissues, projectiles can deflect, deform or tumble and consequently its path may not be straight [1]. On plain radiographs, the path of a wound track is often difficult to ascertain, even in the presence of bone or bullet fragments [2]. Experience from the Johannesburg Trauma Unit has highlighted the use of an unfolded paperclip as an improvised bullet marker that is placed over the wounds prior to X-rays being taken. In addition to supporting initial clinical evaluation, it also serves as a permanent record of the locations of the wounds and can thereby aid the forensic process [3].

Historically, it has been assumed that patients with gunshot wounds (GSWs) or fragment wounds from mines or improvised explosive devices suspected of traversing a major body cavity have sustained visceral injury regardless of whether they manifest physical signs or symptoms. This has previously mandated laparotomy for all abdominal penetrating ballistic wounds. In recent years this dictum has been called to question and with the advent of advanced diagnostic modalities such as multi-detector computed tomography (CT), some authors have advocated a non-operative approach to selected groups of patients [4, 5].

Prior to the current conflicts in Iraq and Afghanistan, military surgical teams have deployed with basic diagnostic equipment in the form of plain radiography and ultrasonography. Since June 2007, a multi-detector CT scanner has been installed at the Role 2(Enhanced) Medical Treatment Facility in Camp Bastion, Op HERRICK. With the introduction of these scanners in the operational environment, we investigated the use of improvised radio-opaque bullet markers in combination with helical volume rendered 3D CT reconstruction in the evaluation of penetrating torso trauma.

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Method

From February 2008, data was prospectively collected on patients undergoing CT scans at the Role 2(Enhanced) Medical Treatment Facility (MTF) in Camp Bastion, Op HERRICK. Casualties who had sustained penetrating ballistic trauma and where the consultant surgeon needed to determine the trajectory of the projectile or rule out intra-cavity injury were included in the study. The torso was defined as the body region extending between the clavicles above and the inferior gluteal crease below. Patients with clinical indications for operation such as haemodynamic instability, peritonitis, blood per rectum, or gross haematuria were taken directly to theatre.

Figure 1. Radio-opaque marker formed from an unfolded paperclip.

An unfolded paperclip was used as a radio-opaque wound marker (Figure 1) and was taped over the wounds prior to CT scanning. CT was performed with a 6-slice multi-detector CT scanner (Phillips, Netherlands) and standardised protocols for chest and abdomen/pelvis were used with the use of intravenous contrast in all cases. A slice thickness of 5mm with a 2.5 mm table index was used routinely. These images were then reconstructed using the EBW workstation (Phillips, Netherlands). All scans were reviewed immediately by the attending consultant general surgeon and reported by a consultant radiologist at the Royal Hospital Haslar, Gosport. For each patient, the clinical outcome following scanning was recorded and included any operative findings.

Results

From February 2008, four patients were identified who satisfied the inclusion criteria; three underwent CT scanning prior to surgery and one following trauma laparotomy. Three patients had sustained gunshot wounds and the other was injured by an improvised explosive device; two patients were children.

Case 1

A 12-year-old boy presented to the Role 2(E) Medical Treatment Facility (MTF) following a gunshot wound to his right buttock. The child had been sitting on the ground at the time of the injury. On assessment in the department he was haemodynamically stable and had no abdominal tenderness. Examination revealed only a single wound on the lateral aspect of his right buttock that was 1cm in diameter. Initial trauma radiographs did not show any retained ballistic fragments. The child was subsequently taken to the operating theatre where he was noted to have a small 3 mm laceration on the left side of his scrotum. In view of the possibility of an occult abdominal or pelvic injury, a CT scan of his abdomen and pelvis was performed. Computerised 3D reconstruction showed the probable path of the bullet from the right buttock to the left side of the scrotum with no abdominal or pelvic pathology (Figures 2 & 3). The wounds were debrided and the child observed overnight. The buttock wound was closed 48 hours later.

Figure 2. 3D CT reconstruction with improvised wound markers visible (highlighted by white arrows).

Figure 3. When the pelvis is rotated into the sitting position, the markers are aligned to reveal the tract of the bullet. Fortunately the bullet did not pass through any vital structure and the patient was discharged 48 hours later.

Case 2

A 14-year old boy was admitted to the MTF after sustaining a GSW to his left flank with an exit wound in his right flank. He was haemodynamically stable but complained of mild abdominal tenderness. Small metallic fragments were visible on plain abdominal radiograph. CT scanning with wound markers revealed that the bullet had passed extra-peritoneally and that he had sustained a fracture of the spinous process of L2 (Figure 4). He did not have any neurological symptoms following the injury. In view of the CT findings, a laparotomy was deemed unnecessary and he underwent debridement of the wounds, which were closed 3 days later. Following an uneventful hospital admission, he was discharged home 4 days following injury.

Figure 4. 3D CT reconstruction with wound markers and the bullet tract passing through fractured spinous process of L2.

Case 3

A 30-year old soldier presented to the MTF following 2 GSWs to his left loin. A single wound was found in the right upper quadrant of his abdomen. He was profoundly hypotensive and was bleeding profusely from his wounds. Initial plain radiographs of his abdomen were difficult to obtain and were suspicious of a fracture of L2. He was immediately transferred to the operating theatre and a trauma laparotomy performed, where he was noted to have a Grade V laceration of his right kidney, a Grade I laceration of his left kidney and was bleeding profusely from a paraspinal wound. He underwent a right nephrectomy, repair of his left renal injury and packing of his paraspinal wound. Following surgery, his physiological parameters improved and he underwent CT scanning with wound markers to investigate his suspected spinal injury (Figure 5). The scan showed a fracture through the transverse process of L1 and through L2 with fragments visible within the spinal canal. The patient was aeromedically evacuated back to the UK with full spinal precautions and underwent spinal stabilisation.

Figure 5. This casualty sustained 2 GSW to the left flank with a single exit wound in the right upper quadrant. Following an emergency laparotomy the patient underwent CT scanning where a fracture of L2 was identified.

Case 4

A 30-year old civilian was involved in an improvised explosive device (IED) explosion sustaining a fragment wound to the right side of his neck. He was transported to the Role 2E facility sitting up where the initial primary survey revealed significant swelling of the neck and surgical emphysema. An x-ray of his head and neck showed that a fragment had traversed the midline. As he was not in respiratory distress and was cardiovascularly stable, a contrast CT angiogram with bullet marker in situ was performed to define and prioritise the injuries and assist in planning the surgical approach. 3D CT reconstruction demonstrated an arterio-venous fistula between the left carotid artery and internal jugular vein and a through and through injury to the trachea (Figure 6). His right side neck vessels were injured. He was transferred to the operating room and underwent left neck dissection, repair of the jugular vein, reverse vein graft to the carotid artery and a tracheostomy. Subsequently he made a full recovery without neurological deficit.

Figure 6. 3D CT reconstruction demonstrating the path of the fragment and an arteriovenous fistula between the carotid artery and internal jugular vein.

Discussion

CT produces cross-sectional images of planar tissue. Each tissue or fluid within the slice will absorb or scatter photons depending on its density; air is assigned -1000 Hounsfield units (HU), water is 0 HU and bone is 1000 HU [6]. Haematoma is approximately 60 HU whereas active bleeding has an attenuation of greater than 100 HU [7]. The track of a

projectile through tissue is defined by alterations in the native attenuation of that tissue. When bleeding, bone fragments or air bubbles accompany the track, the differentiation is straightforward, thereby allowing identification of the projectile path. When projectiles pass through soft tissue, causing oedema formation alone, changes in tissue attenuation can be subtle. The placement of wound markers can therefore aid identification of the projectile path and can help to narrow down the area of interest when interpreting the scans. This information can help inform the surgeon on the need for laparotomy, which can be important in the field hospital, setting where surgical resources are limited and multiple casualties often present from a single incident [8]. It may also help reduce the incidence of negative laparotomy from penetrating torso trauma.

Previous studies in civilian practice have shown that the number of wounds, location and direction the projectile took was rarely correctly recorded in medical notes [9, 10]. The use of markers with CT can therefore provide a permanent and accurate location of the wounds, which increases the ability to reconstruct a potentially complex case in medicolegal testimony.

Conclusion

We describe a new use of a previously described method of marking wounds prior to CT scanning. We believe that the use of bullet markers in penetrating trauma casualties undergoing CT is valuable in the surgical decision making process and allows planning of surgical approaches.

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References

1. Swan KG, Swan RC. Principles of ballistics applicable to the treatment of gunshot wounds. Surg Clin North Am 1991;71(2):221-39.
2. George PY, Goodman P. Radiographic appearance of bullet tracks in the lung. Am J Roentgenol. 1992;159(5):967-70.
3. Brooks A, Bowley DM, Boffard KD. Bullet markers--a simple technique to assist in the evaluation of penetrating trauma. J R Army Med Corps 2002;148(3):259-61.
4. Beekley AC et al. Selective nonoperative management of penetrating torso injury from combat fragmentation wounds. J Trauma 2008; 64:S108-S117.
5. Demetriades D, Velmahos G, Cornwell E et al. Selective nonoperative management of gunshot wounds of the anterior abdomen. Arch Surg 1997;132(2):178-83.
6. Lee H. General Principles of Computed Tomography. Lee H, Krishna C, editors. New York, NY: McGraw-Hill; 1984.
7. Raptopoulos V. Abdominal trauma. Emphasis on computed tomography. Radiol Clin North Am 1994;32(5):969-87.
8. Hinsley DE, Rosell PA, Rowlands TK, Clasper JC. Penetrating missile injuries during asymmetric warfare in the 2003 Gulf conflict. Br J Surg 2005;92(5):637-42.
9. Shuman M, Wright RK. Evaluation of clinician accuracy in describing gunshot wound injuries. J Forensic Sci 1999;44(2):339-42.
10. Ross RT, Hammen PF, Frantz EI, Pare LE, Boyd CR. Gunshot wounds: evaluating the adequacy of documentation at a Level I trauma center. J Trauma 1998;45(1):151-2.