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Assessment of the Mass Casualty Triage during the November 2015 Paris Area Terrorist Attacks: Towards a Simple Triage Rule --Manuscript Draft--

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Abstract:	<p>BACKGROUND: Triage is key in the management of mass casualty incidents.</p> <p>OBJECTIVE: The objective of this study was to assess the pre-hospital triage performed during the 2015 Paris area terrorist attack.</p> <p>Design setting and participant: This was a retrospective cohort study that included all casualties of the attacks on November 13th 2015 in Paris area, France, that were admitted alive at the hospital within the first 24 hours after the events. Patients were triaged as absolute emergency or relative emergency by a pre hospital physician or nurse. This triage was then compared to the one of an expert panel that had retrospectively access to all pre-hospital and hospital files.</p> <p>Outcomes measures and analysis: The primary endpoints was 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.</p> <p>Main Result: Among 337 casualties admitted to the hospital, 262 (78%) were triaged during pre-hospital 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%CI 27% to 47%] and 8% [95%CI 4% to 13%] respectively. Among undertriaged casualties, 8 (23%) were considered as being severely undertriaged. Among overtriaged casualties, 10 (77%) were considered as</p>

being severely overtriaged.

Conclusion: A simple pre-hospital triage for trauma casualties during the November 13th 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 under- and overtriage indicate some possibilities for further improvement.

FUNDING : Assistance Publique-Hôpitaux de Paris

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Assessment of the Mass Casualty Triage during the November 2015 Paris Area Terrorist Attacks: Towards a Simple Triage Rule

Dear Editor,

Thank you very much for giving us the possibility to improve the paper by answering the main concerns raised by the reviewers of our manuscript. You will find below our point-by-point answers to comments. All the corrections can be traced in the revised manuscript.

Reviewer 2

1/ Need to include a rough equivalence to triage system in the introduction. T1 = Immediate, T2 = Delayed, T3 = minimal, T4 = expectant.

We understand the need to describe more precisely our triage tools by using correspondences with other well know published tools. However, this correspondences have been already clearly indicated in the method section of our manuscript: *“Since these triage tools were based on a 3 levels classification, we transformed them into dichotomous tools as follows: FTS 0 or 1, START “immediate” and MPTT “P1” were considered as AE, whereas FTS 2, START “minor” and “delayed”, and MPTT “P2” and “P3” were considered as RE”* (Page 8, line 2-5).

Since these triage tools were based on a 3 levels classification, we transformed them into dichotomous tools as follows: FTS 0 or 1, START “immediate” and MPTT “P1” were considered as AE, whereas FTS 2, START “minor” and “delayed”, and MPTT “P2” and “P3” were considered as RE. These simulated triages were established independently by two senior experts (JPT, AJ) who accessed only to variables available in prehospital conditions. In case of disagreement a consensus was reached by a third expert (MR).

2/ The author is using a nonstandard triage system and needs to explain it.

We respectfully disagree with this comment. First, there is no recognized “standard triage system” and a recent systematic review (Timbie JW *et al.* Systematic review of strategies to manage and allocate scarce resources during mass casualty events. *Ann Emerg Med.* 2013;61:677-89) recognized that important point (See the introduction of our revised manuscript (Page , line) which indicates that *“A systematic review concluded that field triage systems do not perform consistently during mass casualty events.^{11”}) (page 5, line 14-15).*

Second, this triage tools might be considered as the standard in France since more than 30 years. In the initial version, we explained that to the reader:

“This simple triage tool was chosen because it corresponded to that taught and practiced in France for more than 30 years now,¹² following the principle of simplicity recommended after the London attacks in 2005.¹” (page 5, line 19-21).

3/ Did not take into account deterioration in the patients condition.

The role of the triage is to facilitate appropriate orientation of the patient and thus to limit overtriage and undertriage. But, to our knowledge, none of the previously reported triage tools took into account the deterioration during the transport to the hospital. However, we think that the Reviewer is perfectly correct when speaking about the possible deterioration of some patients. In our manuscript, we acknowledged the importance to considered triage as an ongoing process. In our study, casualties send to trauma level 1 centers were triaged during twice during the pre-hospital phase and at the arrival at the hospital, enabling to account for this deterioration risk. The method has been reported in the method section (Page , line):

“In a subgroup of casualties admitted into the level 1 trauma centers, a secondary triage was performed at admission to the hospital (AE/RE) by experienced senior physicians.” (Page 7, line 10-12)”

To our knowledge, the information provided by this double triage analysis is also interesting: *“One hundred and fifteen (34%) casualties were again categorized at admission into level 1 trauma centers, 52 (46%) as AE, 63 (64%) as RE”* (Page 9, line 6-8).

In the discussion, we observed that: *“In a subgroup of casualties, we observed that secondary triage at hospital admission did not significantly improve the proportion of patients appropriately classified”* (Page 10, line 10-12).

4/ Need to address where the patients were sent. What procedure was used to send patients to hospitals? Did they follow the far first doctrine?

In France, severe trauma patients hospital orientation is managed by a centralized medical regulation that send each patient to the most appropriate center according to the pre-hospital assessment. We used the same system on November the 13rd 2015 in Paris.

We emphasized this point in the method section: *“Hospital orientation was managed by the Service d’Aide Médicale Urgente (SAMU) a medicalized civil emergency medical service based on the pre-hospital evaluation and categorization”* (Page 6, line 15-17)

5/ In the qualitative analysis section the author did not consider arterial bleeds in the analysis of staging thoraco-abdominal lesions. Need to consider arterial bleeds.

“Arterial bleeds” is not a variable that was collected. Nevertheless, we report in the Table 2S, the use of Tourniquet, SAP<90mmHg and detailed lesions based on the AIS coding. We believe these variables to be likely to inform readers on the risk for the patient to suffer from an active bleeding.

6/ Needs limitations section separated.

Thanks for this comment. In the revised version of our manuscript, we have added the following sub-sections: “*Synthesis*”, “*Perspectives*” and “*Strengths and limitations*”.

7 / The statement "The observed mortality was lower than the observed mortality of the event (24%), due to the non-inclusion of decreased casualties on scene", is confusing and needs to be rewritten.

We acknowledge this useful comment and modified as following: “*We did not include casualties deceased on scene and thus reported in-hospital mortality among patients that arrived alive at hospital which is significantly lower than the overall mortality of the event (24%).*” (Page 13, line 14-17)

Reviewer 4

9/ The numbers presented (543 casualties, 123 of these died on scene) raise the interest to learn more about how this declaration of 'dead on scene' (a hot topic for every EMS) is regulated in France.

To clarify this point we added in the revised version : “*Patients who were declared « dead on scene » (decision taken by an emergency physician) were not taken by the EMS but by police units and thus not transported to an hospital but directly to the legal medicine institute which is centralized for the Paris area and not situated in an hospital.*” (Page 6, Line 15-17).

10/ Several times the authors refer to previous publications, when discussing some details; e.g. in 'identification of casualties has been previously described'. Not all readers will be on that level of familiarity with the literature! Some explanations would help with the overall readability - even if these seem a waste of words to those as much involved as the authors.

Thanks for this very useful comment. We reformulated with more precision and hope that these modifications could help the readers:

- In the *Measurement and analysis* section: “Casualties were identified through police and hospital registers.⁵ Descriptive data, wounding process, anatomical lesions, pre-hospital triage, mean times of transfer to hospital and surgery rooms, and therapeutic and diagnostic measures were collected using each casualty medical files.” (Page 6 , line 24-25 and page 7, line 1-2)
- In the *Measurement and analysis* section: “Casualties were categorized as AE or RE (Electronic supplement Table S1) then referred to level-1, 2 or 3 trauma centers with appropriate level of care. The pre-hospital categorization came from administrative files of the Préfecture de Police de Paris and from the Assistance Public-Hôpitaux de Paris respectively named “SINUS” and “VICTIMS.” (Page 7 , line 7-10).

11/ This applies also to the passages where 'Kappa scores' are mentioned without an hint of background information.

We added in the statistical analysis an explanation about Kappa scores for readers that would not be familiar with this analysis method: “We used Kappa statistic to measure inter-rater reliability when several experts was involved to categorize a single parameter. A Kappa close to 0 indicates no agreement when a Kappa close to 1 indicates a perfect agreement.” (Page 8, line 21-24)

12/ Furthermore it appears not to be self-explanatory to the non-statistician, that the numbers for 'undertriage', 'overtriage' and 'appropriately classified' (0.36, 0.08 and 0.82) do not add up to 1.

We thank reviewer to bring this point to the discussion. As presented in table 2: undertriage is 1-sensitivity and overtriage is 1-specificity. With different denominator, undertriage and overtriage (and appropriately classified patients) are thus never meant to make 1.

To help reader understanding, we added an explanation with complete formulas in an additional Supplementary Material (Supplementary Material S2) formulated as follow:

Undertriage is patients that were classified RE during prehospital care and AE by experts. The denominator is thus the total number of AE according to the experts.

Overtriage is patients that were classified AE during prehospital care and RE by experts. The denominator is thus the total number of AE according to the prehospital triage.

Formulas (and numbers for prehospital triage) are:

- $Undertriage = 1 - sensitivity = 1 - \frac{True\ Positive}{True\ Positive + False\ Negative} = \frac{False\ Negative}{True\ Positive + False\ Negative} = \frac{35}{61 + 35} = 36\%$.
- $Overtriage = 1 - specificity = 1 - \frac{True\ Positive}{True\ Positive + False\ Positive} = \frac{False\ Positive}{True\ positive + False\ Positive} = \frac{13}{13 + 61} = 8\%$.

Reviewer 5

13/ Line 6. - somatic is not a common word in English ?? change to "physical injuries"
We modified “*somatic injuries*” to “*body injuries*”.

14/ In term of expert review, I note the same experts (MR and AJ) were involved in giving a retrospective expert review as to appropriate triage when all data was available and also a view on triage with the limited data available at the scene. Can it be made clear the order of these expert's review? i.e. did they make a decision on prehospital data only first and then see the more detailed data as otherwise their view may have been altered by such later knowledge

The author is correct in identifying a possible methodological concern. Two experts (MR and AJ) made the retrospective expert review and a third one (BR) made the consensus when a disagreement occurred. However, this analysis was undertaken very early before the submission of the first study to Intensive Care Medicine (thus before May 5, 2019). The second analysis limited to prehospital data was undertaken by two experts (JPT and AJ) and a third one (MR) made the consensus. However, this analysis was undertaken one year later and using completely anonymized data sets limited to prehospital data and without knowledge of the retrospective expert review and thus we believe that the probability that the decision was influenced is not likely. However, in the revised version, we have added some information concerning the way we have proceeded:

“*This analysis took place one year after the reference categorization without knowledge of it.*⁵” (Page 8, line 7).

Moreover, this is only a secondary results of our study and data are provided only in electronic supplements and limitations of the comparisons with other triage tools have been emphasized in the discussion.

15/ I am aware the data is around those arriving alive at hospital within 24 hours - Do we know if there there were any patients who were triaged at the scene who did not make it to the hospital. - I would be particularly interested if there were any who were

triaged RE who did not make it. Could mention of this be included as it would seem critical to the question of whether a dichotomous process is accurate enough for use at frontline

Because our cohort comprises only patients arriving at the hospital, we do not know if some patients who were considered as “dead on scene” were triaged or not. (See our response to comment 9 from Reviewer 4)

16/ Figure 2. legends rather than delay to should possible change to Time to - delay implies poorer response than expected

Correction performed in the revised version.

17/ Supportive tables. S2. 27 year old patient. Colic should be colonic

We modified as suggested.

18/ "a massive event with multisite and multitype attacks". May read better as " highly complex incident involving multiple incident sites , weaponry and mechanisms "

We modified as follow : *“Our study shows that a simple triage categorization (AE/RE) 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”* (Page 10, line 3-5).

19/ Page 11 line 10. Change exit to discharge

We modified as suggested (Page 11, line 14)

20/ Although both are important undertriage is obviously more important. In this regard the dichotomous view seems to perform less well than FTS START MPTT. Taking in to account the most significant undertriaged seem to have been those with penetrating head and thoracoabdominal trauma if the data is possible to interrogate is it possible to look at how the accuracies would fare with the simple addition of "GSW head/neck.thoracoabdominal.....i.e woudl this decrease undertriage and not risk massive overtriage - accept this is a retrospective trawl of data but may push the role of this simple triage tool

We fully agree with the Reviewer’s comment and this is the reason why we analyzed severe undertriage and severe overtriage using our simple triage tool (Electronic supplement table

S4). The results provided by Table clearly suggest that minor changes taking into account head and thoraco-abdominal GSW will improve undertriage. However, we do not think that it will be acceptable to re-analyze our data accordingly and prefer to just add in the discussion what was already written:

“The qualitative analysis provided some clues for future improvement. Emphasizing the need for staging thoraco-abdominal lesions as AE and conversely staging limb lesions without severe hemorrhage as RE may easily and further improve the diagnostic performance of prehospital triage (Electronic supplement Table S4). (Page 13, line 14-17).

Assessment of the Mass Casualty Triage during the November 2015 Paris Area Terrorist Attacks: Towards a Simple Triage Rule

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2 figures + 3 table

Electronic supplements: 4 tables

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Key words

Triage; Disaster medicine; Emergency Surgery; Gunshot wound; Mass casualty; Terrorism

Abstract (281 words)

BACKGROUND: Triage is key in the management of mass casualty incidents.

OBJECTIVE: The objective of this study was to assess the pre-hospital 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 November 13th 2015 in Paris area, France, that were admitted alive at the hospital within the first 24 hours after the events. Patients were triaged as absolute emergency or relative emergency by a pre hospital physician or nurse. This triage was then compared to the one of an expert panel that had retrospectively access to all pre-hospital and hospital files.

OUTCOMES MEASURES AND ANALYSIS: The primary endpoints was 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 pre-hospital 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%CI 27% to 47%] and 8% [95%CI 4% to 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 pre-hospital triage for trauma casualties during the November 13th 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 under- and overtriage indicate some possibilities for further improvement.

FUNDING : Assistance Publique–Hôpitaux de Paris

Introduction

Major incidents resulting in mass casualties occurs more frequently and challenge our ability to provide the best care to most people. Unfortunately, western countries have experienced an increasing number terrorist attacks using fire-arms, explosives, and trucks.¹⁻⁵ These attacks designed to kill and injure the largest number of casualties, using simultaneous attacks and/or 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/or 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 scene of multiple terrorist attacks which were unprecedented since the Second World War in Europe.³⁻⁵ In the present study, prehospital triage performed was analyzed using a dichotomous scale (absolute emergencies (AE) vs relative emergencies (RE)). 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 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 24h 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 24h after the events were excluded. Casualties were managed and transported to hospitals by mobile intensive care units and/or by Fire-Brigade ambulances according to the French standards of prehospital care.¹⁴ Hospital orientation was managed by a physician staffed ambulances (Service d'Aide Médicale Urgente - SAMU). 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 EMS but by police units and thus not transported to an hospital but directly to the legal medicine institute which is centralized for the Paris area and not situated in an hospital..

Measurement and analysis

Casualties were identified via police and hospital registers.⁵ Descriptive data, wounding process, anatomical lesions, pre-hospital 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 score (RTS) scores, Abbreviated Injury Score (AIS), Injury Severity Score (ISS), 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 Transfer was defined as referring the casualty to a hospital other than the one that initially received the casualty, within 24 hours of the injury process.⁵

Casualties were categorized as absolute emergency or relative emergency (*Electronic supplement Table S1*) then referred to level-1, 2 or 3 trauma centers with appropriate level of care. This pre-hospital 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 (AJ, MR) 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 (BR).

Among casualties classified relative emergency, undertriage was defined as the rate of those classified relative emergency in the prehospital field but absolute emergency by the experts. Conversely, among casualties classified as absolute emergency, overtriaged was defined 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 scoring > 3 . Conversely, “severe overtriage” was defined as patients triaged absolute emergency and injuries limited to an AIS scoring 1 or 2. In both undertriaged and overtriaged casualties, those with AIS scoring = 3 were considered as

equivocal (*i.e.*, non severe under/overtriage). Lastly, comparison between prehospital triage performed in real conditions to simulated triage using the three most widely used triage tools were 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 3 levels classification, they were transformed into dichotomous tools as follows: FTS 0 or 1, START “immediate” and MPTT “P1” were considered as AE, whereas FTS 2, START “minor” and “delayed”, and MPTT “P2” and “P3” were considered as RE. These simulated triages were established independently by two senior experts (JPT, AJ) 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 (MR). 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 (standard deviation) or median [interquartile] according to their distribution. Comparison between groups was performed using the Fisher exact method, the Student t test, and the Mann Whitney test. To assess the diagnostic performance, we calculated the rate of undertriage as number of patients misclassified as relative emergency divided by total number of patients triaged as relative emergency (*i.e.* undertriage among patients triaged as relative emergency in the pre hospital 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*). Comparison of undertriage, overtriage and proportion of appropriately classified was performed using the Mc Nemar test. The simple triage method pre- and in-hospital performances (predictive values and likelihood ratios) were compared. With the same parameters, we also compared pre-hospital 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

Pre- and in-hospital triage

Among 543 casualties with body injuries, 337 were admitted to emergency services/trauma centers (Figure 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 (1 absolute emergency and 3 relative emergency).

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 pre-hospital care, the expert panel triaged 96 (37%) casualties as absolute emergencies and 166 (63%) as relative

emergencies (Table 1, Figure 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% to 47%] and 8% [95%CI 4% to 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 thoraco-abdominal and head penetrating injuries and most severe cause of overtriage were related to superficial limb lesions (*Electronic supplement Table S3*).

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*).

In-hospital triage and mortality

One hundred and 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 under- and overtriage indicates that there is some room for improvement. In a subgroup of casualties, the secondary triage at hospital admission did not significantly improve the proportion of patients appropriately classified. Lastly, simulated triage using other triage tools (FTS, START, 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 pre-hospital categorization tools have been added to classic surgical triage without replacing it. Most of them were based on physiological data (consciousness, arterial blood pressure, 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 NATO preferred using the START algorithm based on four variables: walking ability, breathing, radial pulse, and 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 6,095 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%) than comparable triage tools.¹⁹ However, these war triage tools were built and tested for hospital triage by 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, *i.e.* avoiding undertriage. This tends to create a simple pre-hospital 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 RE, and no discharge on day 1 was noted in casualties sorted as AE. 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, pre-hospital 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 RE 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 AE casualties needed secondary transport, only one of them to a level 1 trauma center. Moreover, the AE/RE 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 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 thoraco-abdominal lesions as AE and conversely staging limb lesions without severe hemorrhage as RE may easily and further improve the diagnostic performance of prehospital triage (*Electronic supplement Table S4*). The comparison of the triage diagnostic performance on scene and on 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 AE/ER triage concept has been widely used, not only by professional health care providers but also by the media and live TV channels publishing reports of multiple casualty incidents or terrorist attacks.^{24,25} Consequently, it was understood by the public and adopted as common reporting language tool for all (medical and non-medical) services involved. In the future, in accordance to 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,^{28,29} 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 were 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 pre-hospital and resulted in 36% rate of undertriage and 8% rate of overtriage. The qualitative analysis of under- and overtriage may help to improve crisis management plan for massive events.

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AJ, MR and BR conceived and designed the study. AJ, JPT, MR and BR analysed and interpreted the data. AJ, MR, and BR wrote the initial draft. AJ and BR performed the statistical analysis. All authors subsequently critically edited the report, read and approved the final report. MR had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. MR and BR obtained funding and supervised the study.

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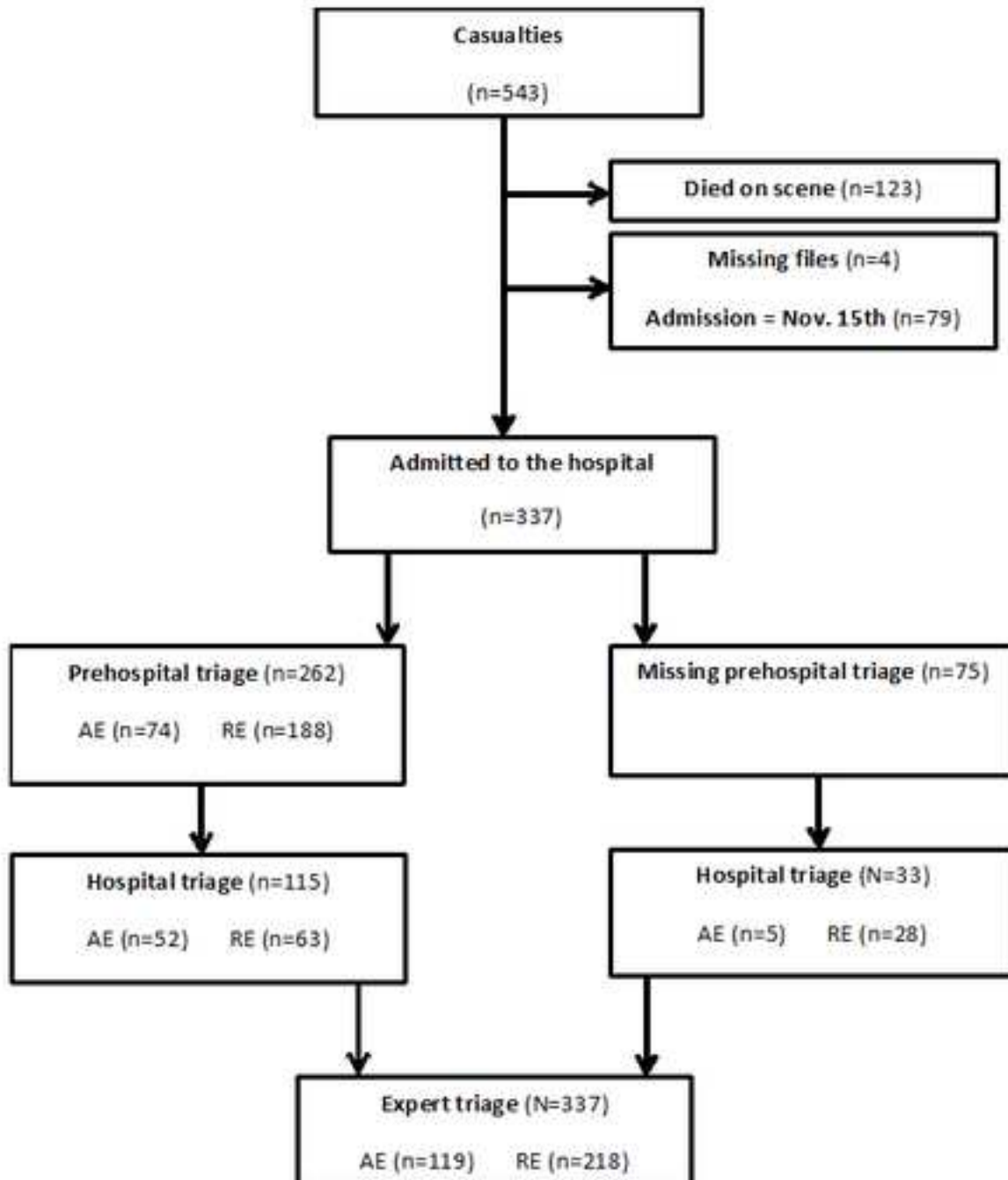
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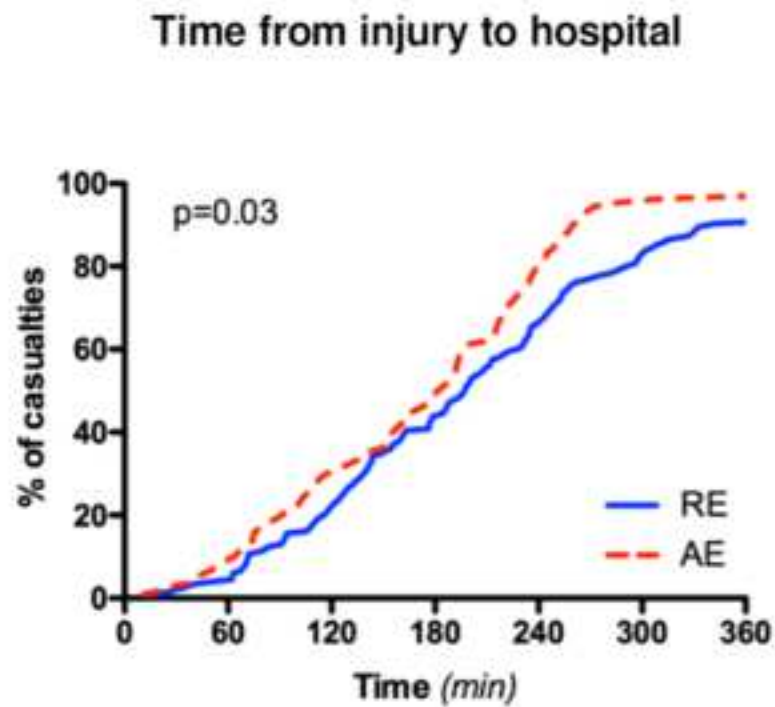
Figure 1

Study flow chart. AE: absolute emergency; RE: relative emergencies.

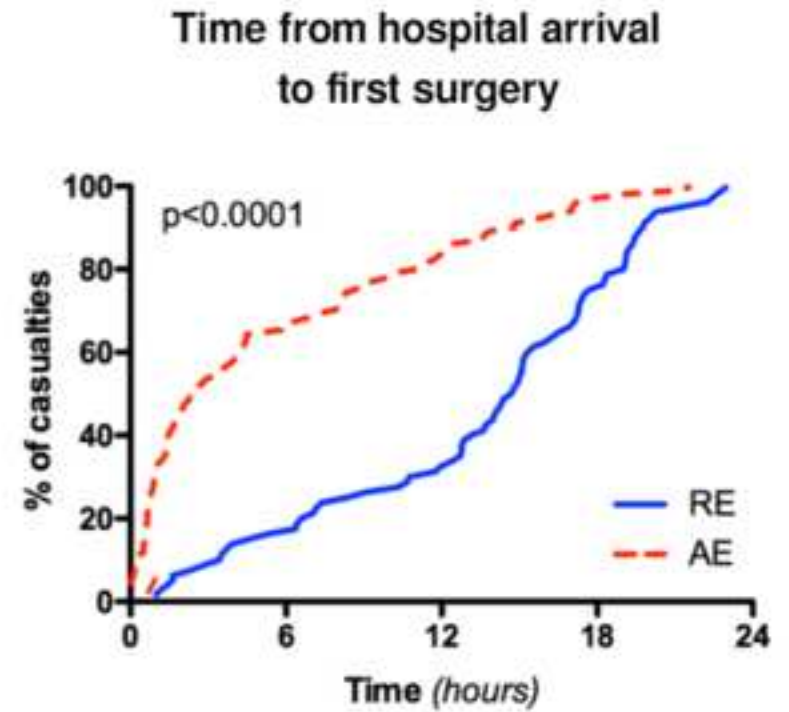
Figure 2

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 (AE; n=119) and relative emergencies (RE; n=218), according to the expert panel classification. P values refer to the comparison of medians.





A



B

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 (year)	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	
SpO₂ (%)	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 Trauma Center	75 (63%)	87(40%)	<0.001
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 (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 (day)	11 [5-21]	1 [0-3]	<0.001
Missing values	0	1	
OUTCOME			
Observed mortality	7 (6%)	0 (0%)	<0.001
Missing values	0	0	

Abbreviations: SAP: systolic arterial blood pressure; CGS: coma Glasgow scale; SpO₂: peripheral oxygen saturation; RTS: revised trauma score; ISS: injury severity score; TRISS: trauma related injury severity score; FAST: focused assessment with sonography in trauma; CT-scan: computerized tomographic scanner; ICU: intensive care unit. Values reported as number (%), median [interquartile], mean \pm standard deviation. *: delay between admission to the hospital and surgery.

Table 2: Diagnostic performance of prehospital triage (absolute (AE) vs. relative (RE) 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 to 0.90)
Negative predictive value	0.81 (0.75 to 0.87)
Positive likelihood ratio	8.11 (4.71 to 13.97)
Negative likelihood ratio	0.40 (0.30 to 0.52)
Proportion of appropriately classified	0.82 (0.76 to 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 to 0.23)	0.23 (0.13 to 0.37)*
Overtriage (1-specificity)	0.16 (0.08 to 0.27)	0.10 (0.04 to 0.20)*
Positive predictive value	0.82 (0.70 to 0.91)	0.87 (0.74 to 0.95)
Negative predictive value	0.90 (0.79 to 0.96)	0.83 (0.72 to 0.91)
Positive likelihood ratio	5.57 (3.13 to 9.92)	8.08 (3.72 to 17.54)
Negative likelihood ratio	0.14 (0.06 to 0.29)	0.26 (0.15 to 0.42)
Proportion of appropriately classified	0.86 (0.78 to 0.92)	0.84 (0.76 to 0.90)

Values are associated with their 95 % confidence interval (CI). *: P<0.05 vs Prehospital. P-values were not adjusted for multiple comparisons and should be interpreted cautiously