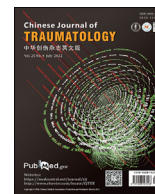


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Original Article

Evaluation of follow-up and long-term outcomes of gunshot and stab wounds in a French civilian population

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ABSTRACT

Purpose: The data concerning long-term follow-up and outcomes of penetrating trauma are poorly detailed in the literature. The main objective of our study was to analyze the hospital and extra-hospital follow-up of penetrating trauma victims and to evaluate the late complications and long-term consequences of these traumas.

Methods: This work was a retrospective longitudinal monocentric observational study conducted at Laveran Military Hospital, from January 2007 to January 2017. All patients hospitalized for gunshot wound or stab wound management during this period were identified via a retrospective systematic query in the hospital information system using the ICD-10 codes. Epidemiological data, traumatism characteristics, hospital management, follow-up and traumatism consequences (i.e., persistent disability) were analyzed. To improve evaluation of traumatism long-term consequences, extra-hospital follow-up data from general physicians (GP) were collected by phone call. During this interview, 9 closed questions were asked to the GP. The survey evaluated: the date of the last consultation related to injury with the GP, the specific follow-up carried out by the GP, traumatism consequences, and recurrence of traumatism. Descriptive, univariate and multivariate with regression analysis were used for statistical analysis.

Results: A total number of 165 patients were included. Median (Q1, Q3) of hospital follow-up was 28 (4, 66) days. One hundred one patients (61.2%) went to their one-month consultation at hospital. GP follow-up was achieved for 76 patients (55.2%). Median (Q1, Q3) of GP follow-up was 47 (21, 75) months. Twenty-four patients (14.5%) have been totally lost to follow up. The overall follow-up identified 54 patients (32.7%) with long-term consequences, 20 being psychiatric disorders and 30 organic injuries. Organic consequences were mainly peripheral nerve damages ($n = 20$; 12.1%). Most of the psychiatric consequences were diagnosed during GP follow-up ($n = 14$; 70%). Seventeen cases (10.3%) of recurrence were found and late mortality occurred in 4 patients (2.4%). High injury severity score, older age and gunshot wound were significantly linked to long-term consequences. Data collection and analysis were carried out in accordance with MR004 reference methodology.

Conclusion: This study showed a high rate of long-term consequences among patients managed for penetrating injury. If all organic lesions are diagnosed during hospital follow-up and jointly managed by hospital and extra-hospital physicians, most socio-psychiatric consequences were detected and followed by extra-hospital workers. However, for half of the patients, the extra-hospital follow-up could not be assessed. Thus, these consequences are very probably underestimated. It appears imperative to strengthen the compliance and adherence of these patients to the care network. Awareness and involvement of medical, paramedical teams and GP role seems essential to screen and manage these consequences.

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Introduction

According to the World Health Organization, trauma and violence are responsible of 9% of global mortality and are the leading cause of death among young adults.¹ The management of patients with gunshot wounds (GSW) and stab wounds (SW) is complex, often multidisciplinary and limited to the period of trauma. Few data exist in France and these data are often focused on pre-hospital or hospital care.^{2–4} The circumstances of occurrences are various: banditry, aggression, self-inflicted injuries, alcohol, familial violence, etc. In Finland, a study conducted in 2014 showed that 12% of patients with trunk wounds died secondarily from alcohol-related or violent problems,⁵ highlighting the secondary importance of long-term care for these patients.

The management of penetrating wounds is one of military doctor's specialties not only in conflict areas during missions in foreign territories, but also on French territory. The long-term monitoring and rehabilitation processes of the wounded soldiers have been developed.^{6,7} Despite this military experience, the hospital management of penetrating trauma for civilian patients appears to be limited to the trauma and its immediate consequences. The follow-up length and compliance rate of patients received outpatient hospital follow-up or extra-hospital follow-up with the general physicians (GP) is unknown. It is currently impossible to assess recurrences or secondary complications.

In view of these elements, description and assessment of the victim's follow-up seem to be essential. The main objective of this study was to evaluate the outpatient hospital and extra-hospital follow-up of penetrating injury victims and to describe long-term consequences of these traumas.

Methods

Study population

This work is a non-randomized retrospective longitudinal monocentric observational study at Laveran Military Hospital (LMH), Marseille, France. From January 2007 to January 2017 patients hospitalized for SW and GSW were extracted from the LMH informatic database via International Classification of Diseases 10 (ICD-10) coding. Fifty-one ICD-10 codes for a total of 1150 extended diagnoses were used to list patients with SW or firearm injuries.

All patients being victims of GSW and/or SW during the study period (January 1, 2007 and January 1, 2017) were included, regardless of the location of the wound (cervico-cephalic region, thorax, abdomen, pelvis, limbs). Only hospitalized patients regardless of the unit (intensive care, thoracic and visceral surgery, maxillofacial surgery, orthopedic surgery or rehabilitation units) were included in the study. Patients with a superficial wound (limited to the skin) were excluded from the study. Patients with deep wounds (beyond the skin) who were not hospitalized in intensive care unit or in a medical/surgical unit after emergency department or resuscitation room management were also not retained. Finally, patients died or transferred during initial management were also excluded from the study population.

Intra-hospital data collection

The following information was collected for each patient: epidemiological details (age, sex, American Society of Anesthesiology score), traumatism characteristics (type of trauma, location of the wounds, severity of the lesions according to the injury severity

score (ISS)⁸), pre-hospital care or direct hospital admission; internal injuries related to GSW or SW, hospital management (surgical vs. non-operative management, post-operative course, specific psychologist consultation during initial hospitalization, length of in-hospital stay, and re-hospitalization). Post-operative complications were classified according to the Clavien–Dindo classification.⁹

Follow-up data collection

Outpatient hospital follow-up related to trauma was studied to collect this following information: attendance at 1-month consultation, type of follow-up in relation to the trauma (medical, psychological, dressings care, physiotherapy, etc.), length of follow-up, traumatism consequences highlighted during the outpatient hospital follow-up (called intra-hospital consequence), and traumatism recurrence identified in LMH informatic database. A consequence was defined as a persistent trauma-related injury after the initial event and could be a disability or disabling or non-disabling symptoms.

To improve evaluation of traumatism long-term consequences, extra-hospital follow-up data from GPs were collected using a phone call. No response to 3 calls during a 4-month period was excluded the GP from our study. During this interview, 9 closed questions were asked to the GP focusing on 3 main points: the date of the last GP consultation related to injury, the specific follow-up carried out by the GP in relation to the trauma (medical, psychological, dressings care, physiotherapy, etc.), and traumatism consequences identified (called extra-hospital consequence) including late trauma-related death, and recurrence of traumatism.

The consequences highlighted both during outpatient hospital and extra-hospital follow-up were separated in 2 categories: organic (peripheral and central neurological, osteoarticular, cardiopulmonary, abdominal, urological, maxillofacial) and psycho-social.

At the end of the 2 kinds of data collections, a predicting factors analysis was carried out.

Statistical analysis

Data were collected and analyzed using Microsoft Corporation® Excel. The categorical variables were synthesized by the absolute frequencies and percentages of each of the observed levels. The continuous variables were synthesized by their median and interquartile interval (median (Q1, Q3)).

Univariate analyses were performed with OpenEpi® (version 3.01) and Epi Info™ (version 7.2.2.2.6), using the Chi-square test or Fischer's exact test (non-parametric test) under the test application conditions, for categorical variables comparisons and using the ANOVA test or Kruskal-Wallis test (non-parametric test) under the test application conditions, for continuous variable comparisons. A value of $p < 0.05$ was considered significant.

A multivariate analysis was performed for the determinants associated with the consequences with software R (version 3.5.1). The classification and regression trees algorithm were used to predict the consequences of injuries and psychiatric consequences. This analysis was performed with the R package "Rpart program Rpart build classification" or regression models represented by binary trees. On each level, population division in 2 groups based on the Gini impurity index had been tried. A univariate analysis was performed to select the variables used in the regression analysis with a 30% threshold.

Data collection and analysis were carried out in accordance with MR004 reference methodology.

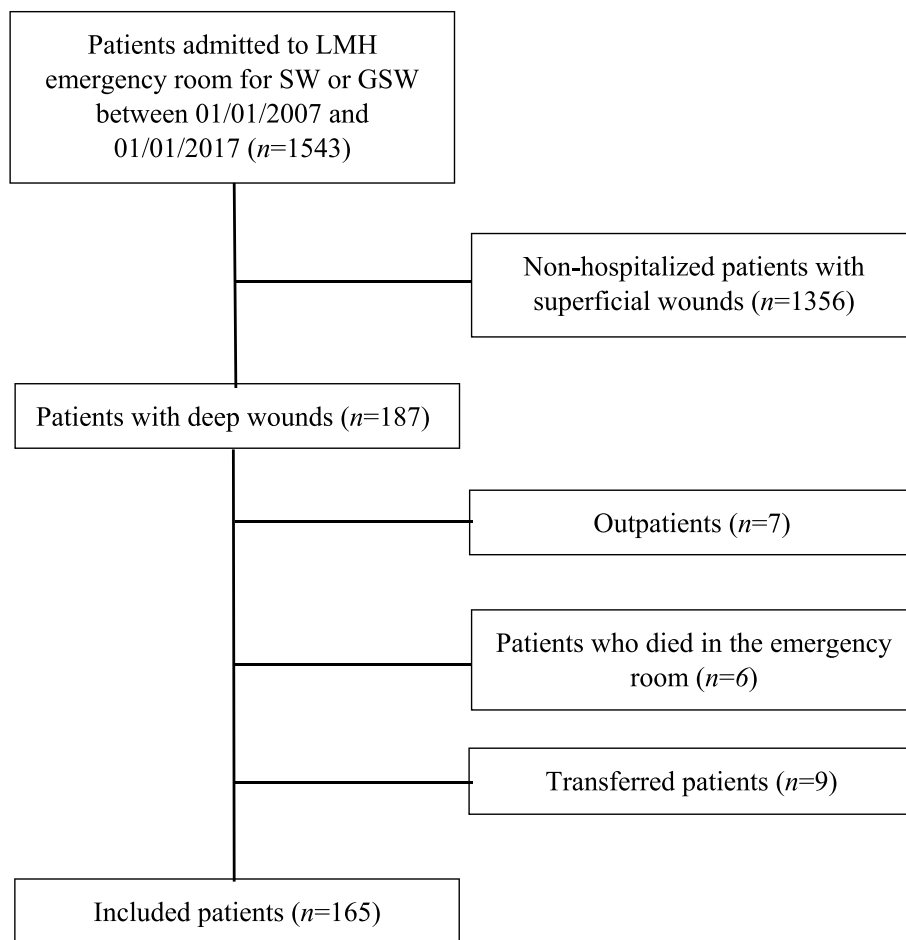


Fig. 1. Flow chart of the patients included in the study. LMH: Laveran Military Hospital; SW: stab wounds; GSW: gunshot wounds.

Table 1 Characteristics of patient and traumatism (n = 165).

Variables	Results
Patient characteristics	
Male sex	151 (91.5)
Age (years)	26 (20, 38)
ASA score	1 (1, 1)
Type of trauma	
GSW	58 (35.2)
SW	107 (64.8)
Mode of occurrence	
Assault	142 (86.1)
Self-inflicted injury	15 (9.1)
Accident	8 (4.8)
Coming mode	
Own resource	95 (57.6)
After pre-hospital care	70 (42.4)
Wounds location	
Thoracic	80 (48.5)
Abdomino-pelvic	82 (46.7)
Cervico-cephalic	33 (20.0)
Upper limbs	33 (20.0)
Lower limbs	43 (26.1)
ISS	
< 10 (minor)	26 (15.8)
10–19 (moderate)	40 (24.2)
20–29 (severe)	69 (41.8)
> 29 (critical)	30 (18.2)

Note: data are presented as n (%) or median (Q1, Q3). ASA: American Society of Anesthesiologists; GSW: gunshot wound; SW: stab wound; ISS: injury severity score.

Results

Epidemiological and injuries characteristics

Finally, 165 patients were included in the study. Fig. 1 represents the flow chart. Most of patients were male (n = 151, 91.5%). The median age was 26 years (20, 38). The characteristics of the patients and traumatism are summarized in Table 1.

The majority of patients were victims of SW (n = 107, 64.8%) during aggression (n = 142, 86.1%). More than half of the patients were admitted without pre-hospital care (n = 95, 57.6%). The GSW/SW distribution did not differ significantly between patients who benefited from pre-hospital care and those who arrived in emergency department by themselves. GSW were more frequent (p = 0.05) for patient without truncal injury (Table 2).

The median ISS was 20 (13, 29) and was significantly higher for patients with thoracic and/or abdominal injury (p < 0.001). Eleven (6.7%) patients were hemodynamically unstable (systolic blood pressure <90 mmHg) at the first medical or paramedical contact; 10 (91.0%) of them had a truncal injury.

Injury management at initial hospitalization

Table 2 details the hospital management and follow-up according to the presence or not of a truncal injury. Patients with truncal injuries were more frequently managed by pre-hospital medical team (p < 0.001). Whatever the location of the lesions,

surgical management was required for 124 patients (75.2%). Surgery was significantly more frequent for truncal injury ($p < 0.001$). Among the operated patients, 13 (10.5%) presented a post-operative complication and 21 (12.7%) a secondary complication. Seventeen (10.3%) of these patients needed a second hospitalization. In 16 cases (9.7%), a surgical operation was performed. These interventions were related to a complication in 10 cases (6%) and to a secondary reconstruction in 7 cases (4.2%). Post-operative complications ($p = 0.003$) and re-hospitalization ($p = 0.001$) were significantly more required for patient with truncal injury.

Half of the patients were hospitalized in intensive care unit during management ($n = 80, 48.5\%$), then in thoracic and visceral surgery for 127 patients (77.0%), orthopedic surgery for 20 patients (12.1%), maxillofacial surgery for 10 of them (6.1%), and finally 5 patients (3.0%) were treated in rehabilitation unit. The median length of hospitalization was 5 days (2, 8) and did not differ significantly whether there was a truncal injury or not ($p = 0.5$ as showing in Table 2).

Post-hospital follow-up

Table 3 lists the trauma consequences identified during outpatient hospital and extra-hospital follow-up of patients with penetrating trauma.

Among the study population, 102 patients (61.8%) went to their 1-month follow-up consultation. Patients with truncal injury were significantly more diligent for this follow-up ($p < 0.001$). Among the patients who did not attend this 1-month follow-up, 37 (22.4%) were never seen again at the hospital and were considered lost to follow-up for LMH. The median duration of outpatient hospital trauma follow-up was 28 (4, 66) days and did not significantly differ according to the internal injury.

At least one quarter of patients presented a consequence followed by hospital physician ($n = 40, 24.2\%$), three-quarters of which being organic injuries ($n = 30, 18.2\%$). Among organic consequences neurological deficit was the most frequent consequence ($n = 22, 73.3\%$): flaccid T4 paraplegia ($n = 1$), cauda equina syndrome ($n = 1$), peripheral neurological deficit ($n = 20$: 9 at upper extremity, 8 at lower extremity, 2 facial nerves and 1 lumbar plexus). Neurological consequences were equally distributed between patients with and without truncal injury (11 and 10 patients, respectively) but most of them had limb injury ($n = 15, 71.4\%$). The other organic consequences were vicious callus ($n = 2$), limping

($n = 1$), pulmonary arterial hypertension ($n = 1$), urethral stenosis ($n = 1$), urinary incontinence ($n = 1$), permanent stoma ($n = 1$), swallowing and speech disorder ($n = 1$). Twenty-three (76.7%) of these organic consequences occurred consecutively to GSW. Only 1 patient died during this follow-up (0.6%). He was a 75-year-old patient who presented a thromboembolic accident following reversal of Hartmann's procedure. During their hospitalization, 26 patients (15.7%) were supported in psychiatric/psychological consultation. Twelve (7.3%) had regular psychiatric follow-up and a persistent psychiatric consequence have been diagnosed for 9 patients (5.4%). Twelve cases (7.3%) of recurrences (4 self-inflicted injuries, 8 cases of aggression) were identified in the hospital records. All these second traumas occurred within 12 months of their initial hospitalization.

GP contact information was invalid for 64 patients (38.8%). For the remaining patients ($n = 101, 61.2\%$), follow-up by GP was evaluable and performed only for 76 patients (46.1%). Among these patients, 13 (7.9%) were lost of follow-up for LMH so that final loss of follow-up population was 24 patients (14.5%). The median follow-up time with GP was 47 (21, 75) months.

Among the GP followed patients, 41 (24.8%) received specific medical follow-up regarding trauma. Half of them had short follow-up for dressing and reeducation ($n = 17$). Twenty-four patients had an extended follow-up for trauma consequences (extra-hospital consequences), representing 14.5% of the total initial population. The most frequent extra-hospital consequences were psychiatric disorder for 14 patients (8.5%). Six patients (3.6%) presented a post-traumatic stress disorder (PTSD) and 8 (4.8%) an anxiety disorder. Five patients are still treated with medication and 6 still took in charge. Among these 14 patients, 3 were already followed during their hospitalization at LMH, 6 patients were followed for immediate post-trauma organic complications (locomotor disorders, peripheral neurological deficit, urinary and abdominal damage) and were jointly followed at LMH. The remaining 4 extra-hospital consequences recorded were deaths (2.4%) reported by GP. Only 1 was notified in LMH database and the other 3 were secondary self-inflicted deaths.

During the GP follow-up, 6 recurrences cases (3.6%) of trauma caused by GSW or SW were identified (2 cases of self-inflicted injuries, 2 cases of self-inflicted injuries secondary to assault trauma and 2 cases of assault trauma recurrence). Of these 6 cases of recurrence, only 1 case was notified in intra-hospital database. Global recurrence count was 17 (10.3%).

Table 2
Hospital management and follow-up according to wounds location.

Variables	Total (n = 165)	Patients with truncal injury (n = 86)	Patients without truncal injury (n = 79)	p value
Trauma characteristics				
ISS	20 (13, 29)	23 (20, 30)	13 (8, 20)	<0.001
GSW	58 (35.2)	24 (27.9)	34 (43.0)	0.05
Patients managed in pre-hospital care	70 (42.4)	50 (58.1)	20 (25.3)	<0.001
Intra-hospital management				
Surgical treatment	124 (75.2)	80 (93.0)	44 (55.7)	<0.001
Post-operative complications (% operated on)	13 (7.9)	12 (14.0)	1 (1.3)	0.003
Secondary complications	21 (12.7)	15 (17.4)	6 (7.6)	0.065
In-hospital length of stay (days)	5 (2, 8)	13 (8, 20)	7 (5, 11)	0.5
Re-hospitalization	17 (10.3)	14 (16.3)	3 (3.8)	0.01
Re-intervention	16 (9.7)	9 (10.5)	7 (8.9)	0.8
Post-hospital follow-up				
One-month hospital follow-up consultation	102 (61.8)	64 (74.4)	38 (48.1)	<0.001
Outpatient hospital follow-up duration (days)	28 (4, 66)	38.5 (15, 144)	11 (1.5, 42)	0.95
Intra-hospital consequences	40 (24.2)	26 (30.2)	14 (17.7)	0.07
Duration of post-trauma monitoring by the GP (months)	47 (22, 75)	46 (23, 75)	48 (20, 75)	0.92
Extra-hospital consequences	24 (14.5)	13 (15.1)	11 (13.9)	1

Note: data are presented as n (%) or median (Q1, Q3).
ISS: injury severity score; GSW: gunshot wound; GP: general physician.

Table 3
Trauma consequences related to GSW and SW, n (%).

Variables	Intra-hospital consequences (n = 40)	Extra-hospital consequences (n = 24)	Total consequences (n = 54)
Total	40 (24.2)	24 (14.5)	54 (32.7)
Organics	30 (18.2)	6 (3.6)	30 (18.2)
Nervous damage	22 (13.3)	2 (1.2)	22 (12.3)
Central	2 (1.2)	0	2 (1.2)
Peripheral	20 (12.1)	2 (1.2)	20 (12.1)
Osteo-articular	3 (1.8)	2 (1.2)	3 (1.8)
Cardiologic	1 (0.6)	0	1 (0.6)
Urinary	2 (1.2)	1 (0.6)	2 (1.2)
Abdominal	1 (0.6)	1 (0.6)	1 (0.6)
Maxillo-facial	1 (0.6)	0	1 (0.6)
Psychiatric	9 (5.4)	14 (8.5)	20 (12.1)
AD	4 (2.4)	8 (4.9)	11 (6.6)
PTSD	5 (3.0)	6 (3.6)	9 (5.5)
Death	1 (0.6)	4 (2.4)	4 (2.4)
Recurrence	12 (7.3)	6 (3.6)	17 (10.3)

GSW: gunshot wound; SW: stab wound; AD: anxiety disorder; PTSD: post-traumatic stress disorder.

Analysis of factors predicting consequences

Table 4 presents the consequence rates of penetrating trauma according to the epidemiological and lesional factors analyzed in univariate form. The ISS > 30, older age and GSW were the 3 significant predictors of overall consequences. On the other hand, regarding psychiatric consequences, only the ISS > 30 was significantly related to the occurrence of a consequence (p = 0.01).

Multivariate analysis, using the classification and regression trees algorithm, identified ISS > 20 and age > 32 years as being the two main predictive factors of long-term trauma consequences.

Discussion

According to the World health Organization, 8 of the 15 leading causes of death of people aged 15–29 years are related to penetrating injuries and their management remains a real long-term medical and surgical challenge.¹ Urban violence is on the rise, and in the Bouches-du-Rhône department alone, nearly 9000 to

10,000 cases of aggression by firearm or knife are recorded each year by the Police and Gendarmerie services.¹⁰ The number of homicides in this area is the highest in France.¹¹ Few data exist in France about penetrating trauma management, and existing studies are limited to epidemiological and descriptive data on pre-hospital or hospital management.^{3,4} This study was conducted to evaluate the follow-up of penetrating trauma victims and the long-term outcomes of these trauma.

It appears that almost one-third of the study population had organic and/or psychiatric consequences at 4 years. No data exists about the overall long-term consequences of penetrating trauma in the current literature to compare with our results. Holbrook et al.¹² evaluated quality of life after major trauma (blunt and penetrating). The authors reported a prolonged and profound level of functional limitation after major trauma at 12-month and 18-month follow-up. For these patients' quality of well-being scores were below the healthy norm of 0.8 in almost 80% of patients. However, they did not detail the reasons of quality-of-life alteration.¹² In another report, the authors demonstrated that quality-of-life was worse in

Table 4
Univariate analysis of consequence of penetrating trauma according to different epidemiological factors.

Variables	Absence of PT consequence	Presence of PT consequence	Univariate		
			OR	95% CI	p value
Age (years)	24.7 (20.2, 35.4)	29.9 (22.1, 41.7)	1	(1.01, 1.06)	0.01
<20	26 (23.4)	10 (18.5)	–	–	–
20–40	66 (59.5)	29 (53.7)	1.1	(0.49, 2.67)	0.76
>40	19 (17.1)	15 (27.8)	2.1	(0.76, 5.55)	0.16
ISS					
<20	48 (43.2)	13 (24.1)	–	–	–
20–29	41 (36.9)	14 (25.9)	1.3	(0.53, 2.99)	0.6
>30	22 (19.8)	27 (50.0)	4.5	(1.97, 10.41)	<0.001
GSW	28 (25.2)	30 (55.6)	3.7	(1.86, 7.36)	<0.001
Surgical patient	79 (71.2)	45 (83.3)	2	(0.89, 4.62)	0.09
Wounds location					
Upper limb	22 (19.8)	11 (20.4)	1	(0.46, 2.33)	0.93
Lower limb	26 (23.4)	18 (33.3)	1.6	(0.80, 3.35)	0.18
Cephalic	10 (9.0)	6 (11.1)	1.3	(0.43, 3.68)	0.67
Cervical	11 (9.9)	6 (11.1)	1.1	(0.40, 3.26)	0.81
Abdomen	53 (47.7)	25 (46.3)	0.9	(0.49, 1.81)	0.86
Thorax	55 (49.5)	25 (46.3)	0.9	(0.46, 1.68)	0.69
Perineum	3 (2.7)	1 (1.9)	0.7	(0.07, 6.69)	0.74
Attendance at the consultation at 1 month	63 (56.8)	39 (72.2)	2	(0.98, 4.01)	0.06

Note: data expressed as n (%) or median (Q1, Q3).

p values less than 0.3 are the variables used for multivariate analysis.

ISS: injury severity score; GP: general physician; GSW: gunshot wound; SB: stab wound; PT: penetrating trauma.

women than in man independently of the trauma mechanism, injury severity and location of injury. Depression and symptoms of acute stress reaction were mainly responsible of the quality-of-life alteration.¹³ Our study included only 8.5% of women. Moreover, it did not assess quality of life but aimed to evaluate persistent disability after trauma. The lack of disability did not mean that there is no quality-of-life impairment.

During outpatient hospital follow-up, one quarter of patients presented long-term consequences mainly (three-quarter of these consequences) being organic consequences. Peripheral nerve damages (PND) with persistent deficit represented half of organic lesions encountered and occurred for 12% of patients. This result is higher than those reported in the current literature. Indeed, in 1998, Noble et al.¹⁴ reported 2.8% of PND among global population of patients with multiple injuries. More recently, in Irak and Afghanistan, PND occurred in 8.1% of combat casualties.¹⁵ Dootz et al.¹⁶ suggested a trend association between PND and mechanism of injury, PND appearing more frequent with explosion and central nervous injury more frequent in case of gunshot injury. We only had 2 cases of central nervous damage in our series. However, there is a recruitment bias, central neurological cases being redirected by pre-hospital care to level 1 trauma centers. Our high rate of PND is probably explained by the mechanism of injury (SW being frequent in French civilian setting), especially by the high rate of limb injury of our series (46%). Indeed, PND are frequently associated with extremities injuries.^{15,16} As in our series, the most common PND reported in the literature are the radial and ulnar nerve in the upper limb and the peroneal nerve in the lower limb.^{15,17} In our series, PND of the upper extremities are as common as that of the lower extremities. In recent war injuries, lower extremity PND appeared more frequent compared to previous conflict and civilian casualties of our series. Indeed, explosions represented the main mechanism of injury during war and are frequently associated with major limb injuries.¹⁵ Conversely, in Syrian war, GSW were the main mechanism of injury and forearm PND were more frequent.¹⁷

Few psychological consequences were noted during outpatient hospital follow-up. GP survey appeared to be of high interest and allowed to find more psychiatric consequences than expected. Indeed, the proportion of psychiatric consequences is significant in our study (12.1%). In the French Army, an article published in the official journal of the Senate in 2015¹⁸ reported high rates of PTSD (12% for Operation Sangaris, a French military operation deployed in the Central African Republic between 2013 and 2016 and 8% for Operation Pamir, a French military mission deployed in Afghanistan from 2012 to 2014). However, this rate is probably underestimated. Indeed, only half of the GP patient follow-up was evaluated in our study. In 2016, in a clinician-administered PTSD scale-1 structured interviews among French soldiers returning from Afghanistan, more than one quarter of soldiers suffered at least 1 mental disorder.¹⁹ After civilian war in Kosovo, prevalence of PTSD in survivors was evaluated at 26%.²⁰ In the civilian field, the prevalence of PTSD differs from one study to another. After Charlie Hebdo and Bataclan attacks in France in 2015, Goodwin et al.²¹ reported a PTSD rate of 11.9% and 14.1%, respectively for the 2 attacks. Alarcon et al.²² showed a high incidence (25%–43%) of acute PTSD symptoms in traumatized patients, particularly victims of interpersonal violence.

PTSD occurrence is a significant socio-economic issue, since victims of PTSD following trauma are subject to social isolation and are 6 times less likely to return to their socio-professional environment.²² In our series, ISS was the only predictive factor of psychological disorder. Some authors found other predictive factors of PTSD following trauma such as female gender, young age, GSW mechanism, chest location, and context of aggression.²² Based on these predictive factors, in trauma context, it is important to track

PTSD to provide early, appropriate, and beneficial treatment for patients and society.

If organic consequences followed by GP were all known in LMH database, psychologic consequences of trauma appeared under-diagnosed during the hospital follow-up (5.4%). The role of GP seems to be important in this context for the diagnosis, management, and follow-up of patients with GSW and SW. Indeed, it is important to note that only half of patients develop symptoms within a month after traumatic event and the delay before the first symptoms can be longer than 12 months for some.¹⁹ This psychologic disorder particularity justifies a long follow-up by GP. In view of the proportion of psychiatric consequences, it seems essential to train teams in screening for PTSD and to involve competent personnel in order to detect early, manage and ensure long-term follow-up in the same way as what has been set up within the French Military Health Service.¹⁹ Indeed, an active health plan has been developed to place military doctors and nurses at the heart of the early detection system for patients with PTSD upon mission's return.¹⁹

Our study found a poor compliance to follow-up. Only two-thirds of patients came at 1-month consultation follow-up and 22% of patients were lost of follow-up at hospital level. This failure to follow-up (FTF) had ever been reported in the current literature.^{22,23} Indeed, Alarcon et al.²² found a 32% rate of compliance with trauma clinic follow-up on a population study of 6800 patients. On the other hand, Aaland et al.²⁴ found a high compliance rate after evaluating trauma clinic and subspecialist (external) follow-up after trauma. The compliance rate at trauma clinic follow-up was 70.8%. However, when adjusting with subspecialist consultation, they objectified an overall rate of compliance of 87.2%. This study did not find any predictive factor. For the authors, system failure (i.e., failure of patient education on the day of hospital discharge and physician discharge orders lacks) was the main cause of missing follow-up.²⁴ For Leukhardt et al.²³ study on 14,784 trauma victims, 62% had follow-up appointments. Orthopedics had the largest portion of the follow-up visits. This study highlighted epidemiological factors such as lower incomes and education level, non-white race and advanced age as predictive FTF. Moreover, the authors demonstrated a significant relationship between FTF, lower ISS and blunt injuries.²³ In our series, we were not able to collect socio-demographical data. However, our results highlighted that patient without truncal injury or with lower ISS were significantly more likely to miss 1-month consultation. Indeed, truncal injuries had frequently more complication and required more new hospitalization following the initial trauma explaining a better compliance to follow-up. Some studies proposed solutions to improve this observation using ways to remind patients of their consultation by telephone call and voice message,²⁵ improving patient education on the day of hospital discharge, and re-educating the physician/nursing team as to the importance for scheduling follow-up appointments.²⁴

To our knowledge, this is the first series to investigate the impact of GP on trauma follow-up and consequences. GP follow-up had permitted to detect new consequences, exclusively psychiatric, and to improve the follow-up for 13 patients lost to follow up by the LMH. Although this survey could only cover half of the patients, it turned out to be very interesting with a high rate of psychiatric consequences later detected (almost 20% of the GP followed population). Moreover, this survey highlighted trauma recurrence evaluated at 10.3%. The survey of general practitioners yielded a recurrence rate that is probably not so far of the reality, but our methodology probably leads to an underestimation of it.

The overall late mortality rate of our study is 2.4%. In the literature, reported overall mortality rates are in the order of 5%–10% including early and in-hospital mortality.^{26,27} Long-term follow-up

is required for adequate evaluation of trauma-related mortality.²⁸ GP survey revealed late mortality related to recurrence (mainly self-inflicted) unknown from hospital medical records. In a retrospective study of 130 patients with penetrating trauma, Inkinen et al.⁵ reported a 13% rate of late mortality verified as accidental, suicidal, or violent. It is noted that in this series, self-inflicted injuries rate was high, representing 23% of the population, i.e., 2 times more than in our population. The late mortality rate in our study is most likely underestimated by the monocentric hospital follow-up collection and the GP survey did not allow to screen the overall population and to correct this bias. This retrospective analysis allowed to identify 3 main predictive factors of long-term consequences of penetrating trauma. As in the literature,²⁹ our study revealed that severe casualties (severe to maximum ISS score in our study) have a significantly higher rate of global consequences but more specifically psychiatric consequences. The study by Alarcon et al.²² did not find a significant relationship between the ISS and the psychiatric impact of trauma. However, the authors found a link between PTSD and the gunshot injury mechanism. Some authors highlighted that major in-hospital complications following trauma have an important impact on functional outcomes.³⁰ In our series, we did not find any significant link between complication rate and long-term consequences but patient with truncal injuries had higher ISS and developed significantly more complication and required more re-hospitalization. The initial severity of the trauma and its management has probably an impact on psychological experience for patient.

In our study, GSW was significantly predictive of overall consequences. GSW did not appear as a predictive factor in specific psychologic consequences analysis, 50% occurring after SW. However, almost 80% of organic consequences occurred consecutively to GSW. These injuries are known to be more vulnerable in terms of lethality, morbidity, injury balance and therefore have serious consequences.^{31,32} The GSW/SW ratio in our population is 1/2 and appears to be higher than those found in French literature, with the most recent studies finding a ratio of 1/6 to 1/7.^{2,4} This high representation of injury mechanism could explain our high rate of consequences.

The age of the patients was a significant predictor of consequences in our study. In the literature, influence of age diverges from one study to another. In the psychiatric field, the literature goes against our result with post-traumatic consequences (PTSD, personality disorder) more frequent when the trauma occurs at an early age.²² No study to our knowledge has shown any link between physical consequences and age. Some studies associate higher age with more frequent morbidity and mortality following trauma.

Some studies, such as the Finnish study by Inkinen et al.⁵ and the study by Cornwell et al.,³³ highlight social and economic factors associated with the morbidity and mortality of violent trauma (self-inflicted injury, aggression). According to these studies, drug and alcohol consumption and precariousness should be considered as warning signs of complications and post-trauma consequences. Dijkink et al.²⁶ uses the term “public health burden” to describe these traumas responsible for premature excess mortality, disability and psychological impact. These socio-economic factors could be considered as warning sign of complications in GP follow-up.

There are several limitations of our study. First, retrospective analysis of hospital data may have led to missing information. Post-hospital data prospectively acquired by phone questionnaire exposed us to memory and information bias, even if this call allowed to refine and complete the hospital database. GP was not known for each patient and some of the GP were retired at the time of the survey and data could not be completed for more than half of the patients.

Our results should be interpreted with caution, considering the recruitment bias and confusion bias due to the monocentric nature of the study. A larger multicentric study using French trauma base could decrease this bias.³⁴

For overall mortality evaluation, it would have been interesting to cross-checked our data with the databases of the Centre for Epidemiology of Medical Causes of Death and the National Health Data System. Moreover, a complementary prospective study focusing on patient recall would provide a more accurate assessment of long-term consequences using quality of life scores and PTSD screening scales such as the Post Traumatic Stress Disorder Checklist Scale and Hospital Anxiety and Depression scale.

In conclusion, our study showed that SW and GSW follow-up is a real management issue. This is a complex subject but not studied in its globality by the current literature. Our study provided an overall epidemiological overview and raised issues regarding the follow-up and long-term consequences of penetrating trauma victims. It shows that one third of patients have long-term organic and/or psychiatric persistent disorders with at least 10% recurrence. However, the hospital follow-up seems insufficient for psychologic disorder diagnosis. It is therefore imperative to strengthen the compliance and adherence to the care network of these patients. It also seems necessary to raise awareness and train medical and paramedical teams on the secondary consequences, follow-up, and overall management of these patients.

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Ethical statement

This study has been approved by the local ethics committee and have therefore been performed in accordance with the ethical standards. Data collection and analysis was carried out in accordance with MR004 reference methodology.

Declaration of competing interest

The authors have no conflict of interest to disclose.

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Author contributions

Julie Fournier contributed at collecting the data, analyzing the data, and writing the final manuscript.

Laure Salou-Regis contributed at collecting and analyzing the data.

Bruno de La Villeon helped collecting and analyzing the data and did the critical revision and final approval of the version submitted.

Ghislain Pauleau helped collecting the data, and did the final approval of the version submitted.

Géraldine Goin helped collecting the data, and did the final approval of the version submitted.

Yvain Goudard contributed to designing the study, analyzing the data, did critical revision and correcting the final manuscript.

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