Original Paper

Current Urology

Curr Urol 2020;14:105–112
DOI: 10.1159/000499251

Received: April 12, 2019
Accepted: June 19, 2019
Published online: June 23, 2020

High Riding Prostate: Epidemiology of Genitourinary Injury in Motorcyclists from a UK Register of over 12,000 Victims

Basil F. Moss[a] Catherine E. Moss[b] Patrick Dervin[c] Thomas Lawrence[d] Sophie Jones[d] Stephen Thomas[a]

[a]Derby Teaching Hospitals NHS Foundation Trust, Department of Urology, Derby; [b]University of Liverpool, Liverpool; [c]University of Nottingham, Nottingham; [d]University of Manchester, Trauma Audit Research Network, Manchester, UK

Key Words
Bladder • Kidneys • Trauma • Urethra

Abstract
Background: The mechanism of motorcycle accidents (high speeds, pelvis behind fuel tank) may predispose to genitourinary injury (GUI) but the epidemiology is poorly understood. Previous studies have assessed GUI patterns in cyclists, and road traffic accident victims in general, but no study has analyzed GUI patterns in a large cohort of motorcyclists. ***Objectives:*** We aimed to better understand patterns of urological injuries among motorcyclists admitted to hospital. We aimed to determine any relationship between pelvic fracture and GUI patterns or severity. ***Methods:*** The Trauma Audit Research Network was reviewed to identify motorcyclists admitted between January 2012 and December 2016 (n = 12,374). Cases were divided into riders (n = 11,926) and pillion passengers (n = 448), and the data analyzed to identify urological injuries and their associations. The associations between pelvic fracture and other injury types were tested for significance by one- and two-way χ^2. ***Results:*** GUI was identified in 6%. Renal trauma was the most common GUI among riders (4%) and pillions (2%). There was no statistically significant relationship between grade of renal trauma and presence of pelvic fracture. Urethral injury occurred in 0.2% of riders and passengers, and bladder injury in 0.4% of riders and 0.7% of pillions. Urethral and bladder injuries were positively associated with pelvic fracture, which was present in 81 and 92%, respectively. Testicular trauma occurred in 0.4% of riders and 0.7% of pillions. Body armor was recorded in 3% of casualties with urological trauma, and 3% overall. ***Conclusions:*** A significant proportion of motorcyclists brought to accident and emergency department have GUI, most commonly renal trauma. Pelvic fracture is more common in pillion passengers than riders, and associated with urethral and bladder injuries, but it does not predict severity of renal trauma. External genital injuries are rare, but we recommend examination in the tertiary survey, as consequences of missed injury are severe. Further research is needed to explore protective effects of motorcyclist clothing.

Introduction

Motorcycling, as most riders appreciate is a risky business [1]. The Department for Transport reported 319 motorcyclist fatalities in 2016, with 5,553 serious injuries. Motorcyclists accounted for 18% of fatalities in 2016,

KARGER
Fax +41 61 306 12 34
E-Mail karger@karger.com
www.karger.com

Basil Francis Moss
Derby Teaching Hospitals NHS Foundation Trust
Department of Urology, Royal Derby Hospital
Uttoxeter Road
DE22 3NE Derby (UK)
E-Mail basil.moss@nhs.net

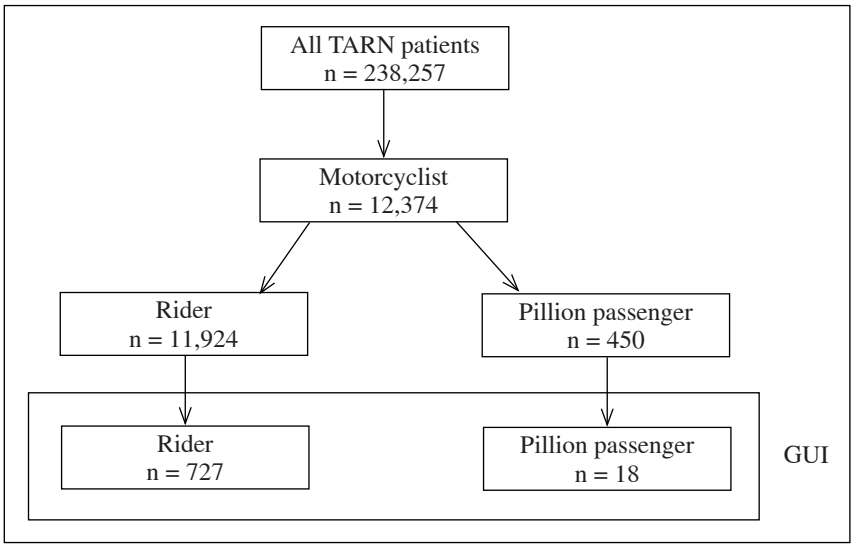

Fig. 1. Inclusion criteria STROBE diagram.

with 6,321 casualties (killed or seriously injured) per billion miles travelled. For comparison, pedal cyclists had 5,353 and car occupants 262 casualties per billion miles [2].

A 2015 review of a Scottish trauma database found an incidence of genitourinary injury (GUI) of 1.5% among all trauma admissions [3], and GUI occurs in 2–3% of injured pedal cyclists [4, 5]. Studies of GUI from two French registries of road traffic trauma admissions included small subgroups motorcyclists: 78 and 453, respectively [6]. Most common were injuries to the external genitalia, followed by kidneys [7].

Renal damage occurs in 1.2–3.3% of trauma, and motor vehicle collisions account for 70% of blunt renal injuries [8]. The relationship between pelvic fracture and bladder injury is known: associated GUI is more common among males (5.3%) than females (3.6%) [9] and 3.6–5.7% with pelvic fracture have concomitant bladder injury [9, 10]. Pelvic fracture is present in 70% of cases of traumatic bladder rupture [11].

The mechanisms involved in a motorcycle crash are a unique combination of high speed and energy with the pelvis tucked behind a hard fuel tank, which may predispose to genitourinary trauma [6], but injury patterns in this cohort are as yet poorly researched. We therefore sought to better understand patterns of urological injury among motorcyclists admitted to hospital, considering also any relationships between pelvic fracture and injury patterns or severity.

Materials and Methods

To better understanding of urogenital injury patterns in motorcyclists, we designed an observational study according to the Strengthening Reporting of Observational Studies (STROBE) criteria. We aimed to analyze a substantial cohort of patients who had been admitted since the establishment of Trauma Centres in the UK (2012), and to include at least 500 cases of GUI. Data on the patient groups (motorcycle riders and passengers) was obtained from a prospectively collected database of hospital trauma admissions, the Trauma Audit Research Network (TARN).

The TARN is an ongoing project developed from the UK Major Trauma Outcome Study, which started in the early 1990s [12]. It is a live database, collecting data on patients admitted to hospitals in England and Wales following trauma, who require critical care resources, stay more than 3 days, or die from their injuries. The data for this study came exclusively from the TARN database without author access to patient records. Specific informed patient consent or ethical approval is not required because no patient identifiers are retained by TARN electronically or on paper. The TARN has Patient Information Advisory Group approval.

The TARN database was reviewed to identify eligible patients. Inclusion criteria were motorcycle riders or passengers admitted between January 2012 and December 2016, who had been entered into the TARN database (n = 12,374), (fig. 1: STROBE diagram, table 1: demographics). The data included age, gender, protection worn (e.g. helmet, body armor), a description of the incident and a summary of injuries sustained. Cases were divided into riders and pillion passengers, and the data analyzed using Microsoft Excel 2016 to identify GUI (kidney, ureter, bladder, testes, urethra, penis, scrotum, prostate, adrenal) and pelvic fractures.

We hypothesized that riders would be more vulnerable to external genital trauma than passengers, owing to their position behind (and likely impact with) the fuel tank. We hypothesized

Table 1. Demographics of entire cohort and studied subgroups

	Motorcyclists	Riders	Passengers	Riders GUI	Passengers GUI
Number, n	1,2374	1,1924	450	727	18
Median age, years	35.0 (23.3–49.7)	35.2 (23.5–49.9)	27.8 (20.0–45.8)	34.0 (23.4–48.4)	24.0 (20.0–34.3)
Male, %	93	94.5	52.9	96.8	83.3
Median ISS	13 (9–21)	13 (9–21)	13 (9–22)	25 (17–36)	27 (17–33)
Initial GCS					
3	2.9	2.8	4.2	6.9	
4–8	2.7	2.7	2.9	3.7	5.6
9–12	2.4	2.3	3.8	3.3	
13–15	87.7	87.8	84.4	82.3	83.3
n/r	4.3	4.3	4.7	3.9	11.1
Operation required, %	59.4	59.3	62.4	51.3	44.4
Known outcome, %	100	100	100	100	100
Mortality, % (95% CI)	3.2 (2.9–3.5)	3.2 (2.9–3.5)	3.1 (1.5–4.7)	9.5 (7.4–11.6)	

ISS = Injury Severity Score; GCS = Glasgow Coma Scale.

Table 2. Frequency of GUI amongst motorcycle riders (n = 11,924; 94.5% male) and pillion passengers (n = 450; 52.9% male)

	Adrenal	Bladder	Kidney	Penis	Perineum	Prostate	Scrotum	Testes	Ureter	Urethra
Riders, n	138	48	477	31	7	1	32	48	3	26
Pillions, n	0	3	11	0	0	0	0	3	0	1

that pelvic fracture would be associated with urethral and bladder injury, and that the presence of pelvic fracture, as a marker of higher energy trauma, might predict greater severity of renal trauma. Associations between pelvic fracture and severity of renal trauma, and between pelvic fracture and presence of bladder or urethral injury, were assessed by two- and one-way χ^2 using Microsoft Excel 2011.

Results

The TARN database was analyzed in December 2018, at which point a total of 12,374 motorcyclist admissions between January 2012 and December 2016 were recorded. Of these, 11,924 were riders and 450 were pillion passengers. Some 94.5% of riders and 52.9% of passengers were male. GUI was identified in 742 admissions overall (6%), 727 riders (6.1%) and 18 passengers (3.8%), riders with a median age of 34.0 (23.4–48.4 years) and passengers with a median age of 24.0 (20.0–34.3 years). The frequency of different GUI is shown in table 2 and figure 2.

Renal trauma was the most common urogenital injury among riders (4%) and pillions (2%). Renal injuries were classified according to American Association for the Surgery of Trauma (AAST) grade (fig. 3). Among riders there were 4 cases of bilateral renal injuries, 94 were AAST Grade I, 116 Grade II, 140 Grade III, 88 Grade IV and 30 Grade V. Among passengers there were no bilateral renal injuries, with 2 AAST Grade I, 6 Grade II, 1 Grade III, 1 Grade IV, and 5 Grade V. Concomitant pelvic fracture and renal injury were tested for association using two-way χ^2: the critical value for $p = 0.05$ was 9.488 for 4 degrees of freedom (df); $\chi^2 = 7.72$, severity of AAST grade was therefore not associated with presence of pelvic fracture.

Bladder injury was identified in 48 riders (0.4%) and 3 pillions (0.7%), and urethral injury 26 riders (0.2%) and 1 pillion (0.2%). Pelvic fracture occurred in 2,067 riders (15%) and 93 passengers (19%). Of all victims with pelvic fracture, 21 riders (1%) and 1 passenger (1%) had a concomitant urethral injury and 40 riders (2%) and 2 passengers (3%) had a bladder injury. Pelvic fracture

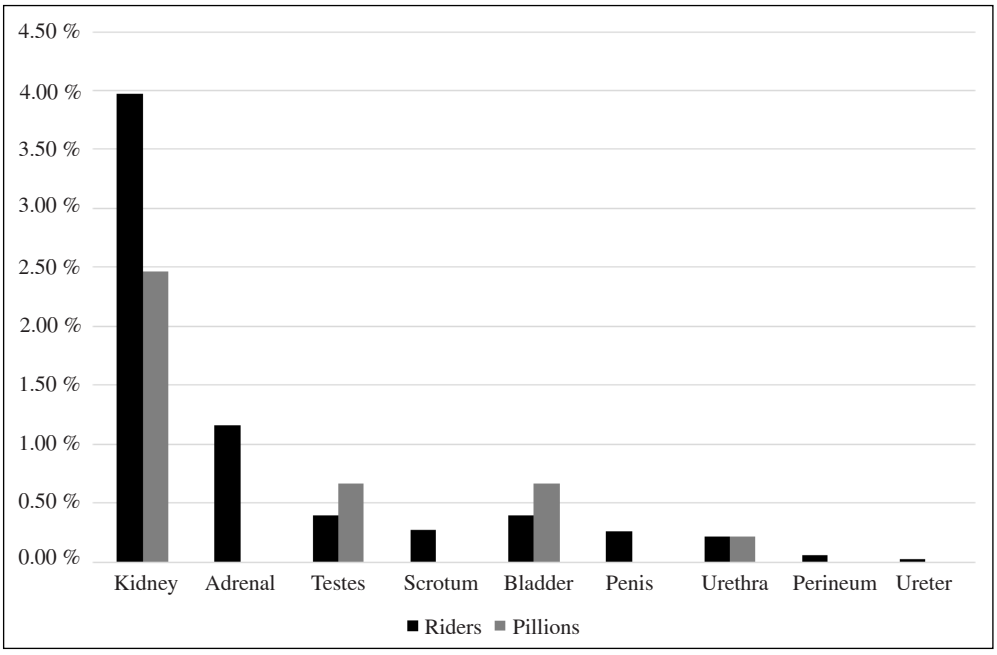

Fig. 2. Overall distribution of GUI amongst victims (n = 742; 716 male) including riders (black) and pillions (grey).

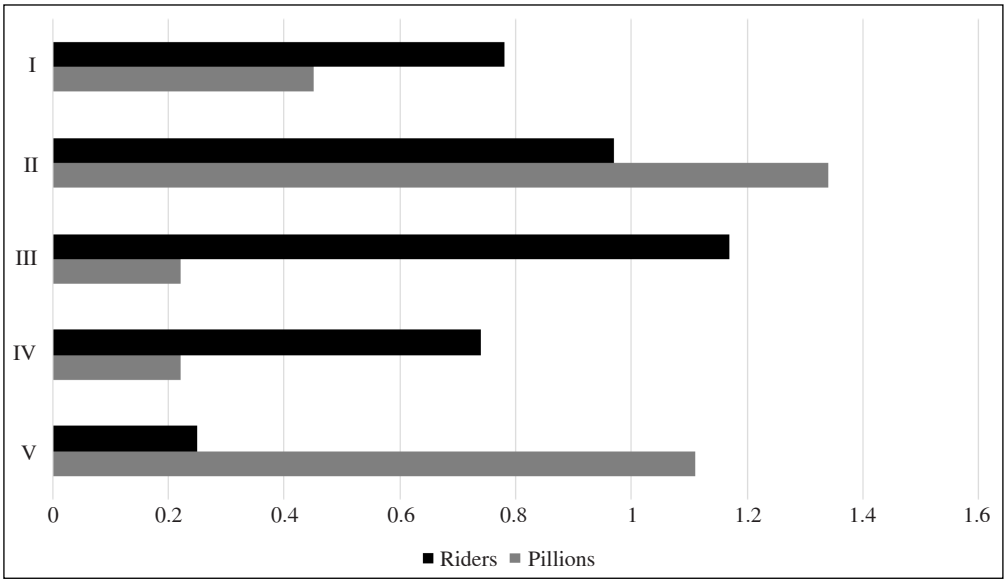

Fig. 3. Renal trauma incidence (%) by AAST grade (n = 488 kidney injuries amongst 484 victims: 4 bilateral kidney injuries) in riders (black) and pillions (grey).

was present in 81% of urethral injuries and 92% of bladder injuries. One prostate contusion was recorded, in a patient with no other urological trauma and no pelvic fracture. Bladder injury was positively associated with pelvic fracture (one-way χ^2, df = 1, $p < 0.01$), as was urethral injury (one-way χ^2, df = 1, $p < 0.01$).

Table 3. Monthly distribution of admissions

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
All admissions, n	540	581	836	1,073	1,346	1,312	1,481	1,400	1,408	1,080	768	632
Urogenital injury, n	33	37	34	60	78	90	82	83	88	55	46	45

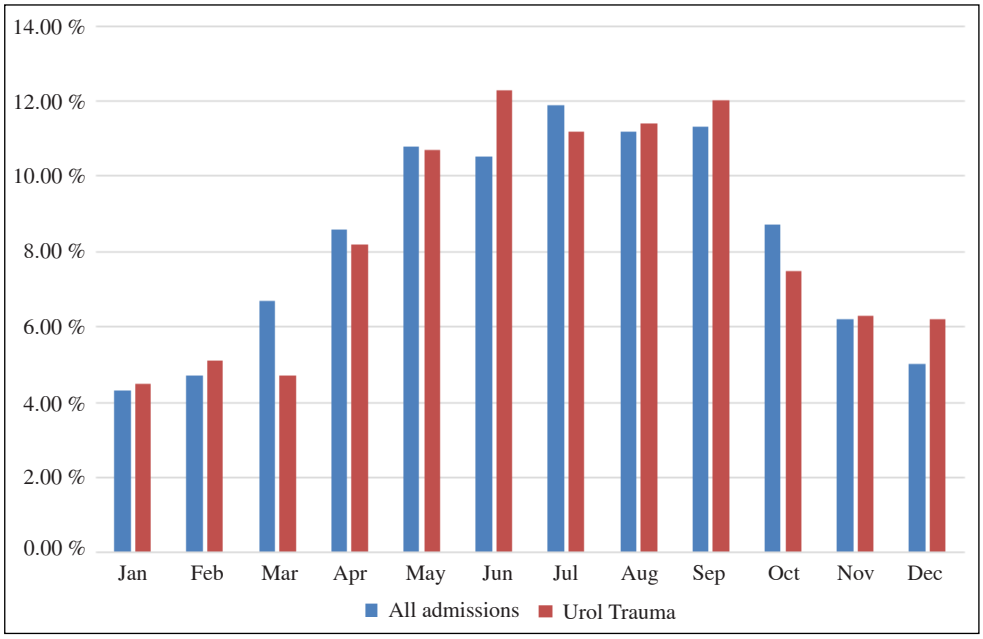

Fig. 4. Distribution of admissions by month as percentage of annual total.

Testicular trauma occurred in 48 male riders (0.4%) and 3 male pillions (0.8%). Scrotal injuries were recorded in 32 riders (0.3%), of which 10 (31%) were concomitant with testicular injury, and 22 were isolated scrotal hematomas or lacerations. Among male riders, 31 penile injuries were recorded (0.3%), and none among male pillion passengers. Body armor was recorded in 3% of the casualties with GUI, and 3% overall, and helmet use in 74% with GUI and 72% overall.

Among admissions with GUI, the month of admission was available for 731. The month with the highest frequency of admissions was June (90 admissions, 12.3% of total) and that with the lowest frequency was January (33 admissions, 4.5% of total). The TARN database was later (May 2019) analyzed for a breakdown of admissions by month of incident. At this time 12,457 admissions were included over the study period January 2012 to December 2016, the month with the highest frequency of overall admissions was July (1,481 admissions, 11.9% of total) and that with the lowest frequency was January (540 admissions, 5% of total) (monthly distribution of injuries: table 3, fig. 4). There was no difference in monthly distribution of injuries between admissions with urogenital injuries and those without (two-way χ^2, df = 11, $\alpha = 0.05$, critical value of $\chi^2 = 19.67$, $\chi^2 = 11.39$).

Discussion

The structure of trauma care in the UK has evolved radically since the establishment of the first major trauma centers in 2012, with more consultant led care,

Table 4. Detection of GUI in trauma

	Examination findings	Diagnostic tests
Penile injury	• hematoma • edema • deformity	• ultrasound • MRI • surgical exploration
Testicular trauma	• hematoma • butterfly ecchymosis • edema • deformity	• ultrasound • surgical exploration
Urethral injury	• hematuria • blood at urethral meatus • urinary retention • any resistance to passing urethral catheter • "high riding" prostate	• retrograde urethrogram
Bladder injury	• hematuria • anuria	• ultrasound (free fluid) • retrograde cystogram • CT with excretory (urogram) phase
Renal trauma	• hematuria • renal angle tenderness • shock	• ultrasound • contrast enhanced CT (e.g. trauma series)

faster imaging, and new management policies such as massive transfusion protocols and the use of tranexamic acid. Despite the challenges of increasing workload at Major Trauma Centres and an ageing cohort of trauma patients, there have been significant improvements in the care and outcomes of patients after severe injury [13]. In this context, an improved understanding of injury patterns among UK trauma patient subgroups may guide specialist care of patients.

We report a 6% incidence of urological injuries among motorcyclists admitted to hospital, including both internal (e.g. renal trauma) and external (genital) injuries. While the overall incidence of these injuries is low, their sequelae can be severe, more so if diagnosis and management is delayed. Renal trauma will commonly be detected on trauma CT, but external genital trauma may be overlooked on secondary survey.

Kidney trauma was the most frequent, in contrast to studies of French trauma registries, which reported external genital injury to be more common [6, 7]. Our results also differ in finding a more even spread of renal injury by AAST grade, in contrast with Terrier et al. [7] who reported a predominance of AAST I injuries. We speculate that smaller motorcycles may be more popular for transport in France, compared to the UK where sales figures show decreasing popularity of small scooters [14], and that riders of more powerful machines may be more at risk for worse renal trauma.

The riders in our study were overwhelmingly male, although there was a slightly higher proportion of females among the pillion passengers. A previous study has remarked upon the high incidence of external genital trauma among motorcyclists due to impact with the fuel tank [7], and we were therefore surprised to find that testicular injuries were twice as common in passengers as riders. This suggests that the fuel tank may be a safer structure to decelerate into than the buttocks of a rider sat in front, and warrants a higher index of suspicion for such injuries in motorcycle passengers. However, it is important to draw attention to the limitation of sample size for motorbike passengers which was much smaller than that of riders.

The incidence of bladder injury among cases with pelvic fracture was lower in our motorcyclist cohort than in previous studies including car occupants [9, 10]. It may be that impact with the fuel tank is a strong factor in pelvic fracture, without a seatbelt contributing to rupture of a full bladder.

Urethral injury was rare at 0.2% overall. This injury is usually identified by signs of urinary retention and blood at the urethral meatus, with "high riding prostate" on rectal examination in rupture of the membranous urethra. Retrograde urethrogram is the gold standard test, and should be performed before catheterization if urethral injury is suspected. In an unstable patient this may have to be delayed, so a gentle attempt may be made to catheterize and if it fails, a suprapubic catheter inserted [15].

Penile injuries were rare (0.3% overall, accounting for 4.3% of GUI), and less common in our cohort than in the French series: Terrier et al. [7] found these to account for 8% of GUI in motorcyclists, and Paparel et al. [6] in 13%. This may reflect greater uptake of protective leather clothing in our cooler climate: evidence exists that weather influences its use [16, 17]. Physicians should maintain a high index of suspicion for this rare injury, as it may be easily missed in a tertiary survey, yet the consequences of delayed diagnosis are severe. Early surgical intervention for penile fracture significantly reduces complications such as erectile dysfunction, painful erections and curvature [18]. When suspected, ultrasound may aid in diagnosis, but where this is negative, magnetic resonance image is the gold standard imaging investigation [19]. A summary of clinical findings and relevant diagnostic tests for GUI in trauma is included in table 4.

The small proportion of riders reported to be wearing body armor is surprising: a 2013 questionnaire found reported use of motorcyclist clothing in 81.4% of UK riders [17]. It is unclear from the data what "body armor"

describes exactly, and we suspect that our data regarding protective clothing are incomplete: this limited our analysis. It should be noted that most motorcyclist clothing sold in the UK contains CE rated (conforming to European Economic Area health and safety requirements) armor. This may be concealed in the elbows, knees and back, and may not be immediately apparent on inspection of the garment in a busy emergency department. Motorcyclist protective clothing has been associated with reduced risk and severity of injury and hospitalisation, even without fitted armor [20] and importantly, protects against soft tissue injury [21].

Our data demonstrates that the rates of admissions peaked through the summer months of June, July and August, with no difference in this pattern identified between those with or without GUI. No conclusions can be drawn from this regarding seasonal differences in the use of protective clothing, as the rates of motorcycling in different months were not studied. While motorcyclists may be less inclined to don heavy garments in the warmer months [16, 17], they may also choose to undertake journeys by alternative means such as car in the colder, wetter seasons. Such variations are beyond the scope of this study.

Conclusion

This is the largest study of GUI among motorcyclists admitted to hospital, and the first to examine injury patterns among riders and passengers separately. Our findings should be generalizable to any UK hospital motorcyclist admissions, and indeed to motorcyclist admissions in comparable countries. The main limitation was the unreliable data on protective clothing, and we have therefore been unable to comment on its effect on GUI patterns.

In summary, GUI is common among motorcyclists, most commonly renal trauma. Pelvic fracture is more common in passengers than riders, and although it is a poor predictor for urethral and bladder injuries, they rarely occur in its absence. Given the high incidence of external genital trauma among motorcyclists and the consequences of delayed diagnosis, we recommend that examination of external genitalia be included in the tertiary survey. Further research is needed to explore the protective effects of motorcyclist clothing, and to this end we recommend a review of the way these data are collected for the TARN database.

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