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Is clinician assessment accurate or is routine pan-body CT needed in the stable intoxicated trauma patient?

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ABSTRACT

Background: We sought to determine if clinician suspicion of injury was useful in predicting injuries found on pan-body computed tomography (PBCT) in clinically intoxicated patients.
Methods: We prospectively enrolled awake, intoxicated patients with low-energy mechanism of injury. For each of four body regions (head/face, neck, thorax and abdomen/pelvis), clinician suspicion for injury was recorded as "low index" or "more than a low index". The reference standard was the presence of any pre-defined significant finding (SF) on CT. Sensitivity, specificity, positive (LR+) and negative (LR-) likelihood ratios were calculated.
Results: Enrollment of 103 patients was completed. Sensitivity, specificity, LR+ and LR-for clinician index of suspicion were: 56%, 68%, 1.75, 0.64 (head/face), 50%, 92%, 6.18, 0.54 (neck), 10%, 96%, 2.60, 0.94 (thorax) and 67%, 93%, 9.56, 0.36 (abdomen/pelvis).
Conclusion: Clinician judgement was most useful to guide need for CT imaging in the neck and abdomen/pelvis. Routine PBCT may not be necessary.
Summary: For awake, stable intoxicated patients after falls and assaults, clinician index of suspicion was most useful to guide the need for CT imaging in the neck and abdomen/pelvis. Our findings support selective use of CT if the index of suspicion is low. Routine PBCT may not be necessary.

Introduction

In the setting of acute alcohol intoxication, patient complaints and clinical exam are thought to be unreliable, often resulting in liberal use of diagnostic imaging modalities after injury.[1,2] While pan-body computed tomography (PBCT) scanning may be justified after high energy trauma, its use in low-energy trauma can result in overutilization of hospital resources and escalation of costs for low therapeutic yields.[3,4] In a prospective study of 295 trauma patients receiving 1097 scans, 416 (38%) were ordered defensively based on trauma surgeon surveys and resulted in $117,985 in excess charges.[3] Another prospective study conducted over four months showed that the implementation of evidence-based guidelines reduced the average number of scans per patient (1.2 vs. 1.9) and the estimated CT charges ($1,842,534 vs. $2,935,024) without incurring any missed or delayed injuries.[5] Although prior studies have addressed injuries in low velocity trauma,[6,7] clinician judgement as to who benefits from PBCT has not been well studied. Our aim was to evaluate the utility of clinician index of suspicion in identifying injuries in intoxicated patients. We hypothesized that clinician index of suspicion is useful in determining the presence of injuries in awake adult intoxicated patients with no evidence of shock after low-energy trauma.

Materials and methods

This prospective observational study was conducted in a level 1 trauma center from May 1, 2016 to February 1, 2019. All participants fulfilled the following inclusion criteria: trauma team activation occurred, alcohol intoxication based on clinician assessment, age ≥18 years, GCS ≥13, systolic blood pressure ≥100 mmHg, heart rate ≤120, base deficit (if done) < −4, normal chest and pelvis x-rays (if done), no fluid/hemorrhage demonstrated on Focused Assessment of Sonography in Trauma (FAST) exam, and a mechanism of a fall < 10 feet, being found down or assault. Exclusion criteria were: need for intubation prior to CT scanning, blood transfusion prior to

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CT scanning, presence of a concomitant penetrating injury, pregnancy, incarceration, or if the trauma attending was not physically present for the initial assessment. Once deemed eligible, the attending completed an anonymous survey documenting their clinical judgement for each of four body regions prior to the patient undergoing CT. The four body regions were: head/face, neck, thorax (including spine) and abdomen/pelvis (including spine). For each body region, the attending recorded the presence of patient complaints and exam findings suggestive of traumatic injuries [signs/symptoms, (SS)] as a dichotomous response, and indicated whether there was a "low index of suspicion" or "more than a low index of suspicion" for having a significant finding (SF) on CT scanning. The interpretation of a "low index of suspicion" was left to the discretion of the individual attending as it was difficult to establish fixed numerical probabilities of a SF among different providers. The survey form was then dropped into a locked box accessible only to the research coordinator prior to PBCT. This study was designed with an intention-to–treat principle: it was not practical to have serum blood alcohol concentrations (BAC) nor urine drug screen (UDS) results available prior to CT scanning, as patients underwent CT expeditiously. Therefore, clinical assessment of alcohol intoxication was sufficient to enroll patients.

Although PBCT was the customary practice, there was no stipulation that a PBCT had to be ordered for every patient. For each body region, a positive test was defined as "more than a low index of suspicion" and a negative test defined as a" low index of suspicion". The reference endpoint was any pre-specified SF found on CT (Table 1). Sensitivity, specificity, positive likelihood (LR+) and negative likelihood (LR-) ratios with 95% confidence intervals (CI) were calculated. The further the likelihood ratios were from 1 the more useful the test. Likelihood ratios above 10 and below 0.1 were felt to provide strong evidence to rule in or rule out diagnoses respectively. Pretest probabilities were estimated based on the prevalence of injuries in similar cohorts of patients in the published literature and our current results. Using LR+ and LR-for clinician index of suspicion for each body region, posttest probabilities were calculated based on an online Fagan nomogram (pre-test odds* LR = post-test odds).[8] Potential sample size of 481 patients would be required based on the method of Buderer[9] with a disease prevalence of 20%, sensitivity 50%, specificity 80%, and a 95% confidence interval (width of 10%). Departure from normality was evaluated by the Shapiro-Wilks test for continuous variables. Median and interquartile range were used for description of variables that were not normally distributed. Statistical analysis was performed using StatsDirect (v. 3.1.22, StatsDirect Ltd., Cambridge, U.K.). A p value of $\leq$0.05 was deemed significant.

As this study did not involve any interventions, had no more than minimal risk, and could not practicably be carried out without waiver of consent, it was approved by the hospital institutional review board with waiver of consent.

Results

During the study period, 121 patients were screened with 19 exclusions, leaving 103 patients enrolled (Table 2). BAC $\geq$80 mg/dl was demonstrated in 78% of cases with urine drug screen (UDS) performed in about half of the patients. Of patients that submitted a UDS, half had a positive test result. Overall, 88 (85%) had either a BAC of $\geq$80 mg/dl and/or a positive UDS. All enrolled 103 patients received head and cervical CT while 88 (85%) received a thorax CT and 89 (86%) received an abdomen/pelvis CT.

The relationship between SS of trauma and clinician assessment was analyzed. For the head/face region, of 91 patients with SS of trauma, 39 (43%) had more than a low index of suspicion, while of 12 patients without SS, none had more than a low index of suspicion ($p = 0.01$). For the neck region, three (27%) of 11 patients with SS of trauma versus seven (8%) of 92 without SS had more than a low index of suspicion ($p = 0.06$). For the chest region, one (6%) of 17 with SS of trauma versus four (5%) of 86 without SS of trauma had more than a low index of suspicion ($p = 0.8$). For the abdomen/pelvis, five (29%) of 17 with SS of trauma versus four (5%) of 86 without SS of trauma had more than a low index of suspicion ($p = 0.006$). Except for the thorax region, clinician index of suspicion was generally associated with SS of trauma for the body regions.

Table 3 shows the utility of clinician index of suspicion in predicting SF for each body region. The strongest LR+ were seen in the neck (6.18) and abdomen/pelvis (9.56) regions, while LR + for the head (1.75) and thorax (2.60) regions were weaker. The LR-for the

Table 2
Patient demographics (n = 103).

Median age (years)[a]	54 (41–61)
Male gender	79 (77%)
Median systolic blood pressure (mmHg)[a]	138 (122–150)
Median heart rate[a]	89 (78–101)
Median base deficit[a] (n = 65)	0 ([−3] − [2])
Blood Alcohol Concentration (BAC) (mg/dl)	
≥80	80 (78%)
≥10 to < 80	2 (2%)
<10	21 (20%)
Urine drug screen	
Not done	55 (53%)
Positive	25 (24%)
Negative	23 (23%)
BAC ≥ 80 mg/dl and/or urine toxicology positive	88 (85%)
Signs and symptoms − head/face	91 (88%)
Signs and symptoms - neck	11 (11%)
Signs and symptoms − thorax	17 (17%)
Signs and symptoms − abdomen and pelvis	17 (17%)
Significant findings − head/face (n = 103)	27 (26%)
Intracranial hemorrhage	16 (16%)
Facial and skull fractures	10 (11%)
Pneumocephalus	1 (1%)
Significant findings- neck (n = 103)	4 (4%)
Cervical spine fracture	4 (4%)
Significant findings- thorax (n = 88)	10 (10%)
Rib fractures	10 (10%)
Hemothorax and/or pneumothorax	1 (1%)
Significant findings − abdomen and pelvis (n = 89)	3 (3%)
Lumbar fractures	3 (3%)

[a] Median values expressed with interquartile ranges.

Table 1
Definitions for significant findings (SF).

Region	Definition
Head	Intracranial hemorrhage, any fracture, pneumocephalus, cerebral infarct, or any facial fracture
Neck	Acute fracture or subluxation, hematoma, air in soft tissues
Chest/thoracic spine	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 and pelvis/lumbar spine	Solid organ injury, suspected hollow viscus injury, intra-abdominal hemorrhage, retroperitoneal hemorrhage, free fluid, lumbar spine fracture or subluxation, pelvic/acetabulum fracture, contrast extravasation in any area

Table 3
Utility of clinician judgement in predicting significant findings on CT.

	No SF	SF	SENS	SPEC	LR+ (95% CI)	LR- (95% CI)
Head/face (n = 103)						
Low index	52	12	56%	68%	1.75 (1.07–2.77)	0.64 (0.39 to 1–0.96)
>low index	24	15				
Neck (n = 103)						
Low index	91	2	50%	92%	6.18 (1.63–15.9)	0.54 (0.16–0.93)
>low index	8	2				
Thorax (n = 88)						
Low index	75	9	10%	96%	2.60 (0.38–15.64)	0.94 (0.62–1.05)
>low index	3	1				
Abdomen/pelvis (n = 89)						
Low index	80	1	67%	93%	9.56 (2.50–24.2)	0.36 (0.06–0.86)
>low index	6	2				

Abbreviations: SENS, sensitivity; SPEC, specificity; LR+, likelihood ratio of a positive test; LR-, likelihood ratio of a negative test; CI, confidence intervals.

head (0.64), neck (0.54) and thorax (0.94) did not provide strong evidence for ruling out SF but the LR-for the abdomen/pelvis region (0.36) was stronger. It is to be noted that the confidence intervals were wide in these LR estimates due to the small sample size.

When LR for SS of trauma were analyzed, SS of head/face trauma had a LR+ (95% CI) of 1.12 (0.94–1.27) and a LR- (95%) of 0.26 (0.04–1.39). For the neck region, the corresponding LR+ was 5.5 (1.47–13.7) and LR-was 0.55 (0.16–0.94). For the thorax, the LR+ was 1.04 (0.28–3.07) and LR-was 0.99 (0.60–1.24). For the abdomen/pelvis region, the LR+ was 6.14 (1.99–9.17) and LR-was 0 (0–0.67). The magnitude of these LRs were comparable to that for clinician index of suspicion, although the LR-for the head (0.25) and abdomen regions (0) provided stronger evidence for ruling out a SF.

To put the LR estimates for clinician index of suspicions in the context of this patient population, the prevalence of SF in each body region was estimated by review of the literature and our study. Final pretest and posttest probabilities were then calculated using the LR estimates and shown in Table 4.

Analysis of patients with BAC of <80 mg/dl (n = 21) vs ≥ 80 mg/dl (n = 73) did not reveal any significant differences in the specificities for clinician index of suspicion for each of the body regions. As there were only 4, 1, 4 and 1 SF in the head, neck, thorax and abdomen/pelvis regions respectively for the group with BAC <80 mg/dl, we felt that the calculated sensitivities would not be meaningful.

In the 103 patients, only two (2%) patients underwent surgical procedures for SF. One underwent operative reduction and fixation of a mandible fracture and the other anterior cervical fusion several months after his injury.

Discussion

While gaining widespread acceptance in the evaluation of blunt trauma, the use of PBCT remains controversial in the evaluation of awake intoxicated patients with low-energy mechanism of injury. The prevalence of injuries is expected to be lower than that seen in high-energy trauma mechanisms, and therefore the reflexive use of PBCT may be perceived as a defensive medical practice in a litigious environment.[3] This study is unique in that it attempts to evaluate clinician suspicion for injuries in the setting of acute alcohol intoxication for all body regions typically imaged with PBCT.

For the head/face region, as the prevalence of a SF in our study was 26%, the LR-of 0.64 would mean that the post-test probability of a SF was 18%. Given the potential consequences of missed intracranial pathology, our findings support liberal head CT for this cohort regardless of level of clinician suspicion.

For the neck region, "more than a low index of suspicion" was useful as a predictor of SF (LR+ 6.25), given the high posttest probability (5–20%). However, the magnitude of the LR- (0.54) was not entirely reassuring, especially when the 95% confidence intervals were wide. Clinical index of suspicion would only be useful if the pretest probability of an injury was very low. The prevalence of a SF in our study was 4%, which is consistent with that found by Benayoun et al.[10] where there was a prevalence of 0.92% in 760 patients after ground level falls. In larger studies, the prevalence is higher. Martin et al. examined intoxicated patients and found that the incidence of cervical spine injury was 10.6%.[11] Khan et al.[12] and Bush et al.[13] found prevalence of 7.6% and 10.3% respectively. It should be noted that these studies with higher prevalence included patients with high energy mechanisms of injury and not just falls or assaults. Therefore, if the pretest probability in a specific cohort was low (0.92–4%), a LR-would mean a posttest probability of 0–2% (Table 4). Recommendations from the National Emergency X-Radiography Utilization Study[14] and the Canadian C-Spine Rule[15] do not advocate clinical cervical spine clearance for intoxicated patients and those with GCS< 15 respectively. Therefore, although the posttest probability is low, imaging is still warranted since out results are derived from a small sample.

For the thorax region, clinician index of suspicion was not useful as the LR+ and LR-were close to 1.0. Most of the SF were rib fractures that did not require operative or other invasive intervention. The prevalence in our study of 10% was similar to that found by Lavingia et al.[16] in a cohort of 156 patients (7%), and higher than that found by Kelleher et al.[17] in a cohort of 115 patients (0%) with low energy trauma. Based on these estimates, the posttest probability was low (Table 4). Coupled with the fact that there were no injuries requiring urgent operative intervention (pneumothorax,

Table 4
Pretest and posttest probabilities of SF for clinician index of suspicion.

	Estimated pretest probability using prior studies and current study	Posttest probability of a positive test	Posttest probability of a negative test
Head/face	26% (current study)	38%	16%
Neck	0.92–4%[10]	5–20%	0–2%
Chest	0–10%[16,17]	0%–22%	0–9%
Abdomen/pelvis	2–6%[17–19]	16–38%	1–2%

hemothorax, great vessel or cardiac injury), this could support the selective use of chest CT. A chest x ray and FAST would likely identify any clinically significant pathology in this population, where mediastinal injuries are very uncommon. A low clinician index of suspicion, together with a normal CXR and negative FAST exam is probably sufficient to exclude significant injuries.

For the abdomen/pelvis region, clinician suspicion for an injury should prompt CT as there is a high posttest probability of a positive test. The low posttest probability of a negative test suggests that no CT scanning is acceptable if the index of suspicion is low. Our prevalence was 4%, similar to that found by Lavingia et al. (6%),[16] Mavridis et al. (2%)[18] and Perez et al. (6.5%).[19] Ko et al.[20] studied a similar cohort of 342 patients who were found down and of which 60% were intoxicated. Only 117 (34%) had CT of the abdomen/pelvis and of these, (12%) were positive but there were only two liver and two renal injuries and three pelvic fractures. It is not clear how many patients had these injuries. The authors concluded that found down patients did not benefit from routine abdominal imaging to detect injuries but that there could be other indications such as sepsis of unclear origin. Based on our posttest probability estimates (1–2%), a CT of the abdomen/pelvis can be omitted if the index of suspicion was low and there was no other indication for abdominal imaging (Table 4).

The LR for SS of trauma were comparable to that for clinician index of suspicion. This was not unexpected, as clinician index of suspicion likely was based on presenting SS of trauma. As we had noted previously, the LR-for the abdomen/pelvis region provided strong evidence to rule out a SF in the absence of SS of trauma.

Several methodological issues warrant further clarification. As patients were enrolled on an intention-to-treat basis, a substantial minority (22%) were found to have a serum BAC of $\leq$80 mg/dl. This study was designed to reflect the practical issue facing trauma surgeons during trauma team activations, where decisions regarding CTs are made with limited information from the initial evaluation without laboratory results. If patients with BAC<80 mg/dl were excluded post hoc, this would make the results of this study less generalizable. Nevertheless, the subjectivity in clinician determination of intoxication was a limitation of the study. In a small prospective study, Kumar et al. compared alcohol levels obtained from breathalyzer tests to clinical tests of balancing on one leg, heel-to-toe walking and the presence of horizontal nystagmus and found poor correlations.[21]

“Change in management” or “clinically significant injuries” were not used as endpoints. “Change in management” is a subjective concept because even a negative test could have changed management. “Clinically significant” injuries, conventionally defined as injuries requiring surgical or other invasive intervention, or aggressive resuscitation, were rare in this study. Only two patients required operative intervention for injury. This was not entirely unexpected for a cohort with low energy mechanism of injury. The focus of this study was to identify SF. Many injuries which are not “clinically significant” but warrant hospitalization and substantial resource utilization.

There were other limitations of this study. (1) The sample size was small and likely resulted in the wide confidence intervals surrounding the likelihood ratio estimations. To achieve the targeted sample would have required a significantly longer enrollment period. As such, this study should be considered exploratory and the results preliminary. (2) Clinician judgement was dichotomized as “low index” versus “more than a low index” which may have oversimplified complex decision-making processes. (3) Using pretest and posttest probabilities to assess the utility of a diagnostic test relied on accurate estimations of the disease prevalence in the cohort in question. Such estimations were likely to be imprecise in the published literature given that this study focused on a highly selected cohort. This study also did not seek to determine acceptable missed injury rates. If the posttest probability of a negative test was higher than an acceptable missed injury risk, a negative test would not be reassuring to clinicians. (5) Not all patients received PBCT, as this was designed as an observational study. We did not exclude patients who did not receive PBCT as these patients could still contribute valuable data.

In conclusion, for intoxicated but awake hemodynamically stable patients with low energy falls or who were found down or assaulted, clinician index of suspicion was most useful in predicting SF in the neck and abdomen/pelvis regions. For each body region, the decision to obtain CT imaging should be guided by the prevalence of injuries and index of suspicion. Our findings support the selective use of abdomen/pelvis CT if the index of suspicion is low. These results should be considered preliminary as the sample size was small. Possible areas for future study include increasing enrollment through a multi-institutional design, using “clinically significant injuries” as a secondary endpoint, and employing a more objective standard to determine alcohol intoxication.

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Conflicts of interest

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.amjsurg.2019.07.010.

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