Assessment of the mass casualty triage during the November 2015 Paris area terrorist attacks: towards a simple triage rule

Arthur James[a,b], Youri Yordanov[a,c,d,e], Sylvain Ausset[f], Matthieu Langlois[b,g], Jean-Pierre Tourtier[h], Pierre Carli[i,j], Bruno Riou[a,d,k,l] and Mathieu Raux[a,b,m], for the TRAUMABASE Group

Backround **Triage is key in the management of mass casualty incidents.**

Objective **The objective of this study was to assess the prehospital triage performed during the 2015 Paris area terrorist attack.**

Design setting and participant **This was a retrospective cohort study that included all casualties of the attacks on 13 November 2015 in Paris area, France, that were admitted alive at the hospital within the first 24 h after the events. Patients were triaged as absolute emergency or relative emergency by a prehospital physician or nurse. This triage was then compared to the one of an expert panel that had retrospectively access to all prehospital and hospital files.**

Outcomes measures and analysis **The primary endpoints were the rate of overtriage and undertriage, defined as number of patients misclassified in one triage category, divided by the total number of patients in this triage category.**

Main result **Among 337 casualties admitted to the hospital, 262 (78%) were triaged during prehospital care, with, respectively, 74 (28%) and 188 (72%) as absolute and relative emergencies. Among these casualties, the expert panel classified 96 (37%) patients as absolute emergencies and 166 (63%) as relative emergency. The rate of undertriage and overtriage was 36% [95% confidence interval (CI), 27–47%] and 8% (95% CI, 4–13%), respectively. Among undertriaged casualties, 8 (23%) were considered as being severely undertriaged. Among overtriaged casualties, 10 (77%) were considered as being severely overtriaged.**

Conclusion **A simple prehospital triage for trauma casualties during the 13 November terrorist attack in Paris could have been performed triaged in 78% of casualties that were admitted to the hospital, with a 36% rate of undertriage and 8% of overtriage. Qualitative analysis of undertriage and overtriage indicate some possibilities for further improvement. _European Journal of Emergency Medicine_ XXX: 000–000 Copyright © 2020 Wolters Kluwer Health, Inc. All rights reserved.**

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[a]Sorbonne Université, [b]Department of Anaesthesiology and Critical Care Paris, Hôpital Pitié-Salpêtrière, Assistance Publique-Hôpitaux de Paris (APHP), [c]UMRS Inserm 1136, [d]Department of Emergency Medicine and Surgery, Hôpital Saint-Antoine, [e]Department of Emergency, APHP, [f]Department of Anesthesiology and Critical Care, Hôpital d'Instruction des armées (HIA), Clamart, [g]Service Médical du RAID, Bièvres, [h]Brigade de Sapeurs-Pompiers de Paris, [i]Service d'Aide Médicale Urgente 75, Hôpital Necker-Enfants Malades, APHP, [j]Université de Paris, [k]UMRS Inserm 1166, IHU ICAN, [l]Department of Emergency Medicine and Surgery, Hôpital Pitié-Salpêtrière and [m]UMRS Inserm 1158, Paris, France

Correspondence to Arthur James, MD, Département d'Anesthésie Réanimation et Médecine Périopératoire, Groupe Hospitalier Pitié-Salpêtrière, 47-83 boulevard de l'Hôpital, 75651 Paris Cedex 13, France
Tel: +33 1 42 17 72 73; fax: +33 1 42 17 73 88; e-mail: arthur.james@aphp.fr

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Introduction

Major incidents resulting in mass casualties occur more frequently and challenge our ability to provide the best care to most people. Unfortunately, western countries have experienced an increasing number of terrorist attacks using firearms, explosives, and trucks [1–5]. These attacks designed to kill and injure the largest number of casualties, using simultaneous attacks and multiple means, require an appropriate medical organization [2]. Triage is a key principle in the management of major incidents, comprising early identification and transport to the most appropriate center within the most appropriate delay. Although both undertriage and overtriage are of paramount importance during a major incident, there is limited evidence-based on existing triage tools. Since prospective research in this area is difficult to conduct and probably unethical, most information has been obtained during simulation research, which may not apply to real conditions [6–8]. Analysis of the triage during major incidents may also be difficult because of either small sample size, study heterogeneity, and biased selection of studied casualties [9–10]. A systematic review concluded that field triage systems do not perform consistently during mass casualty events [11].

In 2015, Paris and its suburb Seine-Saint-Denis were the scenes of multiple terrorist attacks, which were unprecedented since the Second World War in Europe [3–5].

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In the present study, prehospital triage performed was analyzed using a dichotomous scale (absolute emergencies vs. relative emergencies). This simple triage tool was taught and practiced in France for more than 30 years, following the principle of simplicity recommended after the London attacks in 2005 [1,12].

We aimed to assess the diagnostic performance of this triage in this cohort of patients, on a quantitative and qualitative basis, and test its reliability.

Material and methods

This observational retrospective cohort study used medical data from casualties of the Paris area terrorist attacks, collected anonymously, as recently described [5]. Data processing authorization was obtained from the Commission Nationale Informatique et Liberté and the Comité de Protection des Personnes Ile de France, exempting casualties from giving their consent for the use of their data for observational research purposes. This report follows the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) recommendations [13].

Study population

Casualties included in the study were those with somatic lesions and who arrived alive at the hospital within the first 24 h after the attacks of 13 November 2015 [5]. Casualties without body injuries, consulting for psychological trauma, those with no recorded medical condition and who did not require hospital admission, or those presenting to hospital more than 24 h after the events were excluded. Casualties were managed and transported to hospitals by mobile ICUs or by Fire-Brigade ambulances according to the French standards of prehospital care [14]. Hospital orientation was managed by a physician-staffed ambulance (Service d'Aide Médicale Urgente). When needed, priority was given to secure the premises before access to casualties and their evacuation to hospitals in the Paris region, five of them being civilian level-1 trauma centers [5]. The two military hospitals were also considered as level-1 trauma centers. Patients who were declared 'dead on scene' (decision taken by an emergency physician) were not transported by the emergency medical services but by police units and thus not transported to a hospital but directly to the legal medicine institute which is centralized for the Paris area and not situated in a hospital.

Measurement and analysis

Casualties were identified via police and hospital registers [5]. Descriptive data, wounding process, anatomical lesions, prehospital triage, mean times of transfer to hospital and surgery rooms, and therapeutic and diagnostic measures were collected using each casualty medical files [5]. The revised trauma scores, Abbreviated Injury Score (AIS), Injury Severity Score, and the Trauma-Related Injury Severity Score (TRISS) were retrospectively calculated [15,16]. Observed mortality was defined as the occurrence of death during hospitalization and compared to expected mortality using the TRISS [16]. The transfer was defined as referring the casualty to a hospital other than the one that initially received the casualty, within 24 h of the injury process [5].

Casualties were categorized as absolute emergency or relative emergency (Electronic supplement Table S1, supplement digital content, http://links.lww.com/EJEM/A292) then referred to level-1, -2, or -3 trauma centers with an appropriate level of care. This prehospital categorization was reported in by administrative files of the Préfecture de Police de Paris and from the Assistance Public-Hôpitaux de Paris, respectively, named 'SINUS' and 'VICTIMS' [5]. In a subgroup of casualties admitted into the level 1 trauma centers, a secondary triage was performed at admission to the hospital by experienced senior physicians. The final categorization (reference method) was established independently by two senior experts (A.J. and M.R.) from an examination of the complete medical chart (Kappa score 0.92) [5]. In case of disagreement, a consensus was reached by a third expert (B.R.).

Among casualties classified relative emergency, undertriage was defined as the rate of those classified relative emergencies in the prehospital field but absolute emergency by the experts. Conversely, among casualties classified as absolute emergency, overtriaged was defined as the rate of those classified absolute emergency in the prehospital field but relative emergency by the experts.

A further classification identified 'severe undertriage' patients triaged relative emergency and at least one anatomic lesion with AIS >3. Conversely, 'severe overtriage' was defined as patients triaged absolute emergency and injuries limited to an AIS 1 or 2. In both undertriaged and overtriaged casualties, those with AIS = 3 were considered as equivocal (i.e. nonsevere under/overtriage). Lastly, comparison between prehospital triage performed in real conditions to simulated triage using the three most widely used triage tools was made: the Field Triage Score (FTS) [17], the Simple Triage and Rapid Treatment (START) algorithm [18], and the more recent Modified Physiological Triage Tool (MPTT) [19]. Since these triage tools were based on a three-level classification, they were transformed into dichotomous tools as follows: FTS 0 or 1, START 'immediate' and MPTT 'P1' were considered as absolute emergencies, whereas FTS 2, START 'minor' and 'delayed', and MPTT 'P2' and 'P3' were considered as relative emergencies. These simulated triages were established independently by two senior experts (J.P.T. and A.J.) who accessed only to variables available in prehospital conditions. This analysis took place one year after the reference categorization without knowledge of it [5].

In case of disagreement, a consensus was reached by a third expert (M.R.). Kappa scores for TS, START, and MPTT were 0.95, 0.92, and 0.50, respectively. To compare these scores to prehospital triage, the main criteria was the proportion of patients appropriately classified.

In patients admitted to a level-1 trauma center, this new triage method was performed using the same method (absolute vs. relative emergencies) by a highly trained physician. In this subgroup, we also compared the prehospital and hospital triage.

Statistical analysis

Qualitative variables are presented by number and percentage. Quantitative variables are presented by their mean (SD) or median (interquartile) according to their distribution. Comparison between groups was performed using Fisher's exact method, the Student's *t*-test, and the Mann–Whitney test. To assess the diagnostic performance, we calculated the rate of undertriage as the number of patients misclassified as relative emergency divided by the total number of patients triaged as relative emergency (i.e. undertriage among patients triaged as relative emergency in the prehospital field) and overtriage as patients misclassified as absolute emergency among total number of absolute emergencies. We reported negative and positive predictive values, negative and positive likelihood ratio, and proportion of patients appropriately classified (Electronic supplement S2, supplement digital content, http://links.lww.com/EJEM/A292). Comparison of undertriage, overtriage, and proportion of appropriately classified was performed using the Mc Nemar test. The simple triage method prehospital and in-hospital performances (predictive values and likelihood ratios) were compared. With the same parameters, we also compared prehospital triage with published triage methods obtained by simulation (FTS, START, and MPTT) as previously described [20,21]. The Bonferroni correction was applied because of multiple comparisons with the prehospital triage. Missing data were not replaced. We used Cohen's kappa to measure inter-rater reliability when several experts were involved to categorize a single parameter. A Kappa close to 0 indicates no agreement when a Kappa close to 1 indicates a perfect agreement.

All comparisons were two-tailed and a P value <0.05 was considered significant. Statistical analyses were carried out using R (version 3.6.1) software.

Results

Prehospital and in-hospital triage

Among 543 casualties with body injuries, 337 were admitted to emergency services/trauma centers (Fig. 1). Two hundred and sixty-two (78%) of these casualties were categorized during the prehospital phase, 74 (28%) as absolute emergencies, and 188 (72%) as relative emergencies. Secondary transfers occurred in 27 (8%) casualties (12 absolute emergencies and 15 relative emergencies), 4 of them being referred to a level-1 trauma center (one absolute emergency and three relative emergencies).

Expert panel triage

Among all casualties, the expert panel triaged 119 (35%) as absolute emergencies and 218 (65%) as relative emergencies. Among the 262 casualties triaged during prehospital care, the expert panel triaged 96 (37%) casualties as absolute emergencies and 166 (63%) as relative emergencies (Table 1 and Fig. 2). Among casualties not triaged during the prehospital phase ($n=75$), there were 23 (31%) absolute emergencies and 52 (69%) relative emergencies.

Diagnostic performances

The diagnostic performance of prehospital triage is presented in Table 2. The rate of undertriage and overtriage was 36% (95% CI, 27–47%) and 8% (95% CI, 4–13%), respectively. The comparison of prehospital and hospital triages is presented in Table 3.

Among undertriaged casualties ($n=35$), 8 (23%) were considered as severely undertriaged. Among overtriaged casualties ($n=13$), 10 (77%) were considered as severely overtriaged. The main causes of severe undertriage were related to thoracoabdominal and head penetrating injuries and the most severe cause of overtriage was related to superficial limb lesions (Electronic supplement Table S3, supplement digital content, *http://links.lww.com/EJEM/A292*).

Simulated triage

Using simulated triage with access only to prehospital variables, the diagnostic performances of FTS, START, and MPTT were significantly lower than those observed with the simple triage rules when considering the proportion of casualties appropriately classified. Although the overtriage of FTS, START, and MPTT was worse than that observed with the simple triage rules, undertriage in this group was better (Electronic supplement Table S4, supplement digital content, *http://links.lww.com/EJEM/A292*).

In-hospital triage and mortality

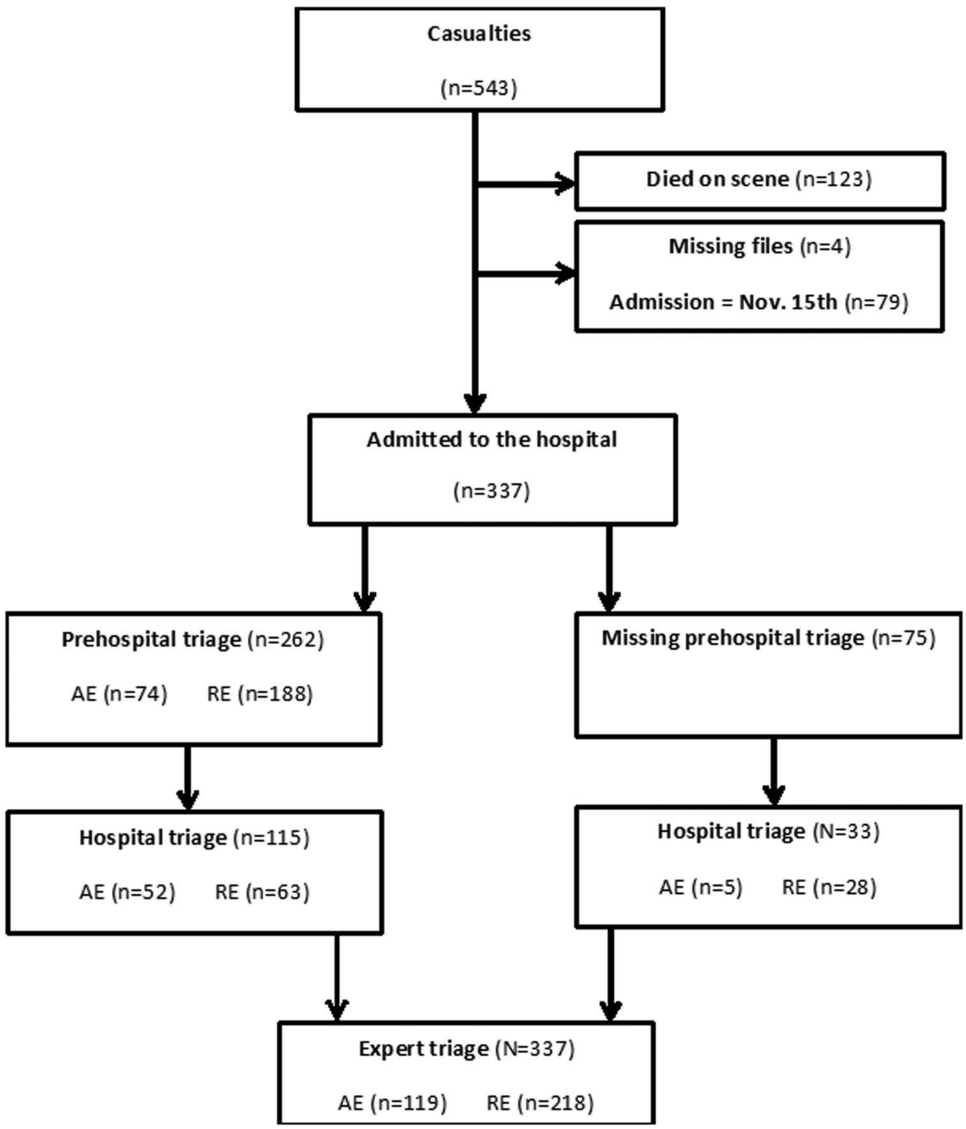
One-hundred fifteen (44%) casualties were again categorized at admission into level-1 trauma centers, 52 (46%) as absolute emergencies, 63 (54%) as relative emergencies.

The observed in-hospital mortality ($n=7$; 2.1%) was not significantly different from that expected ($n=11$; 3.3%; $P=0.92$).

Discussion

This study shows that a simple triage categorization (Absolute Emergencies/Relative Emergencies) was performed on scene in a large proportion of casualties (78%) and had good diagnostic performance during highly complex incident involving multiple incident sites, and both gunshot and explosion, using appropriate diagnostic research methodology [22]. This diagnostic performance did not result in detectable adverse effects since the observed mortality during this mass casualty incident was no higher than that expected during routine trauma care. Nevertheless, the qualitative analysis of severe undertriage and overtriage indicates that there is some room for improvement. In a subgroup of casualties, the secondary

Fig. 1



Study flowchart. AE, absolute emergency; RE, relative emergencies.

triage at hospital admission did not significantly improve the proportion of patients appropriately classified. Lastly, simulated triage using other triage tools (FTS, START, and MPTT) did not perform better than the simple prehospital triage used.

Wartime triage was initially meant to establish surgical priority at a time when this process was the only decisive factor in the prognosis of war casualties [6]. The evolution of war medicine has given rise to the need to prioritize access to other scarce resources such as blood products, diagnostic methods, and life-saving interventions prior to surgery. As a result, preoperative and prehospital categorization tools have been added to classic surgical triage without replacing it. Most of them were based on physiological data (consciousness, arterial blood pressure, and heart and respiratory rates) since they predict both mortality and resource utilization [23,24]. Based on the analysis of radial pulse and consciousness, FTS is the most simple illustration of this rationale [17]. North Atlantic Treaty Organization preferred using the START algorithm based on four variables: walking ability, breathing, radial pulse, and the ability to execute a simple order [18]. This algorithm has been adopted with minimal adjustments by the British and Australian rescue services and the most recent result of its use in Middle Eastern conflicts is the MPTT [19]. The later was derived from a large cohort of 6095 war casualties managed consecutively at Camp Bastion in Afghanistan, and prospectively validated on a cohort of 354 war casualties in the same center, demonstrating a lower undertriage rate (16%)

Table 1 Comparison of absolute and relative emergencies, according to the expert panel classification

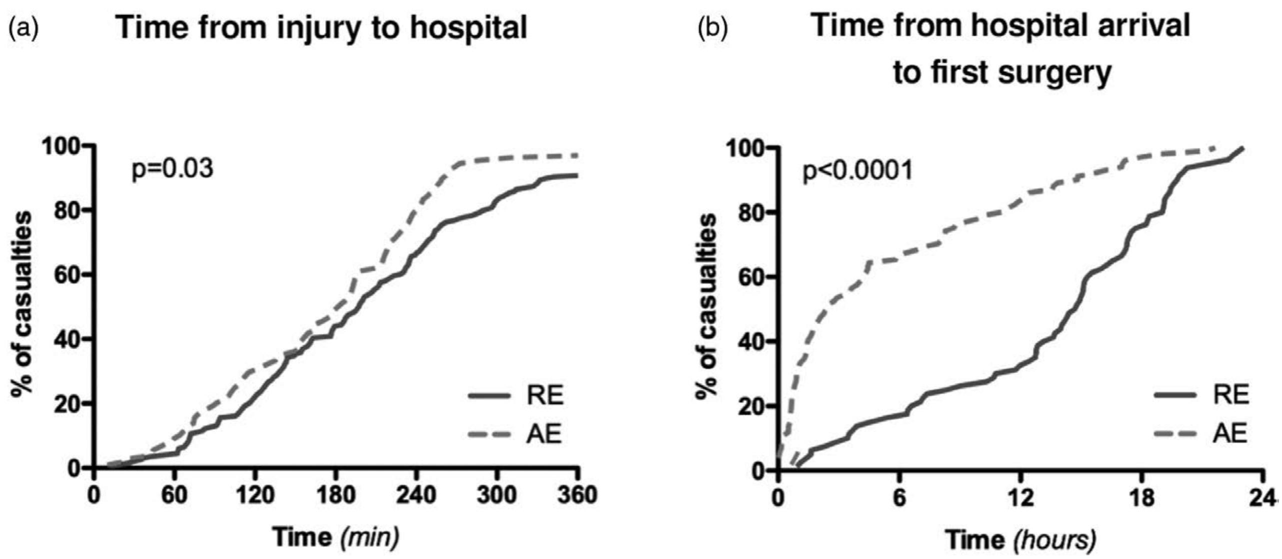
Variable	Absolute emergencies (*n*=119)	Relative emergencies (*n*=218)	*P* value
Age (years)	33±10	33±9	0.82
Men	65 (55%)	138 (63%)	0.13
Women	54 (45%)	80 (37%)	
Missing values	0	0	
Explosion	11 (9%)	40 (18%)	0.03
Gunshot wound	108 (91%)	178 (82%)	
Missing values	0	0	
SAP (mmHg)	118±39	138±18	<0.001
Missing values	14	42	
Heart rate (bpm)	91±29	94±19	0.27
Missing values	18	43	
GCS <15	16 (15%)	0 (0%)	<0.001
Missing values	11	0	
SpO_2 (%)	99 (98–100)	100 (98–100)	<0.001
Missing values	23	59	
Scoring			
Prehospital triage			
Absolute emergency	61 (64%)	13 (8%)	<0.001
Relative emergency	35 (36%)	143 (92%)	
Missing values	23	49	
Hospital triage			
Absolute emergency	71 (71%)	21 (12%)	<0.001
Relative emergency	29 (29%)	148 (88%)	
Missing values	19	49	
Admitted to level 1	75 (63%)	87(40%)	<0.001
Trauma center			
Missing values	0	0	
RTS	7.84 (7.84–7.84)	7.84 (7.84–7.84)	<0.01
RTS <4	6 (5%)	0 (0%)	<0.02
Missing values	0	0	
ISS	11 (9–18)	1 (1–2)	<0.001
ISS >15	49 (41%)	0 (0%)	<0.001
Missing values	0	0	
TRISS	0.989 (0.974–0.991)	0.994 (0.994–0.997)	<0.001
Missing values	0	0	
Hospital resource utilization			
Hospital access time (min)	184 (106–234)	197 (127–259)	0.03
Missing values	11	20	
Biological examination	109 (92%)	113 (52%)	<0.001
Missing values	0	0	
X-ray	61 (51%)	147 (67%)	0.005
Missing values	0	0	
CT-scan	85 (72%)	57 (26%)	<0.001
Missing values	1	0	
Blood transfusion	49 (41%)	0 (0%)	<0.001
Missing values	0	0	
Embolization	5 (4%)	0 (0%)	0.005
Missing values	0	0	
Surgery	101 (85%)	80 (37%)	<0.001
Missing values	0	0	
Surgery access time[a] (min)	146 (47–234)	884 (512–1085)	<0.001
Missing values	0	0	
ICU admission	97 (82%)	0 (0%)	<0.001
Missing values	0	0	
Hospital admission with length of stay <1 day	0 (0%)	97 (45%)	<0.001
Hospital length of stay	11 (5–21)	1 (0–3)	<0.001
(day)	0	1	
Missing values			
Outcome			
Observed mortality	7 (6%)	0 (0%)	<0.001
Missing values	0	0	

Values reported as number (%), median (interquartile), and mean ± SD.
CGS, coma Glasgow scale; CT-scan, computerized tomographic scanner; FAST, focused assessment with sonography in trauma; ISS, injury severity score; RTS, revised trauma score; SAP, systolic arterial blood pressure; SpO_2, peripheral oxygen saturation; TRISS, trauma-related injury severity score.
[a]Delay between admission to the hospital and surgery.

than comparable triage tools [19]. However, these war triage tools were built and tested for hospital triage by a physician and not prehospital triage. As no triage policy has ever given complete satisfaction to its end-users, it is very likely that they will continue to evolve, mainly to distinguish very quickly the most urgent category of casualties, that is, avoiding undertriage. This tends to create a simple prehospital categorization into only two groups.

The dichotomous scale (absolute emergencies/relative emergencies) corresponds to that taught in France after previous terrorist attacks [12], in line with the more recent recommendations of simplicity [1]. This simple tool is widely used in France by paramedics and firemen, as well as media and justice officers [25,26]. The reference standard (expert panel) was appropriate when considering that no admission to ICU, blood transfusion, embolization, or death was noted in casualties sorted as relative emergencies, and no discharge on day 1 was noted in casualties sorted as absolute emergencies. Our study shows that using this simple categorization, 78% of the casualties of a multisite terrorist attack were effectively sorted in the prehospital settings, indicating that it was effectively applied despite the very high number of casualties and persistence of the threat [5]. This method seems more adapted to these circumstances than those conventionally used for prehospital triage like the FTS, START, or MPTT. In the setting of a terrorist attack, these tools proved to be too complicated to use because they require applying an algorithm, measuring vital parameters, and filling in a triage tag. Such a complex process is probably unrealistic in the confusion created by a large-scale terrorist attack, in a dangerous environment where emergency teams are under extreme pressure to stop bleeding and evacuate quickly the casualties while facing the threat of continuing terrorist attacks. Consequently, during massive shootings, prehospital triage can be under-used or not used at all with the risk of important overtriage since the rescue teams will tend, for safety, to transport all the casualties with penetrating trauma only to a level-1 trauma center to the detriment of level 2 or 3 centers which could be less overcrowded and adapted to the care of relative emergencies if they had been appropriately categorized. The absolute emergencies/relative emergencies binary triage limiting overtriage seems then adapted to mass casualties with penetrating injuries during terrorist attacks. The proportion of undertriage and overtriage observed during the Paris attacks (36 and 8%, respectively) should be compared to the best one reported by trained surgeons during war conditions (16 and 28%, respectively) [23]. In the Paris massive event, overtriage was limited, preventing hospital saturation, but undertriage was higher than those observed with other scores. Only 12 absolute emergency casualties needed secondary transport, only one of them to a level-1

Fig. 2



Global cumulative frequency distribution of delay (min) from time of injury to hospital admission (a) and from time of hospital admission to first surgery (b) in absolute emergency (*n*=119) and relative emergencies (*n*=218), according to the expert panel classification. *P* values refer to the comparison of medians.

Table 2 Diagnostic performance of prehospital triage (absolute emergencies) vs. relative emergencies) (*n*=262, 78% of the whole cohort)

Variable	Values (95% CI)
Undertriage (1-sensitivity)	0.36 (0.27–0.47)
Overtriage (1-specificity)	0.08 (0.04–0.13)
Positive predictive value	0.82 (0.72–0.90)
Negative predictive value	0.81 (0.75–0.87)
Positive likelihood ratio	8.11 (4.71–13.97)
Negative likelihood ratio	0.40 (0.30–0.52)
Proportion of appropriately classified	0.82 (0.76–0.86)

CI, confidence interval.

Table 3 Comparison of the diagnostic performance of prehospital triage and secondary triage at hospital admission (absolute vs. relative emergencies) (*n*=115, 34% of the whole cohort, all admitted to a level-1 trauma center)

Variable	Prehospital	Hospital admission
Undertriage (1-sensitivity)	0.12 (0.04–0.23)	0.23 (0.13–0.37)[a]
Overtriage (1-specificity)	0.16 (0.08–0.27)	0.10 (0.04–0.20)[a]
Positive predictive value	0.82 (0.70–0.91)	0.87 (0.74–0.95)
Negative predictive value	0.90 (0.79–0.96)	0.83 (0.72–0.91)
Positive likelihood ratio	5.57 (3.13–9.92)	8.08 (3.72–17.54)
Negative likelihood ratio	0.14 (0.06–0.29)	0.26 (0.15–0.42)
Proportion of appropriately classified	0.86 (0.78–0.92)	0.84 (0.76–0.90)

Values are associated with their 95% confidence interval (CI).
[a]$P<0.05$ vs. prehospital. *P* values were not adjusted for multiple comparisons and should be interpreted cautiously.

trauma center. Moreover, the absolute emergency/relative emergency method did not adversely interfere with the care of casualties since the mortality observed during a massive event was comparable to routine care in traumatology. It should be pointed out that this triage process does not apply to the 'hot zone' where tactical medical units intervene [27].

The qualitative analysis provided some clues for future improvement. Emphasizing the need for staging thoracoabdominal lesions as absolute emergencies and conversely staging limb lesions without severe hemorrhage as relative emergencies may easily and further improve the diagnostic performance of prehospital triage (Electronic supplement Table S4, supplement digital content, *http://links.lww.com/EJEM/A292*). The comparison of the triage diagnostic performance on scene and arrival at the hospital in a subgroup of casualties showed no significant difference in the proportion of casualties appropriately classified, suggesting that it is reproducible (Table 3).

In France, the absolute emergency/relative emergency triage concept has been widely used, not only by professional healthcare providers but also by the media and live TV channels publishing reports of multiple casualty incidents or terrorist attacks [25,26]. Consequently, it was understood by the public and adopted as a common reporting language tool for all (medical and nonmedical) services involved. In the future, in accordance with the Hartford consensus [28], outlining the crucial role of the public to 'stop the bleeding', the bystander's use of this simple triage concept could also be considered to improve prehospital care organization. A binary categorization is simple to understand, easy to remember, and to implement even during stressful events, it does not require complicated measures because it relies on a global and visual assessment of the wounded, it can be taught quickly and performed by first responders, EMTs and also by more specialized teams including physicians enabling everybody to speak the same language. This simple binary approach is flexible and can be used to assess priority for extraction, emergency care, and transport of casualties.

Several limitations should be noted. Because this study was retrospective, it suffers from possible bias, particularly the existence of missing data related to the non-standardization of information from medical records. The injuries were less severe than those previously reported in mass casualty events [29,30] since all casualties were included [5]. Casualties deceased on scene were not included and thus reported in-hospital mortality among casualties that arrived alive at hospital which is significantly lower than the overall mortality of the event (24%). Lastly, data concerning FTS, START, and MPTT were obtained using simulation and not in real conditions and the fact that a dichotomous categorization was used as the reference one may have also biased the comparison.

Conclusion

This analysis of the 2015 Paris area terrorist attacks reports that a simple triage method allowed for a high proportion (78%) of triaged casualties in prehospital and resulted in a 36% rate of undertriage and an 8% rate of overtriage. The qualitative analysis of undertriage and overtriage may help to improve the crisis management plan for massive events.

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Emmanuelle Dolla, MD (Hôpital Pitié-Salpêtrière, APHP, Paris); Christophe Leroy, MD (Direction de l'organisation médicale et des relations avec les universités, APHP, Paris); Pr. Thomas Lescot, MD, PhD, Pr. Dominique Pateron, MD, PhD (Sorbonne Université, Hôpital Saint Antoine, APHP, Paris France); Anne-Laure Feral-Pierssens, MD, Arnaud Folin, MD, Florent Femy, MD (Hôpital Européen Georges Pompidou, APHP, Paris); Prof Matthieu Legrand, MD, Pr. Etienne Gayat, MD, Carl Ogereau, MD (Hôpital Saint Louis, APHP, Paris); Jennifer Truchot, MD (Hôpital Lariboisière, APHP, Paris); Prof Philippe Montravers, MD, Prof Enrique Casalino, MD, Prof Yves Castier, MD (Hôpital Bichat-Claude Bernard, APHP, Paris); Prof Christophe Baillard, MD, Prof Benoît Doumenc, MD (Hôpital Cochin, APHP, Paris); Fabrice Cook, MD, Arie Attias, MD, Adrien Zakine, MD (Hôpital Henri Mondor, APHP, Créteil); Marie Clément Kouka, MD, Brigitte Hennequin, MD (Centre Hospitalier Saint Denis, Saint Denis); Fatima Djamouri, MD, Christophe Quesnel MD (Hôpital Tenon, APHP, Paris); Romain Dufau, MD, Prof Frédéric Adnet, Pr. Frédéric Lapostolle, MD, PhD (Hôpital Avicenne, APHP, Bobigny); Serge Ndoko, MD, Claire Raquillet, MD (Centre hospitalier intercommunal Robert Ballanger, Aulnay sous bois); Christophe Vincent-Cassy, MD, Sophie Hamada (Hôpital Kremlin Bicêtre, APHP, Kremlin Bicêtre); Sébastien Beaune, MD (Hôpital Ambroise Paré, APHP, Boulogne Billancourt); Philippe Laitselart, MD, Elodie Schaeffer, MD [Hôpital d'instruction des armées (HIA) Percy, Clamart]; Alexandre Woloch, MD, Kevin Kearns, MD (HIA Begin, Saint Mandé); Leila Lavagna, MD (Centre Hospitalier André Grégoire, Montreuil); Paer-Selim Abback, MD (Hôpital Beaujon, APHP, Clichy); Djamal Arkoub, MD (Groupe Hospitalier Intercommunal Raincy Montfermeil, Montfermeil); Catherine Le Gall, MD (Centre Hospitalier d'Argenteuil, Argenteuil); Catherine Philipoteau, MD (Centre Hospitalier Intercommunal de Créteil, Créteil); Olivier Ganansia, MD (Hôpital Saint Joseph, Paris); Marc Andronikof, MD (Hôpital Antoine Béclère, APHP, Clamart); Patrick Deschamps, MD, Centre Hospitalier René Dubos, Pontoise); Cécile Garot, MD (Clinique Floréal, Bagnolet); Julien Aguilar, MD (Hôpital Privé de l'ouest Parisien, Trappes); Pr. Bertrand Ludes, MD, PhD, (Institut médico-légal, Paris); Anne François, MD (Etablissement Français du Sang, Paris); all in France.

A.J., M.R., and B.R. conceived and designed the study. A.J., J.P.T., M.R., and B.R. analyzed and interpreted the data. A.J., M.R., and B.R. wrote the initial draft. A.J. and B.R. performed the statistical analysis. All authors subsequently critically edited the report, read, and approved the final report. M.R. had full access to all of the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis. M.R. and B.R. obtained funding and supervised the study.

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Conflicts of interest

There are no conflicts of interest.

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