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Genitourinary injuries following traffic accidents: analysis of a registry of 162,690 victims

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Background

Traffic accidents are the most frequent cause of genitourinary injuries, accounting for 48% to 66% of all kidney trauma (1-3). Nevertheless, the epidemiology of genitourinary system trauma after traffic accidents has not been well studied. Only a few studies have reported the epidemiology of genitourinary injuries within a large database.

Wessels et al reported an incidence of 1.2% kidney traumas in a large cohort of 500,000 patients hospitalized for trauma in the USA (1). More recently the same team reported 9,002 kidney injuries among 3,247,955 trauma injuries in the National Trauma Data Bank (NTDB) (0.3%) (4). These studies were not specifically on traffic accidents and were focused solely on kidney injuries (1, 4). Bjurlin et al reported an incidence of 0.8% kidney trauma among 466,028 motor vehicle collisions (2). The same author found 2.16% genitourinary injuries after 16,585 bicycle injuries(5), the kidney was the most commonly injured (75%) followed by the bladder and urethra (15%), penis and scrotum (10%) (5). Hammad et al analyzed data from a Middle Eastern population, they reported a higher incidence of genitourinary injuries (1.8%) following traffic accidents (6), probably explained by the lower use of seatbelts in this population.

In a previous analysis, we reported an incidence of 0.46% (199/43,056) of genitourinary injuries after traffic accidents (from 1996 to 2001), with 43% being kidney trauma and 24% testicular trauma (7). Kidney injuries following trauma have been well described. However, there exists a paucity of data on other genitourinary injuries and specifically injuries following traffic accidents.

The primary objective of this study was to analyze the frequency and type of all genitourinary injuries following traffic accidents. We used the registry of victims of traffic accidents in the French department of Rhone.

Method

This study uses recorded data from the Rhone Registry. Since 1996, the Association for the Registration of Victims of Traffic Accidents (ARVAC) reports traffic accident cases to the IFFSTAR (French Institute of Science and Technology for Transport, Development and Networks). The Registry covers the Rhône Department (≈ 1.8 million inhabitants, $528/\text{km}^2$) and has been approved by the health authorities (National Registry Committee and National Commission for Information Technology and Civil Liberties N° 999211).

The Registry collects the demographic characteristics of each road traffic casualty (RTC), the type of road user, the characteristics of the crash (time, location, and collision type) and a description of the bodily injuries sustained. The inclusion criteria are as follows: an RTC involving at least one vehicle (motorized or not) occurring in the Rhône area, requiring institutional health care activity from one of the 245 healthcare structures cooperating together, including prehospital primary care teams and forensic medicine institutes.

Data collection method had been described previously (7). Beyond collecting the data, the various required tasks remained the same over time: centralization, verification and collating of information from different sources regarding the same accident and/or victim; coding of the data, storage and filing of dossiers (while complying with the recommendations for confidentiality of access made by the French committee for computing and freedom).

The different populations analyzed were motorists, motorcyclists, cyclists, pedestrians, van drivers, van passengers, bus passengers and skateboard users. We assessed the genitourinary injuries presented in each of these categories.

Trauma to the adrenal glands was considered a genitourinary injury. The severity of injuries was coded with the Abbreviated Injury Scale (AIS version 90) and the Injury Severity Score (ISS) (8). Kidney trauma was mapped within the classifications of the American Association for the Surgery of Trauma (AAST) (9). We converted AIS codes to AAST grade as described by Kuan et al (10). Using this methodology, kidney injuries were categorized by AAST grade as follows: grade I-AIS code 541612, grade II-AIS code 541622, grade III-AIS code 541624, grade IV-AIS code 541626 and grade V-AIS code 541628 (3, 4, 9, 10).

Statistical analyses were performed using SAS (SAS 9.4, SAS Institute Inc., Cary, NC, USA). A p-value of 0.05 was used to define statistical significance. Logistic regression analysis was used to explain the presence of a genitourinary injury whatever its severity according to different factors such age, sex, and crash characteristics.

Results

There were 162,690 victims available for analysis from 1996 to 2013. Of these victims, 963 presented with genitourinary injuries (0.59%). Almost half of these victims (47%) involved motorcyclists, 22% of victims were in a car, 18% in bicycles, 9% were pedestrians and 4% concerned other vehicles like trucks, buses, etc. 51% (491/963) of victims were hospitalized among those, 35% (174/491) required surgical management, the median time of hospitalization was 11 days.

Mean age of victims with genitourinary injuries was 28 years (range 1-88 years), 80% of genitourinary injuries involved males (sex ratio 4:1, 771 men and 192 women). The most commonly injured genitourinary organ was kidney (41%) followed by testicle (23%). Locations and frequencies are reported in **Figure 1**. The most common body zones injured included abdominal, legs, thorax, arms and head (**Figure 2**).

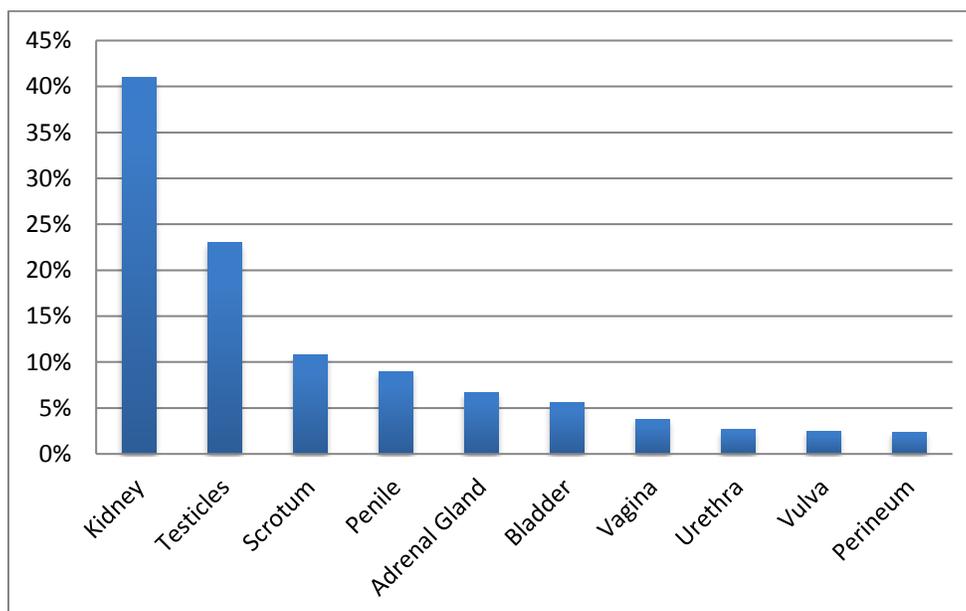


Figure 1 : Overall distribution of genitourinary injuries after traffic accidents (n=963, Rhône road trauma registry, 1996-2013)

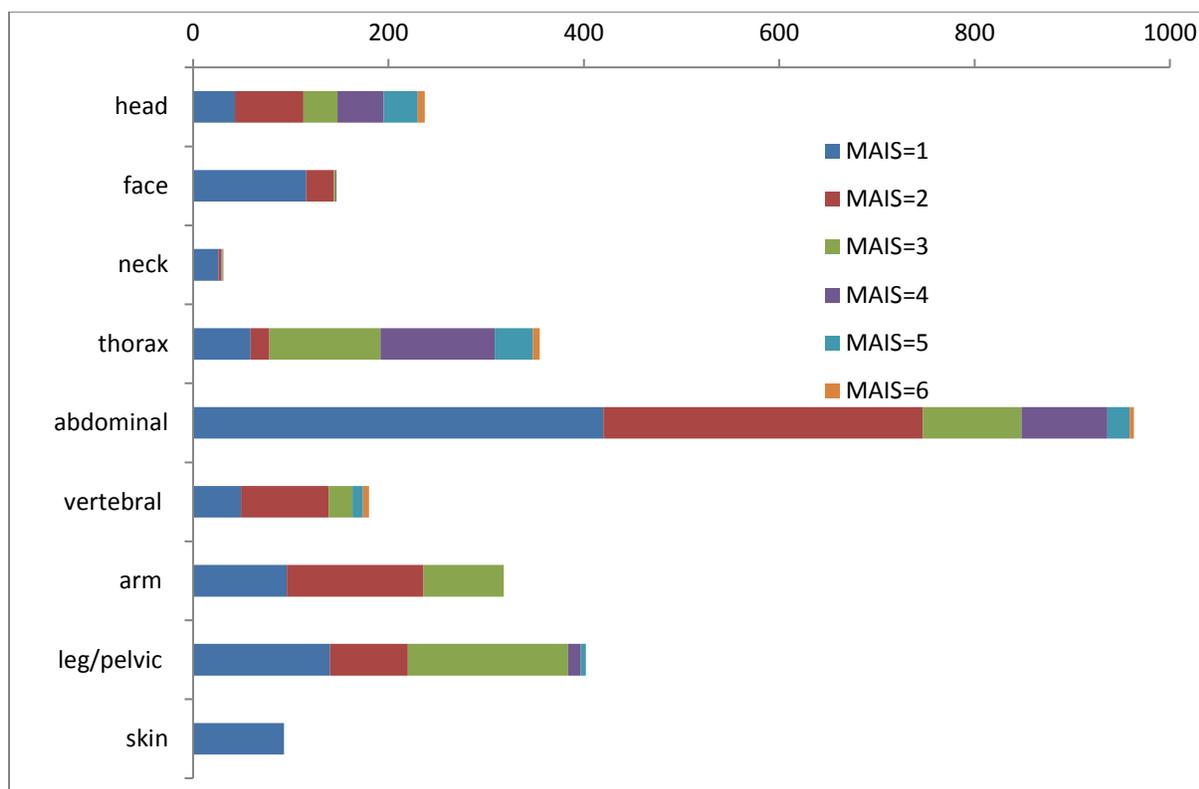


Figure 2 : Concomitant injuries associated to genitourinary injuries, with injury severity score according to Maximum Abbreviated Injury Scale (AIS) (n=963, Rhône road trauma registry, 1996-2013)

There were 208 motorists with genitourinary injuries (22% of genitourinary injuries victims), kidney (70%), bladder (10%) and adrenal gland (9%) were the most frequent lesions and 58% were hospitalized (**Table 1**). Among the 453 motorcyclist victims with genitourinary injuries, kidney (35%) and testicular (38%) injuries were the most frequent, 56% were hospitalized. Within this group, 62% of injuries involved external genitalia; and among these cases, 37 (8%) were penile trauma (**Table 1**). There were 175 cyclists with genitourinary injuries, 70% of injuries involved external genitalia; penile injuries (23%) were the most frequent (**Table 1**). 73.7% (129/175) of cyclist accidents involved just the cyclists with no antagonist. 26.3% (46/175) had a collision with an external object (cars, trucks, cyclists, pedestrians), 25% of the cyclists were

hospitalized. Among the 87 pedestrians with genitourinary injuries, kidney injuries were the most frequent (52%) and 68% were hospitalized (**Table 1**).

	Motorists n=208		Motorcyclists n=453		Cyclists n=175		Pedestrians n=87	
	n	%	n	%	n	%	n	%
Hospitalization	120	58%	252	56%	44	25%	59	68%
Adrenal Gland	19	9%	31	7%	4	2%	9	10%
Bladder	21	10%	17	4%	1	1%	13	15%
Kidney	146	70%	157	35%	29	17%	45	52%
Penile	2	1%	37	8%	41	23%	4	5%
Perineum	3	1%	6	1%	6	3%	7	8%
Scrotum	7	3%	62	14%	30	17%	3	3%
Testicles	11	5%	170	38%	34	19%	4	5%
Ureter	2	1%	1	0%	1	1%	1	1%
Urethra	5	2%	7	2%	6	3%	6	7%
Uterus	4	2%	1	0%	0	0%	1	1%
Vagina	1	0%	4	1%	25	14%	5	6%
Vulva	1	0%	4	1%	14	8%	0	0%
Ovary	0	0%	0	0%	0	0%	1	1%

**Table 1 : Hospitalization rate and type/ frequency of genitourinary injuries
(n=963, Rhône road trauma registry, 1996-2013)**

In total, there were 395 renal injuries, most being low-grade (**Table 2**). Kidney injuries were assigned a renal injury grade per the AAST: grade I - 59%, grade II - 11%, grade III - 16%, grade IV - 9%, grade V - 3% and 2% indeterminate. Distribution of renal injuries among motorists, motorcyclists, cyclists, and pedestrians is presented in **table 2**. The mean AIS was 3 and the mean ISS was 15. More than 50% of genitourinary injuries were associated with low and moderate injury severity scores (**Table 3**), ISS \geq 25 rate was 23% and the mortality rate was 10% (**Table 3**). For victims without genitourinary injuries, there were 91.9% of low and moderate injury severity scores, ISS \geq 25 rate was 0.6%, and the mortality rate was 0.9%.

Grade	All Traffic Accidents		Motorists n=208		Motorcyclists n=453		Cyclists n=175		Pedestrians n=87	
	n	% renal traumas	n	% victims	n	% victims	n	%victims	n	% victims
G1	233	59%	88	42%	91	20%	15	9%	30	34%
G2	45	11%	18	9%	16	4%	4	2%	4	5%
G3	63	16%	19	9%	27	6%	6	3%	7	8%
G4	36	9%	15	7%	14	3%	3	2%	3	3%
G5	10	3%	1	0%	8	2%	0	0%	1	1%
indeterminate	8	2%	5	2%	1	0%	1	1%		

Table 2 : Distribution of renal injuries according to the AAST among motorists, motorcyclists, cyclists and pedestrians (n=963, Rhône road trauma registry, 1996-2013)

MAIS	n	%	Hospitalization n(%)	ISS	n	%
MAIS=1	308	32	41(13)	1'-8	491	51%
MAIS=2	222	23	143(64)	9'-15	139	14%
MAIS=3	181	19	154(85)	16-24	108	11%
MAIS=4	125	13	108(86)	≥25	225	23%
MAIS=5	27	3	25(93)	Total	963	100%
Death	100	10	20(20)			
Total	963	100	491(51)			

Table 3 : Global injury severity according to Maximum Abbreviated Injury Scale (AIS) and the Injury Severity Score (ISS) (Rhône road trauma registry, 1996-2013)

Compared to non-GUI victims, GUI victims were more often young adult (16-25 years old) or elderly (66 years old and more) for motorists; young adult (26-35 years old) for motorcyclists; children (0-15 years old) for cyclists, and there were no differences based on age for pedestrians (Table 4). Thus, there was a strong interaction between road user type and age on the presence of GUI. Therefore, we presented one multivariate model per road user type, using the same factors in each model (Table 5).

For cyclists, only age remains a risk factor for urogenital lesions: compared to those aged 26-35 years old, a two-fold increase in risk was observed for children aged 15 years or younger (OR 2.1, 95% CI: 1.3-3.5) (**Table 5**).

For motorcyclists, even after adjustment, compared to women, a three-fold risk of GUI was observed for men (OR 2.8, 95% CI: 1.9-4.3). Crashes on rural roads had a higher risk of genitourinary injuries than crashes on city streets (OR 1.7, 95% CI: 1.4-2.3). No third party was a protective factor (OR 0.4, 95% CI: 0.3-0.5) compared to a crash with a car, whereas a collision with a heavy vehicle is a risk factor for genitourinary injuries (**Table 5**).

For motorists, the risk of having a genitourinary injury was higher for the elderly (ages 66 – 75; OR 2.6, 95% CI: 1.4-4.9) (ages 76+; OR 3.2, 95% CI: 1.6-6.5). Place and time of day were also predictors of genitourinary injuries. Crashes in the evening or in the first part of the night (8-11 pm [OR 2.6, 95% CI: 1.6 - 4.0] and 0-3 am [OR 3.6, 95% CI: 2.2-6.1]) were more at risk of genitourinary injuries than crashes in the afternoon (4-7 pm; OR 2.1, 95% CI: 1.2-3.5). Crashes on rural roads had a higher risk of genitourinary injuries than crashes on city streets (OR 1.8, 95% CI: 1.3-2.6) (**Table 5**).

For pedestrians, crashes on highways (OR 3.8, 95% CI: 1.4-10.7) and rural roads (OR 3.2, 95% CI: 1.4-7.5) had a higher risk of genitourinary injuries than crashes on city streets (**Table 5**).

Factors	Motorist			Motorcyclist			Cyclist			Pedestrian		
	% GUI n=207	% non-GUI n=75 657	p	% GUI n=453	% non-GUI n=35 476	p	% GUI n=175	% non-GUI n=23 210	p	% GUI n=87	% non-GUI n=14 879	p
Sex			<0.001			<0.001			0.132			0.003
M	62.3%	48.7%		94.5%	85.2%		71.4%	76.3%		67.8%	51.9%	
F	37.7%	51.3%		5.5%	14.8%		28.6%	23.7%		32.2%	48.1%	
Age			< 0.001			0.004			<0.001			0.215
0-15 years	7.2%	5.2%		5.1%	8.5%		58.3%	36.6%		25.3%	27.3%	
16-25 years	39.6%	33.7%		47.2%	49.0%		14.3%	22.0%		17.2%	19.7%	
26-35 years	21.3%	24.7%		27.8%	20.5%		10.3%	13.8%		4.6%	11.4%	
36-45 years	6.8%	15.0%		11.7%	12.5%		7.4%	10.9%		12.6%	9.7%	
46-55 years	8.7%	10.6%		6.0%	6.9%		5.7%	8.1%		10.3%	9.0%	
56-65 years	5.3%	5.7%		1.3%	1.9%		2.9%	5.2%		6.9%	7.6%	
66-75 years	6.3%	3.2%		0.7%	0.4%		0.6%	2.5%		8.0%	7.1%	
+76 years	4.8%	2.0%		0.2%	0.2%		0.6%	0.8%		14.9%	8.3%	
Road network			<0.001			<0.001			0.900			< 0.001
City Street	44.4%	49.1%		65.6%	58.6%		54.9%	53.3%		77.0%	78.5%	
Highway	14.5%	14.7%		3.5%	2.7%		0.0%	0.0%		4.6%	1.0%	
Rural Road	26.6%	14.8%		17.2%	9.6%		2.9%	3.9%		6.9%	2.1%	
Other	14.5%	21.4%		13.7%	29.0%		42.3%	42.9%		11.5%	18.3%	
Time of accident			<0.001			<0.001			0.110			0.024
0-3 am	14.0%	5.2%		5.1%	3.1%		0.0%	1.4%		2.3%	1.7%	
4-7 am	13.5%	8.9%		6.6%	6.2%		1.7%	3.0%		11.5%	6.0%	
8-11 am	13.0%	15.8%		11.7%	12.2%		9.7%	12.9%		17.2%	19.0%	
12 am-3pm	13.0%	17.6%		21.9%	17.9%		18.9%	16.3%		21.8%	18.4%	
4-7 pm	16.4%	21.5%		32.5%	26.3%		26.3%	26.0%		31.0%	28.1%	
8-11pm	20.3%	10.7%		10.4%	10.2%		9.1%	5.3%		9.2%	6.2%	
Unknown	9.7%	20.3%		11.9%	24.1%		34.3%	35.3%		6.9%	20.5%	
Antagonist			0.001			<0.001			0.022			< 0.001
Motorist	50.2%	64.3%		60.9%	40.8%		9.1%	18.4%		64.4%	79.8%	
None	16.4%	11.7%		20.8%	45.3%		73.7%	66.5%		-	-	
Van/bus	7.7%	5.2%		2.9%	1.5%		1.7%	0.8%		12.6%	5.5%	
Fixed obstacle	18.4%	13.4%		10.8%	6.2%		6.9%	6.9%		-	-	
Other	7.2%	5.4%		4.6%	6.2%		8.6%	7.4%		23.0%	14.7%	

Table 4 : Comparison of Genitourinary (GUI) and non Genitourinary (non GUI) victims by road user type (n=150 144, Rhône road trauma registry, 1996-2013)

Factors	Motorist			Motorcyclist			Cyclist			Pedestrian			
	OR	95% CI		P	OR	95% CI		P	OR	95% CI		P	
Sex				0.004				<0.00				0.00	
M	1.51	1.13	2.01		2.83	1.89	4.25				1.96	1.24	3.084
F	1				1						1		
Age				<				0.009				<0.00	
0-15 years	1.74	0.96	3.15		0.47	0.30	0.74		2.13	1.28	3.52		
16-25	1.18	0.82	1.72		0.72	0.57	0.90		0.86	0.47	1.59		
26-35	1				1				1				
36-45	0.53	0.29	0.98		0.67	0.48	0.93		0.91	0.44	1.86		
46-55	1.00	0.58	1.74		0.61	0.40	0.93		0.94	0.43	2.05		
56-65	1.17	0.60	2.27		0.45	0.19	1.03		0.73	0.27	1.99		
66-75	2.63	1.40	4.94		0.99	0.31	3.18		0.30	0.04	2.26		
+76 years	3.23	1.60	6.51		0.90	0.12	6.66		0.93	0.12	7.04		
Road				0.002				<0.00					<
City Street	1				1						1		
Highway	1.04	0.69	1.57		1.12	0.67	1.88				3.79	1.35	10.66
Rural	1.84	1.31	2.58		1.74	1.35	2.25				3.21	1.37	7.481
Other	0.98	0.62	1.53		0.66	0.48	0.89				0.57	0.29	1.120
Time of				<0.00				0.040					
0-3 am	3.63	2.18	6.07		1.43	0.91	2.25						
4-7 am	2.07	1.24	3.45		0.85	0.57	1.27						
8-11 am	1.10	0.66	1.83		0.80	0.58	1.10						
12 am-	0.99	0.59	1.64		1.01	0.78	1.31						
4-7 pm	1												
8-11pm	2.56	1.62	4.05		0.84	0.60	1.18						
Unknown	0.74	0.41	1.35		0.64	0.46	0.91						
Antagonis								<0.00					<
Motorist					1						1		
None					0.36	0.28	0.46				-		
Van/bus					1.24	0.70	2.19				2.67	1.38	5.149
Fixed					1.18	0.86	1.61				-		
Other					0.53	0.34	0.83				2.04	1.22	3.417

Table 5 : Risk factors for Genitourinary injuries: odds ratios estimated from a multivariate logistic regression (n=150 144, Rhône road trauma registry, 1996-2013)

Discussion

The trauma system in France is based on prehospital care coordinated by the “Service d’Aide Medicale Urgente (SAMU)” and the Service Medicale d’Urgence et de Reanimation (SMUR). A medical regulator from the SAMU makes the initial assessment of trauma severity by phone, and then sends a medical team to the victims for the pre-hospital care (or pre-hospital resuscitation), victims are then transported to the most suitable trauma center. The anesthesiologist-intensivist is the center of this network, and the trauma surgeon does not exist, specialist surgeons treat the injured organ of their skillset(11, 12). The difference between the trauma system in France and USA has been well described by Nathens et al(13).

In this study, we report a 0.59% overall rate of genitourinary injuries following traffic accidents. Kidney trauma was the most frequent genitourinary injury (14), 41% in our study, 75% in Bjurlin et al(5), 51% in Zink et al(15) and 67% in Bariol et al(16). In a population-based study on kidney trauma, frequency ranged from 0.3 to 3%(1, 4). We report a low overall incidence of kidney injury after traffic accidents (0.22%), quite similar to that reported by Hotaling et al in the largest population-based study of trauma published from a registry in the United States and Puerto Rico (9,002/3,247,955; 0.3% renal injuries)(4). In Hotaling’s study, the distribution of kidney injury according to AAST grade was: grade I - 30%, grade II - 30%, grade III - 19%, grade IV - 15%, grade V - 5% (5). These trends were reflected in our study with the large majority being low-grade kidney injuries (Grade I and II). However, the Hotaling study was not specifically on traffic accidents and they focused only on kidney injuries (4). Kuan et al reported renal injury

mechanisms of motor vehicle collisions, among 115 subjects with renal traumas, 72.5% were low-grade (17).

Most patients with genitourinary injuries were male, 80% in this analysis and the male gender predominance was also reported by Wessells and Hotaling et al with the same trends(1, 4). Male sex continued to be an independent predictor when factoring ISS and AIS grades, mechanism of injury and age (1).

Motorcyclists and cyclists were most often exposed to external genitalia trauma, respectively 62% and 70% of their genitourinary injuries. In contrast, we reported 12% of external genitalia injuries among motorists. This is explained by the protection of the driver's compartment(18).

Bjurlin et al reported 2% of genitourinary injuries following bicycle accidents, with kidney injuries being predominant (75%) followed by bladder and urethra (15%), and penis and scrotum (10%) (5). Kim et al reported 2.2% of genitourinary injuries following mountain bike injuries (19), the most frequent organ injured was the kidney (80%), followed by the ureters (8%), the scrotum (8%) and the testicles (4%). These trends are different in our study, 70% of injuries involved external genitalia among which penile trauma (23%) was the most frequent. Conversely to Bjurlin, we observed a low rate of bladder/urethral injuries among motorcyclists and cyclists, which is consistent with Kim study(5) which did not report any bladder and urethral injuries. This does not imply that this injury is rare but might be explained by a frequent misdiagnosis at the time the patient is admitted.

Kidney injuries in bicyclists were less frequent in our analysis and injury grade according to AAST were typically low with 52% being grade I injuries. The low proportion of collisions (cyclist versus other vehicle/pedestrian) in our study (26%) might explain these different trends. As we saw in multivariate analysis, no third party was a protective factor for genitourinary injuries. Moreover, falls without any other user were probably of a higher speed for mountain bikes than for bicycles in transportation places, especially in urban areas.

Cyclists and motorcyclists are most often exposed to external genitalia injuries due to an upward force on the bony structures of the pelvis with impact on the bicycle/motorcycle frame. Meredith et al reported that 85% of pelvic injuries in motorcycle crashes were due to an impact with the motorcycle fuel tank during the crash(18). Cyclists had a lower rate of testicular trauma than motorcyclists (19% vs 38%), which may be explained by the absence of a fuel tank.

Penile trauma occurred most frequently among cyclists, and physicians should maintain a high awareness for this type of injury because it can be very difficult to diagnose. In a meta-analysis, Amer et al reported that early surgical intervention of penile fracture was associated with significantly fewer complications than conservative management or delayed surgery (20). Surgical intervention results in significantly less erectile dysfunction, curvature and painful erections than conservative management (20). In cases with a concern for penile trauma, ultrasound may be used; however, this is very operator dependent. MRI is another good diagnostic tool, yet accessibility may be difficult, especially in emergencies when there are other major injuries to be treated(21).

In our previous analysis, we reported no ureteric injuries (7), nor were there any in the Bjurlin et al study (5). In the current series, we found 5 (0.5%) ureteric injuries, an under-diagnosis at the time the patient is evaluated may explain this very low rate. CT of the genitourinary system with an injection of contrast enables ureteric rupture diagnosis with good sensitivity (7, 22); however, it is essential to ask the radiologist for delayed imaging in order to highlight urinary extravasation (7, 23).

The current study showed that abdominal, leg, thorax, arm, head and vertebral trauma were the most common regions associated with GU injuries. Bjurlin et al found that patients with vertebral fracture following bicycle accidents had bladder and urethral injuries in 37.7% of cases and 22.6% had kidney injuries(5). Physicians in trauma centers must be aware of possible concomitant genitourinary injury even if the primary trauma involves the head or a vertebral fracture.

In multivariate analysis, only young age remains a risk factor for this type of lesion. These findings are consistent with the fact that GU injuries presented by cyclists are predominantly of minor gravity. Conversely, for motorists and pedestrians, we found many factors known to be associated with the severity of the accident: male sex, having an accident on a rural road, at night, or with a heavy vehicle. These factors, combined with the speed and violence of the shock, are quite consistent with the more serious GU injuries presented by these types of users, including a significant proportion with kidney damage. For motorists, being elderly was associated with an additional vulnerability for GU injuries. For motorists and motorcyclists, the highest risk of genitourinary injuries remained for men, even after considering the road user type and different characteristics of the crash. This may be explained by a higher prevalence of at-risk road

behaviors, such as speeding or alcohol abuse. Not surprisingly, the crash characteristics linked to the highest probability of genitourinary injuries were night, rural roads, and collision with a heavy vehicle, which correspond to known factors of severity.

To our knowledge, this is the largest report in the literature of genitourinary injuries following traffic accidents. However, this study has two limitations. First, our sample represents a single department in France, it could introduce population bias, which may under- or overestimate genitourinary injuries. As the prevalence of genitourinary injuries is different from one user type to another, we gave most of our results according to these criteria, in order to make our results more comparable with other studies which could have a different distribution of user type amongst their victims. Second, with our population-based data, we were not able to account for the management of trauma, outcomes, and the quality of care varying between different trauma centers.

Conclusions

Genitourinary injury is an infrequent trauma following traffic accidents, with kidneys being the most commonly injured. Physicians must maintain a high awareness for external genitalia injuries in motorcyclists and cyclists.

Conflicts of Interest

The authors have no conflict of interest to disclose with respect to this article.

Author contribution statement

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