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External signs of trauma: A poor predictor of injury in found down and ground level falls

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ABSTRACT

Background: The significance of external signs (EST) and signs or symptoms of trauma (SS) after ground level falls or found down (GLF/FD) is unclear. We hypothesized that EST and SS were associated with injury.

Methods: Patients with GLF/FD were retrospectively studied. SS was defined as having any EST, tenderness, or subjective complaint. Outcomes were any significant finding (SF) and Injury Severity Score (ISS) > 8. Diagnostic accuracy of EST and SS were assessed with positive and negative likelihood ratios (LR+, LR-).

Results: Of 578 patients, 66% and 95% had EST and SS respectively. For EST, LR+ and LR-were 1.14 and 0.76 (SF), and 1.21 and 0.64 (ISS>8). For SS, LR+ and LR-were 1.07 and 0.19 (SF), and 1.03 and 0.49 (ISS>8).

Conclusion: EST lacked sufficient diagnostic accuracy for SF and ISS>8. Lack of SS was reasonably accurate in ruling out SF but not ISS>8. Triage utilizing EST alone for GLF/FD is not useful.

Introduction

Patients presenting to the Emergency Department (ED) after ground level fall and found down (GLF/FD) episodes remain a triage and diagnostic dilemma. Appropriate utilization of resources and correct choice of clinical pathway is key to prompt identification and intervention in both medically and traumatically induced life-threatening physiologic derangements.[1–3] Guidelines have been rigorously developed to guide standardization and best practice of triage pathways.[4,5] Even with these tools, mistriage persists.[3]

In patients with low-energy falls, injuries are common (18–63%).[3,6,7] On the other hand, interventions for these injuries are relatively infrequent, leading to recommendations for selective rather than pan-body computed tomographic (CT) imaging based on clinical exam[6,7,8]

The reliability of clinical exam, however, has not been rigorously evaluated in this cohort. A retrospective study of patients with GLF found that of 327 patients with a normal abdominal exam, 12.5% had an injury and of 320 patients with a negative chest exam, 23% had a chest injury, although only less than 4% underwent any procedural intervention.[8] A retrospective study also found similar rates of torso injuries in elderly patients with intracranial hemorrhage after falls.[6] In a prospective study of intoxicated patients with GLF/FD, we found that neither clinician judgment nor signs and symptoms of trauma were consistently predictive of injuries.[9] These studies were based on patients who had underwent trauma team evaluation or were selected from included in trauma registries, and thus may have constituted biased samples of the entire cohort presenting to the ED with GLF/FD.

As clinical exam can be difficult due to mental status alterations and other physiologic derangements, external signs of trauma (EST) might be a simple and reliable way to differentiate patients who have significant injuries from those who do not. However, in our preliminary report of 153 patients found down undergoing trauma team activation (TTA), the presence of EST was not associated with significant injury.[10] We therefore aimed to evaluate whether EST in an undifferentiated cohort of GLF/FD patients regardless of TTA could predict significant findings (SF) on imaging. Our hypothesis was that EST was associated with SF. We further hypothesized that a combination of EST, subjective complaints (SC) and tenderness on exam (TOE), collectively grouped as signs and symptoms (SS) of trauma, were associated with SF and injury severity.

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Materials and methods

A retrospective study from a single institution was conducted over a three-month period, January 1, 2017 to March 31, 2017 following Institutional Review Board approval. We queried a prospectively maintained electronic database of ED admissions and included all patients with GLF/FD mechanisms as primary cause for presentation. Our triage process was as follows: those meeting trauma activation criteria were triaged to TTA which consisted of two levels of activation. Those not meeting criteria for TTA but meeting criteria for an expedited evaluation pathway were evaluated by an ED team headed by an emergency medicine physician. Patients not meeting criteria for TTA nor the ED expedited evaluation pathway were seen in the ED as a “regular” patient. Although there was no standardized protocol for CT imaging of suspected injuries, CT was used liberally but at the discretion of both trauma and emergency medicine teams. Details of the criteria for TTA and expedited evaluation have previously been published.[11]

For this study, EST was defined as any sign suggestive of traumatic injury visually apparent externally. SF was defined as any injury found on radiologic imaging defined *apriori* in Table 1. SS was defined as the presence of any of the following: EST, SC or TOE. The primary outcome was any SF and the secondary outcome was moderate or higher injury severity, defined by an Injury Severity Score (ISS) of >8. We analyzed the significance of EST and SS as categorical variables in predicting the study outcomes, both for each patient in an aggregated manner and also separately for different body regions, categorized as head/neck, chest/abdomen and upper/lower extremities. Also, in order to evaluate the utility of the institutional trauma triage criteria, we also examined the relationship between TTA, the study variables (EST, SS) and the outcomes.

The diagnostic utility of SS, EST and TTA for the study outcomes were each expressed as positive (LR+) and negative (LR-) likelihood ratios (LR) with 95% confidence intervals. A LR+ of close to 10 provides strong evidence that a condition is present when the test is positive while a LR-of close to 0.1 suggests that a negative test can rule out a condition. Univariable analysis was performed using the Mann Whitney *U* test, chi-square test or Fisher’s exact test where appropriate. Significance level was set as $p < 0.05$. Statistical analysis was assisted by StatsDirect (version 3.1.8.0, Merseyside, U.K.) and an online web-based likelihood ratio calculator.[12] Based on our previous work,[9] assuming a 5% rate of SF without EST versus a 15% rate of SF with EST, and a 50% prevalence of EST in the total cohort, with a power of 0.8, 141 patients would be required in each group.

Results

578 patients met inclusion criteria in this period. Median age was 80 (68–88) years with 61% being female. Median ISS was 1 (interquartile range, 0–5) and 18% had an ISS>8.87 (15%) were found down. The vast majority (95%) had at least one SS, and 66% had at least one EST. A SF was detected in 256 (44%) and overall, in-hospital mortality was 7/578 (1%). Trauma team activation occurred in 85 (15%).

There were no age and gender differences for patients with EST or SS compared to those without EST or SS (Table 2). Patients with EST or SS were more likely to have any SF and higher injury severity, although in both groups, median ISS was low (≤2). Moderate to severe injury severity (ISS >8) was associated with EST (21% vs 12%, $p = 0.01$) but not SS at the 5% significance level. The presence of any EST did not have sufficient diagnostic utility for SF or ISS>8 based on LR+ and LR-. The presence of any SS did not have sufficient diagnostic utility for ISS>8 but the absence of any SS was useful but not absolute in ruling out any SF (LR- = 0.19).

The association between EST and the study outcomes for separate body regions is shown in Table 3. Although the presence of EST in different regions was associated with SF in the corresponding regions, the magnitude of the LR-tests suggests that the lack of EST in these body regions was not sufficient to rule out SF in the respective body regions. The magnitude of the LR + tests also suggests that the presence of EST could not definitively rule in SF. With respect to ISS>8, chest/abdomen and extremity EST were significantly associated with moderate to severe injury but not EST of the head/neck. LR-results again indicated that the lack of EST was also not sufficiently accurate to exclude moderate to severe injury severity.

Table 4 shows the association between SS in separate body regions and the study outcomes. As the magnitudes of LR-were close to 0.1 in all three body regions for SF in the corresponding body regions, the results suggested that the absence of SS in a specific body region was sufficiently accurate in ruling out SF in that particular body region. However, we noted a very low prevalence (<5%) of patients negative for SS overall and in specific body regions (Tables 2 and 4). For ISS>8, SS in these body regions lacked diagnostic accuracy based on the LR magnitudes.

Patients who were triaged to TTA had similar rates of SF (47% vs 44%, $p = 0.61$) compared to those who were not (Table 5). TTA however was associated with moderate to severe injury severity (26% vs 17%, $p = 0.04$) as well as mortality (5/85 [6%] vs 2/493 [0.4%], $p < 0.0001$), compared to those without TTA. For both study outcomes, LR+ and LR-were close to 1 indicating that our existing TTA protocol was not sufficiently discriminatory.

Discussion

Kornblith et al.[2] highlighted the complexity of the unconscious found down trauma patient, concluding that triage decisions made with inadequate data may lead to misclassification and delay definitive care of either medical or traumatic illness. The authors also found that these patients often have both traumatic and medical diagnoses as the cause of major physiologic derangement. A multicenter trial also confirmed that 56% of found down patients had traumatic injuries with medical diagnoses noted in more than 75%, often requiring cross-consultation by trauma and medical services. Age was determined as an independent predictor of mistriage, as were EMS identified signs of trauma.[3] Jacobs et al.

Table 1
Study definitions of significant findings.

	Significant findings
Head/neck	Intracranial hemorrhage, any fracture or spine subluxation, pneumocephalus, cerebral infarct, neck hematoma, globe injury, air in soft tissues.
Chest/abdomen	*Chest:* rib or sternal fracture, hemothorax, pneumothorax, pneumomediastinum, air in soft tissues, injury to heart, injury to great vessels, mediastinal hemorrhage, contrast extravasation in any area, thoracic spine fracture. *Abdomen*: solid organ injury, suspected hollow viscus injury, pneumoperitoneum, intra-abdominal hemorrhage, retroperitoneal hemorrhage, free fluid, lumbar spine fracture or subluxation, pelvic or hip fracture.
Upper/lower extremities	Fracture, dislocation, contrast extravasation

Table 2
Characteristics of patients with and without EST and SS.

	Median age[a]	Male gender	Trauma activation	Median ISS[a]	Any SF	LR+	LR-	ISS>8	LR+	LR-	Mortality
Any EST											
No (n = 196)	80 (64–88)	73 (37%)	18 (9%)	1	74 (38%)	1.14 (1.02 –1.28)	0.76 (0.60 –0.97)	24 (12%)	1.21 (1.07 –1.37)	0.64 (0.44 –0.92)	0
Yes (n = 382)	81 (69–88)	150 (39%)	67 (18%)	2	182 (48%)			80 (21%)			7/(2%)
P	0.17	0.65	0.007	<0.0001	0.02			0.01			P = 0.06
Any SS											
No (n = 31)	81 (74–88)	11 (35%)	7 (23%)	0	4 (13%)	1.07 (1.04 –1.11)	0.19 (0.07 –0.53)	3 (10%)	1.03 (0.99 –1.07)	0.49 (0.15 –1.59)	0
Yes (n = 547)	80 (68–88)	212 (39%)	78 (14%)	1	252 (46%)			100 (18%)			7 (1%)
P	0.70	0.71	0.2	<0.0001	0.0003			0.22			0.53

Abbreviations: EST, external signs of trauma; SS, signs and symptoms of trauma, SF, significant findings; ISS, Injury Severity Score; LR+, positive likelihood ratio, LR-, negative likelihood ratio.
LRs expressed with 95% confidence intervals.
[a] Expressed with interquartile ranges.

analyzed 207 patients in their trauma registry with the diagnosis of “found down” and similarly confirmed that although 82% were eventually admitted to their trauma service after initial evaluation, 76% had other “acute medical diagnoses”.[1]

Much has also been published about the potential severity of low energy falls, particularly in the geriatric population where undertriage and the lack of recognition of injury potential has led to worse outcomes.[5,13–15] On the other hand, given that the GLF/FD cohort has an overall low injury severity (median ISS = 1 in this study), the possibility of overtriage and committing unnecessary resources and personnel on the part of the trauma team is very real. To enable expedited evaluation of elderly patients with low energy falls not meeting TTA criteria but who may have increased risk for deterioration and thus require interventions, we implemented in 2009 an expedited evaluation pathway under the direction of the emergency medicine physician. This pathway reduced time to CT imaging and ED length of stay without affecting overall mortality and allowed conservation of trauma team resources and time.[11]

In a prior study, we found that SS did not predict head or cervical injury in intoxicated patients undergoing TTA but was useful for predicting abdominal injuries.[9] Our current study attempted to mitigate selection bias by including all consecutive ED patients, regardless of whether trauma activation criteria were met. Our results indicated that patients triaged to undergo TTA had similar rates of SF (47% vs 44%, p = 0.61) compared to those without trauma activations. Although TTA was associated with a higher prevalence of moderate to severe injury and mortality, the magnitude of LRs (Table 5) suggested that clinical judgement in activating the trauma team was not accurate in anticipating SF or moderate to severe injury severity. This reiterates findings in the published literature demonstrating that trauma activations and early triage decisions are not sufficiently accurate to predict significant findings nor injury severity in this cohort.[1,2,3]

In investigating SS with respect to an unselected GLF/FD cohort, this study provides unique insight to these often-overlooked details that may aid in triage pathways. Since this study included patients with altered mentation, this might explain why EST alone had no additional contribution to either positive or negative prediction (Tables 3 and 4). In contrast, by including all SS, those extra components that are relayed via patient participation, a negative likelihood ratio approaching 0.1 suggests that an absence of *all* SS was reliable in ruling out SF (Table 2). This finding is consistent across all body regions (Table 4). However, the absence of SS lacked discriminatory value in ruling out moderate to severe injury severity (Tables 2 and 4). This apparent “paradox” might be because of the low prevalence of patients without SS (5%), as well as the lower prevalence of those with ISS>8 (18%) vis-à-vis those with any SF (44%). From a practical management standpoint, most if not all patients with altered mental status would have had CT imaging of the brain and cervical spine. The issue is whether CT torso imaging can be omitted without SS of torso injury. The prevalence of torso SF was 157/578 = 27% (Table 4). If this was assumed to be the pre-test probability, applying a LR-of 0.1, the post-test probability would be 4%. This provides some justification for not proceeding with *routine* CT imaging of the torso. However, repeated evaluation (tertiary surveys) by the trauma team is essential as clinical situation might change.

Table 3
Association Between EST with the study outcomes.

EST (head/neck)	SF (head/neck)	LR+	LR-	ISS>8	LR+	LR-
No (n = 325)	11 (3%)	2.21 (1.90–2.56)	0.25 (0.15–0.44)	52 (16%)	1.18 (0.95–1.47)	0.87 (0.71–1.07)
Yes (n = 253)	59 (23%)			52 (21%)		
P	<0.0001			0.19		
EST (chest/abdomen/pelvis)	SF (chest, abdomen/pelvis)					
No (n = 493)	106 (22%)	4.01 (2.71–5.95)	0.73 (0.66–0.82)	69 (14%)	3.19 (2.19–4.65)	0.74 (0.64–0.85)
Yes (n = 85)	51 (60%)			35 (41%)		
P	<0.0001			<0.0001		
EST (upper/lower extremities)	SF (upper/lower extremities)					
No (n = 388)	15 (4%)	2.58 (2.09–3.18)	0.37 (0.24–0.58)	58 (15%)	1.47 (1.14–1.89)	0.80 (0.67–0.96)
Yes (n = 189)	41 (22%)			46 (24%)		
p	<0.0001			0.008		

Abbreviations: EST, external signs of trauma; SS, signs and symptoms of trauma, SF, significant findings; ISS, Injury Severity Score; LR+, positive likelihood ratio, LR-, negative likelihood ratio.
LRs expressed with 95% confidence intervals.

Table 4
Association Between SS with the study outcomes.

SS (head/neck)	SF (head/neck)	LR+	LR-	ISS>8	LR+	LR-
No (n = 252)	4 (2%)	1.85 (1.67–2.05)	0.12 (0.04–0.30)	43 (17%)	1.07 (0.88–1.26)	0.94 (0.73–1.20)
Yes (n = 326)	66 (20%)			61 (19%)		
P	<0.0001			0.66		
SS (chest and abdomen/pelvis)	SF (chest and abdomen/pelvis)					
No (n = 285)	11 (4%)	2.68 (2.33–3.07)	0.11 (0.06–0.19)	35 (12%)	1.41 (1.19–1.67)	0.64 (0.48–0.84)
Yes (n = 293)	146 (50%)			69 (24%)		
P	<0.0001			0.0005		
SS (upper/lower extremities)	SF (upper/lower extremities)					
No (n = 290)	4 (1%)	2.05 (1.82–2.32)	0.13 (0.05–0.34)	46 (16%)	1.14 (0.93–1.38)	0.87 (0.69–1.10)
Yes (n = 288)	52 (18%)			57 (20%)		
P	<0.0001			0.2		

Abbreviations: SS, signs and symptoms of trauma, SF, significant findings; ISS, Injury Severity Score; LR+, positive likelihood ratio, LR-, negative likelihood ratio.
LRs expressed with 95% confidence intervals.

Table 5
Trauma Team Activation – Association with the study outcomes.

Trauma team activation	Any SF	LR+	LR-	ISS>8	LR+	LR-
No (n = 493)	217 (44%)	1.11 (0.75–1.64)	0.98 (0.92–1.05)	82 (17%)	1.59 (1.03–2.46)	0.91 (0.82–1.01)
Yes (n = 85)	40 (47%)			22 (26%)		
p	0.61			0.04		

Abbreviations: SF, significant findings; LR+, positive likelihood ratio; LR-, negative likelihood ratio, ISS, Injury Severity Score.
LRs expressed with 95% confidence intervals.

There were several limitations of this study. (1) There was no standard imaging protocol for identification of significant injuries. As imaging modalities were based on clinician discretion, missed injuries were possible. (2) Accuracy in this retrospective review was dependent on quality of documentation. Lack of consistency potentially underlies clinical insignificance, loss of meticulousness of exam or documentation deficiency, or communication gaps/ barriers between patient and care providers. Signs and symptoms may have been missed in some cases and the margin of omission error is unknown. (3) Objective scoring of mental status such as Glasgow Coma Scale, or NIH Stroke Scale was not performed in all patients, particularly in those who did not undergo TTA. Not all patients underwent toxicology or serum alcohol tests. (4) Critical time-based interventions or disposition status were not evaluated as endpoints. (5) No cost analysis was performed.

Conclusions

EST alone cannot accurately discriminate between the presence or absence of SF and/or ISS>8 in patients with GLF/FD. Rather, it is the constellation of all signs and symptoms (external signs of trauma, subjective complaints, and tenderness on exam) that when absent can reliably predict the lack of SF. In addition, current triage protocols with trauma team activation are not able to anticipate SF and ISS>8. Meticulous detection and recognition of SS during initial evaluation represents an opportunity for improved decision making and triage. These preliminary results should be verified by larger prospective studies with complete evaluation data and follow-up.

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Declaration of competing interest

There are no conflicts of interest to report.

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