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# Unexpected multiple intra-abdominal injuries after projectile fragmentation: report of three cases

## Parça tesirli mermiyle beklenmedik çoklu karıniçi yaralanmalar: Üç olgu sunumu

**Aytekin ÜNLÜ,[1,2] Patrizio PETRONE,[3] Tamer KARŞIDAĞ,[1] Juan A. ASENSİO[1]**

Explosives create and energize particles that act as projectiles prone to further fragmentation or create other secondary missiles in the body. These fragments may result in secondary injuries. This has been repeatedly described in the orthopedic and neurosurgical literature. We report the same process for abdominal injuries after fascial penetration in the military setting. This is an observational case series study. Local wound exploration as a standard approach was performed in conscious patients who sustained abdominal wall injuries. Patients with negative physical examination were excluded from the study. An intraperitoneal injury was assumed in those with a full-thickness fascial defect, and laparotomy was performed. Twenty patients met the study eligibility criteria. Of those 20 patients, 12 had negative wound exploration and were excluded from the study, while abdominal organ injuries were found in eight (40%) patients. During laparotomy, projectile-induced injuries in a sprayed distribution were found in three (38%) of these patients. These injuries were far from the predictable trajectory and in the absence of bone fragmentation. The overall mean number of peritoneal defects was 1.7, and a mean 6.8 intra-abdominal injuries for each peritoneal defect were found when through-and-through injuries were excluded. Despite a single peritoneal defect, there may be multiple intraperitoneal injuries due to further fragmentation of the projectile. Under mass casualties, wound exploration with a full-thickness fascial defect could serve as an indicator of possible intra-abdominal injuries, and consequently indicate exploratory laparotomy.

***Key Words:*** Abdominal; explosive; penetrating injuries; projectile; fragmentation.

Patlayıcılar, daha fazla parçalanmaya eğilimli veya vücut içinde daha başka mermiler oluşturan parçacıklar yaratıp onlara enerji yüklerler. Bu parçacıklar ikincil yaralanmalara yol açabilirler. Bu durum ortopedi ve nöroşirürji literatüründe tekrar tekrar anlatılmıştır. Biz, askeri ortamda fasyayı deldikten sonra oluşan karın yaralanmaları için de aynı süreci raporlamaktayız. Bu bir gözlemsel olgu serisi çalışmasıdır. Karın duvarı yaralanmalarına maruz kalmış bilinci açık hastalarda standart yaklaşım olarak lokal yara eksplorasyonu uygulandı. Fiziksel inceleme sonuçları negatif hastalar çalışmadan çıkartıldı. Tam kat fasya defekti olanlarda periton içi yaralanma olduğu varsayılarak laparotomi uygulandı. Yirmi hasta çalışmaya uygunluk kriterlerini karşılamıştı. Bu 20 hastanın 12'sinde yara eksplorasyonunda anormal sonuç çıkmadı, sekiz (%40) hastada abdominal organ yaralanmaları saptandı. Laparotomi sırasında bu hastaların üçünde (%38) mermi yaralanmaları dağınık bir dağılım sergiledi. Bu yaralanmalar öngörülen mermi yolundan uzakta olup kemik parçalanmamıştı. Perforan yaralanmalar dışlandığında genelde ortalama periton defekti sayısı 1.7 olup her bir periton defekti için ortalama 6.8 karın içi yaralanma mevcuttu. Tek bir periton defektine rağmen merminin parça tesirli olması nedeniyle birden çok sayıda periton içi yaralanma oluşabilmektedir. Kitlesel yaralanmalarda tam kat fasya defektiyle yara eksplorasyonu olası karın içi yaralanmaların bir göstergesi olarak işlev gördüğü gibi sonuçta eksploratuvar laparotomiyi gerektirir.

***Anahtar Sözcükler:*** Karın; patlayıcı; penetran yaralanmalar; mermi; fragmantasyon.

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[1]Division of Trauma Surgery and Surgical Critical Care, Dewitt Daughtry Family Department of Surgery, University of Miami Miller School of Medicine, Ryder Trauma Center, Miami, Florida, USA; [2]Division of Health, Gendarmerie General Headquarters, Ankara, Turkey; [3]Ministry of Health, La Plata, Province of Buenos Aires, Argentina.

[1]Dewitt Daughtry Aile Hekimliği-Cerrahi Travma Cerrahisi ve Cerrahi Yoğun Bakım Bölümü, Miami Üniversitesi Tıp Fakültesi Ryder Travma Merkezi, Miami, Florida, ABD; [2]Jandarma Genel Komutanlığı, Sağlık Bölümü, Ankara, Türkiye; [3]Sağlık Bakanlığı, La Plata, Buenos Aires, Arjantin.

Correspondence *(İletişim):* Patrizio Petrone, M.D. 15 - 1308, 3º "A" 1900 La Plata, Argentina.
e-mail *(e-posta):* patrizio.petrone@gmail.com

During the last century, most battlefield injuries have been caused by projectiles created due to fragmentation of explosives.[1,2] Military missiles with explosive coverings such as mortars or high-explosive shells are designed to fragment and thus maximize damage. In order to increase the probability of an impact, these ammunitions are designed to create multiple high- and low-velocity fragments, weighing between 200 and 500 mg.[3] As described for soft point bullets,[4] we speculate that these irregular-shaped, sometimes large fragments are prone to further fragmentation upon entering the tissues, thus increasing the amount and degree of injury.

Shattered and fragmented bone caused by missiles or secondary blast effect can also act as secondary missiles that further increase tissue injury.[5-8] This phenomenon has been shown in both the neurosurgical and orthopedic literature.[9-13] Small entry wounds from a fragment are deceptive, as they could be associated with extensive internal injury and do not always follow a straight line.[14] In this report, we describe the same process for abdominal injuries thereby increasing injury severity.

All casualties were evacuated by Turkish Army helicopters. Time from the field to the combat support hospital was less than 50 minutes. They were resuscitated during evacuation by the Trauma Evacuation Team, and none of the casualties was hypotensive on arrival.

All conscious casualties sustaining abdominal wall injuries were evaluated with physical exam. Systematic wound exploration was employed in all patients. When possible, wounds were explored in the operating room under local anesthesia with adequate instruments and exposure. Whenever a full-thickness fascial defect was detected, the presence of an intraperitoneal injury was assumed and exploratory laparotomy was performed.

A total of 20 patients met the eligibility criteria of this observational study. Twelve patients had negative wound exploration and were subsequently excluded from the study. Eight (40%) patients presented full-thickness fascial defects, all of whom sustained intra-abdominal injuries confirmed during laparotomy. One patient had isolated American Association for the Surgery of Trauma-Organ Injury Scale (AAST-OIS) Grade II liver injury that was primarily repaired. The remaining seven patients mostly sustained multiple small and large bowel injuries. In three (3/8, 38%) of these patients, wide-angled and sprayed distribution of projectile associated with intra-abdominal injuries was found during laparotomy, exceeding the number of fascial defects. These injuries were far from a possible and predictable trajectory and in the absence of bone fragmentation. The mean number of peritoneal defects was 1.7, and a mean 6.8 intra-abdominal injuries for each peritoneal defect were found after through-and-through injuries were excluded.

Clinical presentation, physical exam and outcome of the three above-mentioned patients are presented below.

## CASE REPORTS

***Case 1–*** Injury was due to an assault, hand-grenade explosion type. The patient presented with a single midline 0.6 cm abdominal wall defect. Wound examination showed a single fascial defect and physical examination revealed positive rebound tenderness. At laparotomy, a 3 mm perforation on the ileal antimesenteric wall was found, as well as hematomas on the mesentery junction of the transverse and sigmoid colon. These hematomas were explored, and 3-5 mm perforations on the mesenteric wall of the sigmoid and transverse colon were found, which were debrided and primarily repaired. Re-examination of the peritoneum showed a single shrapnel entrance.

***Case 2–*** Injury was due to an improvised explosive device (IED). The patient presented a 3 cm right lower quadrant defect with small bowel evisceration and a 0.5 cm infraumbilical midline defect. He also had minor cutaneous fragment wounds on the lower and upper extremities. At laparotomy, multiple AAST-OIS Grades I-IV ileal injuries in a 20 cm segment were found, and subsequently treated by resection and anastomosis. AAST-OIS Grade II ascending colon and AAST-OIS Grade II urinary bladder perforations were also found and primarily treated. Careful inspection was performed and no additional peritoneal penetration was found. The abdominal wall defect was debrided and irrigated vigorously and closed primarily with closed suction drainage.

***Case 3–*** Injury in this case was due to an IED. Abdominal wall defects were located in the left upper

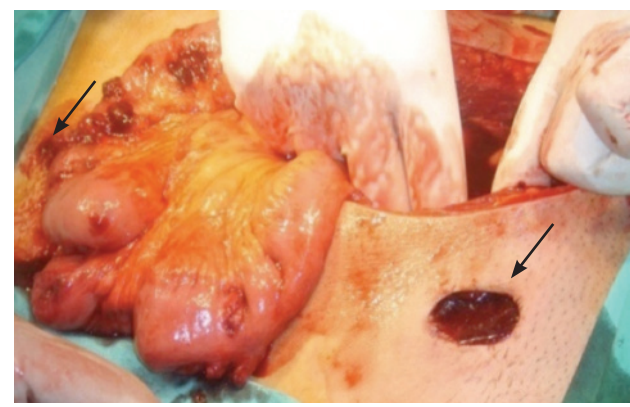

**Fig. 1.** Multiple small bowel injuries and two entrance wounds (arrows).

*(Color figure can be viewed in the online issue, which is available at www.tjtes.org).*

quadrant (4 cm, oval-shaped) and suprapubic (0.8 cm, irregular-shaped) regions. During laparotomy, multiple AAST-OIS Grade I-IV injuries involving a 30 cm small bowel segment as well as multiple AAST-OIS Grade II cecum, transverse colon and rectum injuries were present (Fig. 1). Resection of the affected small intestinal segment and primary suture of the other large intestinal injuries were performed. There were widespread intra-abdominal injuries despite only two entrances.

All three patients were transported to the military base hospital after they gained full gastrointestinal recovery, and from there they were discharged without complications.

## DISCUSSION

The anatomical distribution of the wounds was similar between explosives and gunshot wounds. In orthopedic trauma, injuries are mostly caused by fragments (60-70%).[15-17] Likewise, abdominal injury incidence has been reported to be 10%, and most commonly due to the same mechanisms as limb injuries.[18]

Explosives usually cause multiple penetrating torso injuries.[15,19,20] The conventional approach is typically to explore the fragment wounds.[21] Under mass casualty circumstances like the London and Madrid bombings, trauma centers may have much higher negative laparotomy rates.[19,22,23] Wound exploration may help in the decision-making process to choose surgery candidates, thus more hospital resources can be available when needed.

Bala et al.[24] reported that the majority of the related fragment injuries were inflicted to small and large intestines, and in one-fifth of these cases, the injuries involved more than one segment of the bowel. They explained this special pattern of injury by the multiplicity of penetrations over a large area.

This pattern was also observed in the cases of the present report, but was not essentially attributable to multiple penetrating fragments. While missile fragmentation in the body may increase the temporary cavity effect and tissue damage, the explosives are specifically designed to create fragments to maximize damage via projectile injuries. These fragments have irregular shapes and lack streamlining. As in some missile types, they are prone to further fragmentation upon hitting the target, and after penetrating the tissue, they exert a thumbling[6] or shimmy effect, which further increases tissue damage. However, weakened structurally by the detonation, a fragment may further break during the shimmy effect against tissue resistance or en route, creating extensive internal damage despite a single wound.

In the present report, all wounds were individually assessed, if possible, given the patient's hemodynamic status. All patients with a full-thickness fascial defect had a positive laparotomy. One patient had a non-therapeutic laparotomy, sustaining an injury to the liver. Patients with negative wound exploration were discharged without any evidence of a missed injury, which was later confirmed by a proper follow-up. In 38% of our patients, when the through-and-through injuries were excluded, we found multiple injuries mostly on the antimesenteric bowel wall. Besides the fact that the bowel is very mobile and one can find injuries outside the estimated trajectory, after peritoneal penetration, these injuries were scattered unevenly at a wide angle, which we could describe as 'spraying many fragments from a barrel'.

In conclusion, meticulous abdominal exploration is mandatory for every penetrating abdominal injury. While recognizing the small number of patients in this series, we emphasize that, despite a single peritoneal defect, there may be multiple intraperitoneal injuries due to further fragmentation of the projectile. Under mass casualty disaster, surgeons need to be expeditious in clearing the operating rooms for other casualties, and it is only under these circumstances that exploration of a wound with a full-thickness fascial defect could serve as an indicator of possible intra-abdominal injuries, indicating exploratory laparotomy. One should be alert to unexpected intra-abdominal injuries associated with explosive-related fragments.

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