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GENERAL REVIEW

A review of open pelvic fractures with concurrent genitourinary injuries

Eric H. Tischler[1] · Adam J. Wolfert[1] · Thomas Lyon[2] · Nishant Suneja[1]

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Abstract

Introduction Open pelvic fractures (OPFs) are uncommon but potentially lethal traumatic injuries. Often caused by high energy blunt trauma, they can cause severe injury to abdominal and pelvic structures. We sought to conduct a review of the literature in order to ascertain the rates of genitourinary injury and vaginal laceration after OPF and the rates of resulting infection and mortality.

Methods A review of PubMed was conducted to identify studies reporting the rates of genitourinary injury from OPF. Study characteristics, patient characteristics, and outcomes were collected. The data were pooled, and descriptive statistics were obtained.

Results Eight studies encompassing 343 patients were included. Average age was 35.1 years (10–85.9), 28% were female, and the average Injury Severity Score was 26.5 (4–75). 95.5% of patients had a blunt mechanism of injury. Motor vehicle collision (23.9%), motorcycle accident (19.7%), and pedestrian struck (19.3%) were the most common etiologies. Overall mortality and infection rates were 31.2% and 18.7%, respectively. 19.7% of patients suffered an injury to the genitourinary system, and 32.4% of females sustained a vaginal laceration.

Discussion OPFs have the potential for extremely high morbidity and mortality. While much research has been done to prevent early mortality from hemorrhage, there is comparatively little research into late mortality stemming from infection and sepsis. Intravenous antibiotics are the mainstay of treatment, and local antibiotics usage has been encouraged. In patients with a vaginal laceration, it is important to provide antibiotic coverage for vaginal flora.

Keywords Open pelvic fracture · Genitourinary injury · Trauma · Infection · Antibiotics

Introduction

Open pelvic fractures (OPF) are a rare, yet devastating injury. OPF is defined as a fracture of the pelvis with direct communication to the outside environment through either the skin, rectum, and/or vagina [1]. Pelvic fractures comprise 3% of all skeletal injuries; 2–4% are OPFs. OPFs are associated with a high energy blunt or penetrating trauma mechanism of injury, most commonly from motor vehicle/pedestrian struck collisions. High energy pelvic impaction may cause medial fracture displacement, penetrating pelvic organs susceptible to wound inoculation and poly-microbial sepsis [1, 2]. The literature has reported associated genitourinary injuries including: bladder, urethra, rectum, and vagina; however, much of the reported literature consist of case reports, case series, and small retrospective studies.

Our aim was to conduct a review of the literature in order to ascertain rates of genitourinary injury and vaginal laceration from open pelvic fractures and the corresponding rates of infection and mortality. Additionally, we sought to review the literature surrounding the management of these associated injuries.

✉ Eric H. Tischler
erictischler@gmail.com

[1] Department of Orthopaedic Surgery and Rehabilitation Medicine, SUNY Downstate Health Sciences University, 450 Clarkson Avenue, MSC 30, Brooklyn, NY 11203, USA

[2] Department of Orthopedic Surgery, New York University Langone Hospital, 150 55th Street, Brooklyn, NY 11220, USA

Methods

A review of the current literature was conducted. PubMed was queried from the inception of the database to 2021. The database was queried to identify all studies on open pelvic fractures and concomitant genitourinary or gastrointestinal injuries. Inclusion criteria consisted of: (1) case series and cohort studies that reported either rates of infection, gastrointestinal injury (GI), genitourinary injury (GU), and/or vaginal laceration following OPF. Exclusion criteria were: studies not in English language, case reports, studies that reported combined rates of GI, GU, vaginal injuries among open and closed pelvic fractures.

The database was systematically searched using database specific combination of keywords and medical subject heading (MeSH) including: "Orthopedics"; "Fracture(s)," "Pelvic; Open, Closed"; "Genitourinary"; "Gastrointestinal"; "Vaginal"; "Superficial Infection"; "Deep Infection"; "Wound Dehiscence"; "Pulmonary Embolism," "Venous Thromboembolism," "Deep vein thrombosis," "mortality"; "in-hospital mortality." Reference lists in the included studies were utilized to obtain additional studies.

Studies were included regardless of publication date in order to provide the most comprehensive review of this topic. Due to the small number of studies and lack of prospective studies, further exclusion based on date would have limited analysis.

Two independent reviewers (EHT, AJW) evaluated eligible studies by titles and abstracts. Full text of relevant articles for further qualification was completed. All disagreements between reviewers were resolved through discussion to reach consensus. Data were extracted onto a pre-planned Microsoft Excel spreadsheet (version 16.32). Data fields included study characteristics (authors, year of publication, region of study, data source, study design, period of study), patient age, and outcome as defined above.

Statistical analyses were performed using Microsoft Excel (Version 16.45, Microsoft Corporation, 2021). Descriptive statistics were calculated based upon the weighted average of the number of patients in each study.

Results

Four-hundred forty-five studies were initially reviewed. Of these studies, 85% did not differentiate between open and closed pelvic fractures. Of the remaining studies, only eight published between 1980 and 2018 met inclusion criteria and were included in final review [3–10]. Characteristics of selected studies are included in Table 1. A total of 343 patients with an open pelvic fracture were identified. The average age at time of injury was 35.1 (Range: 10–85.9) years. 28% of patients were female. The average injury severity score (ISS) was 26.5 (Range: 4–75).

Of the patients with a reported mechanism of injury, 95.5% (252/264) and 4.6% (12/264) were blunt and penetrating traumas, respectively. The most common etiologies were motor vehicle collision (23.9%; 63/264) followed by motorcycle accident (19.7%; 52/264) and pedestrian struck (19.3%; 51/264). Of the patients with penetrating trauma, the vast majority were gunshot wounds. Mechanism of injury is reported in Table 2.

Three studies reported fracture pattern of the open pelvic fracture [4, 7, 8]. Of 137 fracture patterns reported, 40.1% (55/137), 46.0% (63/137), and 8.0% (11/137) were anteroposterior compression (APC) fractures, lateral

Table 1 Characteristics of studies included in the systematic review

Study	Patients (*n*)	Age (years)	ISS	Mortality (*n* (%))	Infection (*n* (%))	GU injury (*n* (%))	GI injury (*n* (%))	Female (*n* (%))	Vaginal laceration (*n* (% of female patients))
Cannada [3]	64	34 (17–57)	26 (9–50)	15 (23%)	10 (16%)	11 (17%)	20 (31%)	21 (33%)	9 (43%)
Black [4]	52	39 (19.3–85.9)	23 (4–50)	10 (19%)	–	8 (15%)	14 (27%)	9 (17%)	5 (56%)
Fu [5]	42	38	24.8	11 (26%)	–	6 (14%)	9 (21%)	17 (41%)	–
Giordano [6]	30	28.4 (19–46)	21 (15–41)	12 (40%)	–	7 (23%)	11 (36%)	5 (17%)	–
Dong [7]	41	32.8 (15–58)	31.4 (10–75)	10 (24%)	7 (17%)	12 (29%)	10 (24%)	9 (22%)	2 (22%)
Dente [8]	44	39.2 (13–77)	29.6 (10–66)	20 (45%)	6 (14%)	–	9 (20%)	14 (32%)	3 (21%)
Perry [9]	31	34 (10–75)	–	13 (42%)	10 (32%)	6 (19%)	11 (35%)	9 (29%)	1 (11%)
Jones [10]	39	32	29 (13–75)	16 (42%)	8 (21%)	9 (23%)	13 (33%)	12 (31%)	4 (33%)
Total	343	35.1 (10–85.9)	26.5 (4–75)	107 (31.2%)	41 (18.7%)	59 (19.7%)	97 (28.2%)	96 (28.0%)	24 (32.4%)

ISS = Injury Severity Score; GU = genitourinary; GI = gastrointestinal

Table 2 Mechanism of injury of open pelvic fracture in the included studies

Cause of injury	Number of patients (*n*)	Percentage of total patients (%)
Blunt trauma	**252**	**95.45**
MVC	63	23.86
Motorcycle	52	19.70
Pedestrian struck	51	19.32
Not categorized traffic accident	33	12.50
Industrial/heavy equipment	13	4.92
Fall	21	7.95
Not categorized blunt trauma	19	7.20
Penetrating trauma	**12**	**4.55**
Gunshot wound	8	3.03
Stab wound	1	0.38
Not categorized penetrating Trauma	3	1.14
Total	**264**	**100.00**

MVC = motor vehicle collision

compression (LC) fractures, and vertical shear (VS) fractures [11], respectively. Of the APC fractures, 21.8% (12/55), 30.9% (17/55), and 47.3% (26/55) were APC I, II, and III, respectively. Distribution of LC I, LC II, and LC III fractures was: 31.7% (20/63), 39.7% (25/63), and 28.6% (18/63), respectively. Three studies reported the Gustilo classification for 124 open pelvic fractures [7, 8, 10, 12], of which 16.1% (20/124), 38.7% (48/124), and 45.2% (56/124) were Type I, Type II, and Type III fractures, respectively. Fracture characteristics are reported in Table 3.

The overall reported mortality rate was 31.2% (107/343). Ninety-seven (28.2%) patients sustained an injury to the gastrointestinal system. Fifty-Nine (19.7%) patients sustained an injury to the genitourinary system. Twenty-four female patients sustained a concurrent vaginal laceration from their open pelvic fracture, representing 8.9% and 32.4% of total and female patients, respectively. The overall rate of wound infection was 18.7% (41/219).

Discussion

The aim of this study was to conduct a review of open pelvic fracture associated gastrointestinal, genitourinary, and vaginal injuries and determine the risk of mortality and infection.

Mortality

Pelvic fractures with open wounds in the perineum have a significantly higher morbidity and mortality. An injury severe enough to cause an open pelvic fracture will often present with other concurrent injuries contributing to high mortality rates.

Duchesne et al. [13] compared outcomes between open-book pelvic fractures with and without a perineal open wound. Patients with open perineal wound had significantly higher rates of sepsis, pelvic sepsis, ARDS, and multi-organ system failure [13]. Furthermore, patients with open peroneal wound injury also contributed to substantially higher hospital cost and length of stay [13].

Mortality rates from open pelvic fractures have improved over time given the continued algorithmic development of damage control orthopedic protocols [14]. From 1982 to 1983, Richardson et al. [15] and Naam et al. [16] reported a 50% and 60% mortality rate among patients with hemorrhagic open pelvic fractures, respectively. In 2020, Tseng et al. [17] and Mi et al. [18] reported a mortality rate of 21.6% and 23.7%, respectively. Siada et al. [14] proposed

Table 3 Fracture characteristics of included studies

Study	Patients (*n*)	Anteroposterior compression (APC)			Lateral compression (LC)			Vertical shear (VS)	Gustilo classification		
		APC I	APC II	APC III	LC I	LC II	LC III	VS	Type I	Type II	Type III
Cannada [3]	64										
Black [4]	52	1	3	11	11	10	8	–	–	–	–
Fu [5]	42	–	–	–	–	–	–	–	–	–	–
Giordano [6]	30	–	–	–	–	–	–	–	–	–	–
Dong [7]	41	9	6	6	1	7	3	9	10	17	14
Dente [8]	44	2	8	9	8	8	7	2	9	16	19
Perry [9]	31	–	–	–	–	–	–	–	–	–	–
Jones [10]	39	–	–	–	–	–	–	–	1	15	23
Total		12	17	26	20	25	18	11	20	48	56

that this improvement in mortality is due to advances in care of pelvic fracture patients including use of a standardized algorithm, the advent of massive transfusion protocols (MTP) to address hemorrhage and coagulopathy, as well as increased use of pelvic angiography.

The injury severity score (ISS) is a simple and validated scoring tool used to summarize the severity of injuries in trauma patients severity between patients with injuries in different anatomic regions ranging from 0 to 75 [19, 20]. In our study, the mean ISS was 26 representing profound injury, the highest category. Bolorunduro et al. [20] demonstrated that ISS of > 25 had an odds ratio of mortality of 55–89 when compared to ISS of < 9. This effect was particularly pronounced in female patients [20]. Giordano et al. [6] reported that among 30 patients with an OPF, all observed deaths were among patients with an ISS greater than 35. Furthermore, Hanson et al. [21] reported that among 43 open pelvic fractures cases, the average ISS for patients that survived and died was 26 and 40, respectively. High mortality seen in patients with an open pelvic fracture, as demonstrated in this review, can be explained by the extent of traumatic injury as evidenced by a high ISS.

Fracture management

Early management of OPF management focuses on resuscitation and management of hemodynamic stability. Surgical stabilization of the pelvis provides both bony stability and control of bleeding [22–24]. Early stabilization of the pelvis has been shown to improve outcomes with a reduction in blood loss and required transfusion [25]. Anterior external fixation is commonly utilized to stabilize acute pelvic fractures [22, 24, 25]. Pelvic binders are utilized to provide initial temporary stability to the pelvis and reduce blood loss and can be applied in the prehospital setting or on presentation to the hospital [26–28]. While pelvic binders are excellent option and are the preferred noninvasive method to achieve temporary stabilization of the pelvis, pelvic binders can lead to soft tissue damage due to excessive pressure as well as preclude access to much of the abdomen, pelvis, and perineum [34]. Therefore, pelvic binder usage is usually limited to 24–48 h and external fixation is also beneficial for trauma patients undergoing concomitant procedures such as an exploratory laparotomy [25, 26]. External fixation can be used as definitive fixation or be transitioned to internal fixation for definitive management, while a pelvic binder must be replaced with another form of fixation [26, 28].

Concurrent genitourinary injuries

Pelvic fractures are highly associated with injury to other abdominal and pelvic organs. Acute management of genitourinary injuries in the setting of a pelvic fracture requires a multidisciplinary interdepartmental approach including obstetrics/gynecology, urology, and general surgery. Injury to the bladder is common in pelvic fractures. Moss et al. [29] reported that among 12,374 motorcyclists admitted to the hospital, 81% and 92% of bladder and urethral injuries presented with pelvic fractures.

Bladder injury

Patients presenting with clinical evidence of a pelvic fracture and hematuria, retrograde cystography must be performed as bladder injury is present in almost one third of cases [30, 31]. Retrograde cystography is not indicated in isolated pelvic fractures without hematuria; however, warranted if clinical suspicion of a bladder rupture is present (oliguria, abdominal distention, inability to urinate, suprapubic pain, or altered mental status) [30]. Bladder imaging is recommended with pubic symphysis widening or obturator ring displacement more than 1 cm [30–32].

Management of a bladder rupture depends on anatomic location as well as associated injuries. The American Urological Society recommends that intraperitoneal bladder and complicated extraperitoneal injuries including bony involvement or concomitant vaginal or rectal lacerations injuries be repaired surgically [30]. Uncomplicated extraperitoneal bladder injuries can be managed with prolonged drainage by foley catheter [30, 31]; however, among patients undergoing pelvic open reduction and internal fixation, extraperitoneal bladder injuries should then be repaired surgically to minimize postoperative infection [30, 31]. Yao et al. [33] reported a statistically significant reduction in periprosthetic infection after ORIF for pelvic fracture among patients undergoing surgical repair of extraperitoneal bladder rupture rather than conservative management.

Urethral injury

Urethral injuries are also commonly associated with pelvic fractures. If a urethral injury is suspected, such as in the case of blood at the urethral meatus, bladder drainage with a foley catheter should be avoided and a retrograde urethrogram should be performed to assess for injury [30, 31]. In the trauma patient undergoing volume resuscitation, urinary drainage is important. In the case of a suspected urethral injury in a patient with pelvic trauma, a suprapubic catheter can be placed [30]. No current evidence exists suggest that placement of a suprapubic catheter increases the risk of infection of orthopedic implants during ORIF of a symphyseal injury. Injuries to the kidney, ureters, testes, ovaries, and uterus are also possible requiring prompt evaluation by urology or obstetrics and gynecology.

Vaginal injury

Niemi et al. [34] reported that among 114 female patients with pelvic fractures, 4 (3.5%) reported a vaginal laceration. Furthermore, one patient reported a delayed vaginal laceration diagnosis over 72 h and developed extensive pelvic abscess requiring multiple drainage procedures. Li et al. [2] demonstrated that among 25 patients with pelvic fractures, vertical shear fractures sustained a higher incidence and severity of vaginal injuries compared to patients with Anterior–Posterior compression (APC) fractures ($p=0.034$).

Infection and sepsis

As patients with OPF with concurrent genitourinary injuries progress throughout treatment, the risk of mortality shifts from hemodynamic instability to complications of wound infection and sepsis [25]. Li et al. [2] retrospectively reported a 25% infection rate among patients with an open pelvic fracture and vaginal injury. Prompt identification of the injury and initiation of appropriate antibiotics is crucial for infection control. The literature has consistently demonstrated that patients with early antibiotic administration had significantly decreased rates of wound infection compared to patients with delayed antibiotic administration [35, 36]. In addition to timing of antibiotics, broad coverage empiric antibiotics is required given the presence of poly-microbial infection associated with OPF genitourinary injuries [37].

Local administration of antibiotic-coated polymethylmethacrylate (PMMA) beads introduced into the open pelvic wound has been recently popularized [37–39]. Zalavras et al. [38] and Ostermann et al. [39] reported that the local antibiotic plus systemic antibiotics has been shown to significantly decrease the rate of infection in open fractures. There is current debate as to the removal of PMMA antibiotic beads. Although antibiotic beads can continue to elude antibiotics for up to months, the bead surfaces theoretically may serve as a nidus for bacteria colonization, particularly after elution completion [40, 41]. Fernando et al. [42] reported that 73% (37/51) patients with pelvic or extremity fractures did not undergo final bead removal. No wound complications at long-term follow-up were observed (range 6 months-5 years) [42]. Additionally, Owen et al. [43] demonstrated that topical vancomycin and tobramycin powder applied deep to the surgical wound during ORIF for pelvic fractures decreased the rate of surgical site infections.

Appropriate antibiotic regiment is important to reduce infection rates. No strong recommendations exist for antibiotic coverage in OPF with concomitant GU injury. Practice guidelines recommend systemic antibiotics with coverage for gram-positive organisms as soon as possible after an open fracture with additional gram-negative coverage for Gustilo type III open fractures [12, 44–46].

Selection of appropriate antibiotic coverage in the setting of a vaginal laceration is more challenging. Lactobacilli species predominate, while many other species of aerobic and anaerobic species are also present [47]. Limited research exists on appropriate antibiotic coverage for a vaginal laceration in the setting of pelvic fractures. A randomized controlled trial demonstrated second-generation cephalosporin decreased rate of infection for third- or fourth-degree perineal tears after childbirth [48]. Metronidazole has also been suggested for anaerobic coverage, though its efficacy has not been established [49]. Suneja et al. [50] reported the use of metronidazole-coated PMMA beads additionally containing vancomycin and tobramycin with no signs of infection at one-year follow-up after an open pelvic fracture with concomitant vaginal laceration. This represents a viable option to provide aerobic and anaerobic coverage locally in the setting of an open pelvic fracture.

Limitations

This review is not without limitations. As with any review, we are limited by the current literature. Many of the included studies have either small sample size or are retrospective studies or case series. Furthermore, data heterogeneity is present due to variation in wound classification as well as protocol advancement over time. Therefore, given the paucity of data on surgical management of open pelvic fractures, large cohort prospective and retrospective studies are warranted to allow for future systematic review and meta-analyses to aid in stronger clinical recommendations for open pelvic fractures with concurrent GU/GI injuries.

Conclusion

Open pelvic fractures are a devastating injury with high rate of mortality and infection. A concomitant genitourinary injury due to displacement of fracture fragments has been documented. Although extensive damage control orthopedic research has been published to refine methods of resuscitation to reduce mortality from hemorrhage, the current literature for appropriate type and duration of antibiotic coverage remains sparse. Prospective multi-center prospective studies are required to further improve outcomes and mortality among patients with open pelvic fracture injuries with associated genitourinary injuries.

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