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Review Article

Extra Articular Pelvic Fractures with Concomitant Gastrointestinal Injury Caused by Ballistic Trauma are Harbingers of Intra-Abdominal and Retroperitoneal Abscesses

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Abstract

Introduction: Gastrointestinal (GI) injuries with associated pelvic fractures caused by ballistic trauma result in local contamination. Recent literature has suggested that irrigation and debridement may not be necessary despite GI contamination. Although this approach my not alter the incidence of osteomyelitis, there is a lack of evidence that irrigation and debridement of bone fragments could alter the incidence of retroperitoneal and intra-abdominal abscesses. We hypothesize that contaminated and devascularized bone fragments from Extra-Articular Pelvic Fractures (EAPF) can become a nidus of recalcitrant intra-abdominal and retroperitoneal infections. The goal of this study was to examine the outcomes of contaminated EAPF in ballistic trauma managed without local irrigation and debridement.

Methods: A 1-year prospective study of consecutive adult patients presenting to a Brazilian level 1 trauma center with abdominopelvic gunshot wounds and EAPF or GI injury that did not undergo operative debridement and washout of the soft tissue neighboring the fracture site. The main outcome measure was development of soft tissue infectious complication defined as peritoneal or retroperitoneal abscess.

Results: A total of 82 patients were divided into 3 cohorts: A) EAPF with an associated GI injury (n=32, 39%), B) EAPF with a urological injury or no associated GI or urological injury (n=21, 26%), and C) isolated GI injury without an associated EAPF (n=29, 35%). Overall, 14 patients (17%) developed an infectious complication, 11 patients from cohort A (34%), 1 patient from cohort B (5%), and 2 patients from cohort C (7%). The odds of developing an infectious complication in cohort A were 10.5 times higher compared to cohort B and 7.1 higher compared to cohort C. Cohort A was found to have significantly higher readmission rates and lengths of stay. Compared to other areas of the gastrointestinal tract, the odds of developing an infectious complication were 6 times greater for an injury to the rectum.

Conclusion: GI injuries with pelvic fractures caused by ballistic trauma are associated with up to 10 fold increase in retroperitoneal and intra-abdominal abscesses. Future studies are needed to investigate whether, during the trauma laparotomy to repair GI injuries, irrigation and debridement of devascularized bone fragments embedded in the soft tissue would decrease the incidence of post-operative infection.

Keywords: Abscess; Gunshot wound; Infectious complications; Pelvic fracture

Introduction

Firearm injuries continue to be a major cause of morbidity and mortality worldwide, in both civilian and military populations [1,2]. As a result, the shared understanding amongst trauma surgeons with regards to the management of specific patterns of Gunshot Wounds (GSW) has grown and resulted in less aggressive operative strategies [3-5]. However, ballistic trauma to the abdominopelvic region is frequently associated with injuries to the Gastrointestinal (GI) tract that lead to contamination [4,6]. Therefore, a conservative management of the local contamination of associated pelvic fractures in this setting could potentially result in infectious complications.

Expedited surgical debridement and antimicrobial therapy are advocated for high velocity ballistic injuries to the pelvis with an intra-articular (i.e., acetabular, sacro-iliac joints) component [4-7]. This approach potentially decreases the risk of fulminant joint infection and subsequent chronic complications [4,6-8]. Although infectious complications in isolated pelvic fractures caused by low-velocity GSW are uncommon, concurrent injuries to the GI tract could potentially result in recalcitrant intra-abdominal and retroperitoneal infections, particularly in the presence of devitalized bony fragments and devascularized/injured soft tissue [6-8]. However, previous studies suggest that irrigation and debridement of Extra-Articular Pelvic Fractures (EAPF) caused by low-velocity GSW may not be necessary despite concomitant GI injury [8,9]. Although this approach my not alter the incidence of osteomyelitis, there is a lack of evidence that irrigation and debridement of bone fragments could alter the incidence

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of retroperitoneal and intra-abdominal abscesses. Contaminated bone fragments embedded in devascularized soft tissue can become a nidus of recalcitrant intra-abdominal and retroperitoneal infections [10-13]. The goal of this study was to examine the outcomes of contaminated EAPF in ballistic trauma managed without local irrigation and debridement. We hypothesized that patients who sustained GSW with concomitant EAPF and GI injury would have higher soft tissue infectious complication rates compared to patients without associated GI injuries.

Methods

This single-center, prospective, observational, descriptive, study was approved by the Research Ethics Committee of the Risoleta Tolentino Neves Hospital (Belo Horizonte, Brazil), and was in accordance with research ethics resolution number 196/96 of the Brazilian Ministry of Health. This study was registered under study registration number CAAE 39504714.3.0000.5149 (Registered October 1, 2010). Consent for publication was obtained from patients or next of kin.

Setting

The study was conducted at a single Brazilian level 1 academic trauma center between January and August 2016. The catchment area of this trauma center comprises the city of Belo Horizonte; the third largest metropolitan area in Brazil with approximately 5.2 million inhabitants. The trauma center receives nearly 10,000 trauma patients a year, 70% are victims of penetrating traumas; mostly from firearms.

Inclusion and exclusion criteria

Consecutive trauma patients between the ages of 14 and 66 years with abdominopelvic gunshot wounds were screened. Those who sustained either a GI injury (i.e., stomach, small intestine, colon, or rectum) and/or Extra-Articular Pelvic Fracture (EAPF) (sacrum, ilium, pubis, ischium, or coccyx) were included in the study. Patients were divided into 3 cohorts for comparison: A) EAPF plus associated GI injury, B) EAPF without GI injury plus or minus urological injury, C) GI injury without associated EAPF. None of the patients in the cohorts underwent operative debridement and washout of the soft tissue neighboring the fracture site. All patients received intravenous cefazolin 1g (2g if > 80Kg and < 120Kg) and metronidazole (500mg) for 24 hours.

Exclusion criteria encompassed patients with isolated lumbar spine or pelvic fractures deemed to be intra-articular (i.e., acetabular fractures or those extending into the sacroiliac joints). Moreover, patients who were hemodynamically unstable on arrival, who required admission to the Intensive Care Unit (ICU), underwent damage control surgery, and those who underwent parenteral nutrition were excluded given possible association between hemorrhagic shock, peri-operative transfusion of blood products, with postoperative infection and immunomodulation [14]. Hemodynamic instability was defined as systolic blood pressure < 90mmHg and the necessity for transfusion of Packed Red Blood Cells (PRBC) or any other blood product.

Data collection and follow up

The following data points were recorded prospectively: age, sex, site of GI injury, site of pelvic fracture, occurrence of bladder or ureteric injury, general surgical operative management, Length of In-Patient Hospital Stay (LOS), readmission, and mortality.

Our main outcome measure was the development of infectious complications defined as peritoneal or retroperitoneal abscesses confirmed by surgery, percutaneous drainage of the collection, or microbiology results of specimens. Patients were followed from the time of admission until hospital discharge, and had two study follow-up visits at 15 and 30 days post-discharge. Any suspicion of intra-abdominal or retroperitoneal infection, including discharge of purulent secretion through bullet wounds, prompted investigation with abdominal and pelvic Computed Tomography (CT) with intravenous, oral, and rectal contrast if indicated (Siemens Somatom Balance CT57, Berlin, Germany).

Statistical analysis

Mean values were calculated for continuous variables. Continuous variables were compared using student's t-test, whilst categorical variables were analyzed utilizing the Chi-square statistic. We fitted a logistic regression model which estimates the odds ratios and 95% confidence intervals and a log-binomial model which estimates the risk ratios and 95% confidence intervals. Cohort B was used as reference cohort in regression models. Statistical significance was assumed with a p-value < 0.05. Analyses were performed using SPSS Version 20 (IBM Corporation, USA, 2011).

Results

A total of 82 patients met the study inclusion criteria: Cohort A: (n=32, 39%), Cohort B: (n=21, 26%), and Cohort C: (n=29, 35%) (Table 1). The mean age of the patient population was 27.5 years (SD 11.4), 95% of patients were male.

	Cohort A (n=32)	Cohort B (n=21)	Cohort C (n=29)	p-value
Age in years, mean (SD)	28±13.5	26±12.8	29±11.2	
Male sex	29 (91)	21 (100)	28 (97)	0.27
ISS, median (IQR)	15 (9-18)	9 (4-9)	9 (8-16)	<0.001
Infectious complication	11 (34)	1 (5)	2 (7)	0.004
Readmission	6 (19)	1 (5)	0 (0)	0.027
Mortality	1 (3)	0 (0)	0 (0)	0.46
All values to be completed as n (%) unless otherwise stated				

Table 1: Patient characteristics.

Cohort A: Extra-Articular Pelvic Fractures (EAPF) with associated GI injury caused by ballistic trauma; Cohort B: EAPF without GI injury plus or minus urological injury caused by ballistic trauma; Cohort C: GI injury caused by ballistic trauma without associated EAPF.

Infectious complications

Overall, 14 patients (17%) went on to develop an infectious complication defined as intra-abdominal/retroperitoneal abscess. Statistically significant higher rates of infectious complications were observed in cohort A (n=11, 34%) compared to cohort B (n=1, 5%), and cohort C (n=2, 7%); *p*=0.0005. The likelihood of infectious complications was 10.5 times higher in those with EAPF and GI contamination as compared with those with EAPF without GI contamination (OR 10.5, 95% CI 1.2-88.7, p=0.0312). Furthermore, the likelihood of infectious complications amongst those with EAPF and GI contamination was 7 times higher compared to those with GI injuries and no EAPF (OR 7.1, 95% CI 1.4-35.4, p=0.0494).

The mean length of time between the initial operation and the diagnosis of the infectious complication was 13.9 (±5.7) days. Every patient received appropriate antimicrobial therapy regardless of the management strategy. Of those with infectious complications, abscesses were percutaneously drained under ultra-sound or CT scan guidance in 57% (n=8) of patients. The remaining 6 patients underwent a laparotomy for abscess drainage, all of those patients belonged to cohort A. In all cases treated through a laparotomy, the abscess cavity contained purulent secretion, necrotic tissue and bone fragments (Figure 1 and Figure 2). Fluid collected from the abscesses of 7 patients was subjected to culture. The most frequent bacterial isolates were *Escherichia coli*, *Staphylococcus aureus*, and *Enterococcus faecalis* (Table 2).

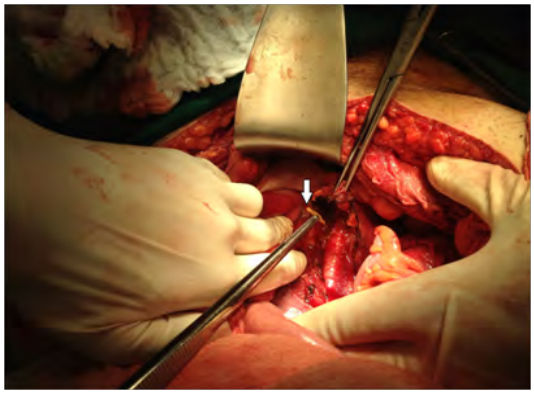

Figure 1: Intra-operative photograph depicting a displaced bone fragment (arrow) removed from an abscess cavity extending into the retro peritoneum in a cohort a patient (Extra-Articular Pelvic Fractures (EAPF) caused by ballistic trauma with associated GI injury).

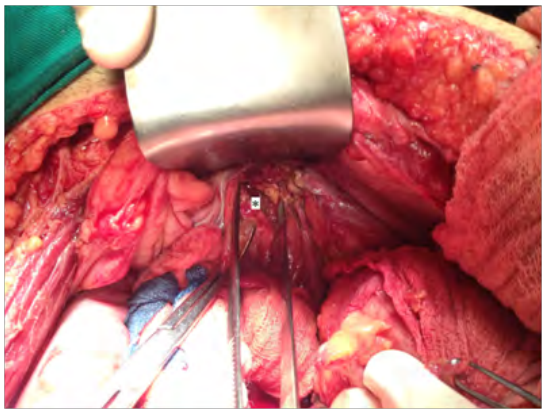

Figure 2: Intra-operative photograph of an abscess cavity (asterisk) extending into the retro peritoneum from a patient in cohort An Extra-Articular Pelvic Fractures (EAPF) caused by ballistic trauma with associated GI injury).

Type of GI injury

We attempted to discern whether the site of GI injury could be associated with infectious complications. Within the patients from cohort A, we determined the site of GI injury. Rectal injuries accounted for the majority of infectious complications in cohort A (n=9, 82%). Of the twenty-one patients from cohort A whom did not have an infectious complications, only five had an injury arising from the rectum (n=5, 24%). Patients who had a rectal injury with an associated EAPF were 6 times more likely to develop an infectious complication than patients with a GI injury from another site and an EAPF (RR 5.8, 95% CI 1.48 - 22.6, p=0.0028).

	Cohort A (n=32)	Cohort B (n=21)	Cohort C (n=29)
Site of GI injury			
Stomach	3 (9)	-	1 (3)
Small bowel	24 (75)	-	21 (72)
Colon	19 (59)	-	21 (72)
Rectum	14 (44)	-	2 (10)
Bladder Injury	6 (19)	5 (23)	2 (10)
Site of pelvic fracture			
Sacrum	11 (34)	3 (14)	-
Ilium	16 (50)	12 (57)	-
Pubis	2 (6)	3 (14)	-
Ischium	3 (9)	3 (14)	-
Coccyx	2 (6)	0 (0)	-
All values to be completed as n (%) unless otherwise stated			

Table 2: Injury patterns.

Cohort A: Extra-Articular Pelvic Fractures (EAPF) caused by ballistic trauma with associated GI injury; Cohort B: EAPF caused by ballistic trauma without GI injury plus or minus urological injury; Cohort C: GI injury caused by ballistic trauma without associated EAPF.

There were no cases of leaks from GI anastomosis or suture repairs in any of the patients in cohorts A and C. Similarly, there were no bladder fistulas in patients who sustained bladder injuries in cohort B. A total of 12 patients in cohort A underwent a colostomy during the initial operation, 7 of them developed a pelvic abscess. One patient in cohort C underwent a colostomy and there were no complications. There were no colostomies performed in cohort B patients.

Readmission rates & length of stay

Patients from cohort A were found to have had a significantly higher readmission rate related to their infectious complications (n=6, 19%) compared to cohort B (n=0, 0%) and cohort C (n=1, 5%), p-value of 0.024. In addition, the median length of stay during the first admission was longer in cohort A (8.5 days) compared to cohort B (5.0 day) and cohort C (4.0 days), p-value less than 0.0001.

Discussion

Our study prospectively documented intraabdominal and retroperitoneal infectious complications in patients with EAPF and had three main findings. Firstly, the odds of infectious complications in patients with EAPF and associated GI injuries (cohort A) was 10.5 times higher when compared to those with EAPF alone or with associated bladder injuries (cohort B, p=0.0312) and 7.1 times higher when compared to those with GI injuries without EAPF (cohort C, p=0.0494). These findings are in keeping with our hypothesis that the combination of contaminated and devascularized soft tissue with bone fragments displaced from pelvic fractures could become a nidus of intra-abdominal and retroperitoneal abscesses in the setting of gastrointestinal injuries. The lack of difference in the odds of abscess formation between cohorts B and C suggests that the combination of

GI contamination and EAPF was a key factor (OR 1.48, 95% CI 0.13-17.50, p=0.755). Moreover, abscess fluid culture bacterial isolates from cohort A also suggest that the primary source of contamination was from the gastrointestinal tract (Table 3).

Bacterial isolate	Cohort A	Cohort B	Cohort C
Escherichia coli	5	0	1
Staphylococcus aureus	3	1	0
Enterococcus faecalis	2	0	1
Proteus mirabilis	1	0	0

Table 3: Abscess fluid culture isolates.

Cohort A: Extra-Articular Pelvic Fractures (EAPF) caused by ballistic trauma with associated GI injury; Cohort B: EAPF caused by ballistic trauma without GI injury plus or minus urological injury; Cohort C: GI injury caused by ballistic trauma without associated EAPF. All patients in cohort A and C had concomitantly 2 or more bacterial isolates in every culture. Fluid cultures were performed in the microbiology laboratory of the Risoleta Tolentino Neves Hospital.

The second main finding of our study was that patients in cohort A with rectal injuries were 6 times more likely to develop an infectious complication than patients with an injury in another location of the GI tract. The anatomical locations of the colon and the rectum render these organs more susceptible to injuries in ballistic pelvic trauma. In our series, only the small bowel was injured more frequently. In general, the complication rate of traumatic rectal injuries is greater than 50% and septic related complications occur in approximately 15% of the patients. It has been well documented in previous studies that the incidence of abscess formation in penetrating abdominal/pelvic trauma with multivisceral injuries increases with concomitant colorectal injury [15,16]. Comparably, our results showed that the odds infectious complications was also augmented with concurrent rectal injuries. This notion and concluded that further supported by the results of the abscess fluid culture isolates in our study.

Lastly, patients who developed infectious complications had significantly higher readmission rates and longer hospital lengths of stay. Previous studies have shown an association between infectious complications in trauma patients with a more prolonged stay in the hospital [14,17,18]. Although extended stay in hospital can be linked to several factors, the higher readmission rate in our study population was directly linked to the formation of intra-abdominal and retroperitoneal abscesses.

Our findings show that given the higher likelihood of soft tissue infectious complications and its associated prolonged length of stay and readmissions, the rationale for local debridement and washout of these injuries seems logical. Nonetheless, this approach remains poorly defined mainly because previous studies were limited by three important factors: retrospective nature, small sample size, and large variability in patient population and surgical management. We compiled data obtained from contemporary publications to validate those limitations. Our analysis revealed that in those studies only 37 patients' unequivocally sustained injuries to the GI tract with concurrent EAPF caused by ballistic trauma [9,19-21]. The studies by Watters J, et al. and Muhdi S, et al. describe a total of 10 patients who underwent debridement and or washout of contaminated tissue and fracture site, none of them developed an infection. An additional seven patients in the studies by Bartkiw MJ, et al. and Demirbas S, et al. underwent similar procedure, only one patient developed local infection. Collectively in those studies, 20 patients with GI tract injury and concurrent EAPF caused by ballistic trauma did not undergo debridement or washout, 5 of those patients developed local infection [9,19-21]. An additional retrospective study by Rehman S, et al., showed no cases of intra-abdominal or retroperitoneal abscesses postoperatively in patients who underwent laparotomy for repair of GI injury with concurrent EAPF caused by ballistic trauma [8]. According to this study, however, washout of the contaminated area was performed at the discretion of the surgeon. Therefore, the actual role of debridement and washout of those injuries cannot be determined by their results. Moreover, data pertaining to the clinical condition of the patients and the severity of the injuries were not reported [8]. Lastly, in a more recent systematic review of 58 articles pertaining to debridement practices in gunshot-induced fractures the authors conclude that EAPF with bowel injury have conflicting evidence for debridement [7]. The authors of that study did not recommend for or against washout and debridement of gunshot-induced EAPF with bowel injury given the limited number of studies on this topic, and concluded that prospective trials for extensive versus superficial debridement of bowel-contaminated ballistic fractures are needed [7].

Our study has a series of limitations. This was a prospective observational study; we are not able to ascertain if washout and debridement of the area of the fracture and adjacent tissue can potentially reduce the rate of abscess formation postoperatively. However, our findings support additional investigation into the role of this approach. Secondly, this was a single-centre trial and results may not be extrapolated to all centers. Lastly, our sample was limited to patients without hemodynamic instability on arrival; thus, findings may not be extrapolated to all patients with trans-cavitary GSW. The rationale of excluding hemodynamically unstable patients was to reduce confounding risk factors for infection (i.e., received blood products, required intensive care unit admission, and underwent damage control procedures). Hence, the incidence of abscesses reported herein can be primarily attributed to local factors at the site of the injury involving contaminated devascularized soft tissue and bone fragments displaced from pelvic fractures.

Conclusion and Implications

Gastrointestinal and colon injuries with concomitant pelvic fractures caused by ballistic trauma are associated with up to 10 fold increase in retroperitoneal and intra-abdominal abscesses. Future studies are needed to investigate whether, during the trauma laparotomy to repair GI injuries, irrigation and debridement of devascularized bone fragments embedded in the soft tissue would decrease the incidence of post-operative infection.

List of abbreviations

- GSW: Gunshot wound
- GI: Gastrointestinal
- EAPF: Extra-articular pelvic fracture
- ICU: Intensive Care Unit
- PRBC: Packed Red Blood Cells
- LOS: Length of Stay
- CT: Computed tomography

Statement

- Consent to Publish was obtained from all patients involved in this study as per study protocol registration number: CAAE

39504714.3.0000.5149. Registered October 1, 2010. A copy of the consent form is available upon request

- **Ethics Approval:** approved by the Research Ethics Committee of the Risoleta Tolentino Neves Hospital (Belo Horizonte, Brazil), and was in accordance with research ethics resolution number 196/96 of the Brazilian Ministry of Health. Study Registration: CAAE 39504714.3.0000.5149. Registered October 1, 2010
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