Enhancing Detection of Hidden Injuries: Evaluating the Precision of Abdominal Ultrasound as a Supplementary Tool in Penetrating Trauma Evaluation

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Abstract:

Background: Systematic Sonography Looking for Occult Wounds (SSLOW) represents a novel approach in trauma evaluation, specifically targeting the detection of intra-abdominal injuries in cases of penetrating trauma. Despite its potential significance, there remains a dearth of empirical evidence regarding its effectiveness. This study endeavors to evaluate the accuracy and efficacy of the SSLOW examination in this context.

Methods: Conducted over a span of 10 months, this prospective case series was carried out at the Accident and Emergency Department (A&E) . Enrolled participants comprised individuals aged 16 years and above who presented to the A&E department with penetrating abdominal trauma. Initial assessment involved the performance of an E-FAST examination for all patients. Subsequently, in cases where the E-FAST results were negative, a SSLOW examination was conducted. Specifically, the sonographer focused on identifying any evidence of free fluid accumulation amidst the loops of bowel. The outcomes of the SSLOW examination were then compared with the standard care procedures, including surgical consultation, serial abdominal and E-FAST examinations, laparotomy, and a 7-day follow-up period. The results were categorized into true positives, false positives, true negatives, and false negatives, facilitating the calculation of sensitivity, specificity, positive predictive value, negative predictive value, and likelihood ratios.

Results: Among the participants, there were 5 (12%) true positives, 1 (2%) false positive, 37 (86%) true negatives, and zero (0%) false negatives. SSLOW exhibited a sensitivity of 100% (95% CI 5–100%) and a specificity of 97% (95% CI 74–96%). The positive predictive value was determined to be 80% (95% CI 1.0–64%), while the negative predictive value was found to be 100% (95% CI 88–100%). Furthermore, the positive likelihood ratio was calculated as 8.4 (95% CI 3.69–19.1), with a negative likelihood ratio of 0.

Conclusion: The findings of this study suggest that the SSLOW examination holds promise as a valuable adjunct in the comprehensive assessment of penetrating abdominal injuries.

Introduction:

In the realm of trauma evaluation, the Focused Assessment with Sonography for Trauma (FAST) has established itself as a pivotal clinical tool. This bedside examination is applicable across both blunt and penetrating trauma scenarios, facilitating the prompt identification of intraperitoneal and pericardial fluid collections. The FAST's attributes include its accessibility, non-invasiveness, rapidity, repeatability, and avoidance of radiation and contrast agents. Over time, its scope has expanded to encompass thoracic cavity assessment for hemothoraces and pneumothoraces, evolving into the Extended FAST (E-FAST). (Somcharit, 2016)

Studies have documented the sensitivity and specificity of the FAST and E-FAST examinations in detecting free intraperitoneal and pleural fluids, underscoring their clinical utility. Despite advancements, the traditional FAST exam has limitations, particularly in detecting small volumes of free fluid, a crucial consideration in cases of penetrating abdominal injuries. (Akoglu et al., 2018)

The identification of occult penetrating bowel wounds is imperative to prevent complications such as peritonitis, which can lead to substantial morbidity and mortality. Systematic Sonography Looking for Occult Wounds in Trauma (SSLOW) represents a novel technique aimed at enhancing the detection of isolated bowel or solid organ injuries resulting from penetrating abdominal trauma. Analogously, the secondary FAST exam has shown promise in improving sensitivity for detecting intraperitoneal fluid in blunt trauma cases. (Rupp et al., 2018)

The SSLOW examination involves meticulous ultrasound assessment using a linear probe, systematically covering the anterior abdomen to identify pockets of free fluid between bowel loops, delineated by geometric shapes. This technique offers potential benefits in settings where resources are limited, such as the Georgetown Public Hospital Corporation (GPHC) in Guyana, the sole tertiary care referral center in the country. (Baron et al., 2018)

Trauma remains a significant cause of morbidity and mortality globally, including in Guyana, where it ranks among the top ten causes of death. Conventional diagnostic modalities like upright chest X-rays and computed tomography (CT) have limitations, with CT missing clinically significant bowel injuries in a notable percentage of cases. In contrast, ultrasound is more accessible at GPHC's Emergency Department, setting the stage for exploring the accuracy of the SSLOW exam in comparison to established diagnostic approaches such as exploratory laparotomy, serial abdominal examinations, advanced imaging, or a seven-day follow-up protocol. (Wisquars, 2016)

Methods:

The research spanned a 10-month period, conducted at the Accident and Emergency (A&E) department . Patients were prospectively collected during this period. The study size was determined by the duration of the primary investigator's ultrasound fellowship. Inclusion criteria comprised patients aged 16 years or older presenting to the A&E with penetrating abdominal trauma, aligning with the legal age of consent . Enrollment occurred when trained personnel were available. Exclusion criteria included patients with abdominal evisceration, known ascites, or a positive E-FAST exam. The specific objectives were to evaluate the feasibility of implementing

the SSLOW examination and its accuracy among trauma patients at GPHC compared to standard treatments, such as advanced imaging, serial abdominal exams, and exploratory laparotomy. Patients were followed until discharge, with a 7-day follow-up via phone call.

The SSLOW exams were conducted by emergency medicine residents undergoing emergency residency training and registrars who had completed emergency medicine residency. These physicians undergo structured ultrasound training as part of their residency program, performing a minimum of 250 ultrasounds under supervision. Point-of-care ultrasound (POCUS) is routinely employed in their clinical practice. The SSLOW exam builds upon basic skills utilized in other POCUS applications. Each provider received a twenty-minute lecture on the SSLOW examination and underwent two observed training scans with ultrasound faculty. SSLOW examinations were supervised by a residency-trained emergency medicine specialist. Surgeons and surgical residents were informed of SSLOW examination results. Approval for the study was obtained from the GPHC and Vanderbilt University Medical Center Institutional Review Board (IRB).

All patients with penetrating trauma received comprehensive emergency medical stabilization as per standard care, including an E-FAST. If the E-FAST examination yielded negative results, a SSLOW examination was conducted. The SSLOW examination was performed by an emergency medicine-trained physician or resident with additional ultrasound training and familiarity with the SSLOW technique. The examination was conducted with the patient in the supine position using a Sonoscape S2 ultrasound machine equipped with a 10 MHz linear probe. The probe was systematically moved across the abdomen in a lawn-mower fashion, with the sonographer assessing for free fluid accumulation between bowel loops forming geometric shapes. SSLOW results were compared to standard care, and sensitivity, specificity, positive predictive value, negative predictive value, and likelihood ratios were calculated.

Patient data were recorded and conveyed to the principal researcher. Patient consent was obtained by the treating physician. Data collection was performed on a designated form by the treating physician and submitted to the researcher. Patient follow-up was conducted by the researcher. Data were entered into a password-protected Microsoft Excel spreadsheet and analyzed using the Statistical Package for the Social Sciences (SPSS) on a secure computer system.

Results:

A total of 43 patients were enrolled in the study, with any patient showing a positive initial E-FAST examination being excluded. Patient demographics and injury details are summarized in Table 1. Penetrating injuries were predominantly caused by knife wounds (44%), followed by ice picks (28%) and scissors (19%). Four patients had other mechanisms of injury, including a gunshot wound, large piece of glass, broken glass bottle, and a scalpel injury. No injuries were self-inflicted.

Among the enrolled patients, six positive SSLOW examinations were recorded. Notably, one patient with a 3-cm stab wound to the right lower quadrant (RLQ) had a negative FAST but a positive SSLOW result. This patient underwent exploratory laparotomy, revealing a 1-cm laceration to the cecum. The remaining five patients with positive SSLOW results were managed expectantly. Four of these patients initially had negative FAST exams but later showed positive

findings on subsequent examinations, indicating minor solid organ injuries that did not necessitate surgical intervention. Additionally, one patient had a positive SSLOW examination despite a negative E-FAST result, but subsequent serial examinations and follow-up revealed no confirmed injuries. Another patient with negative FAST and SSLOW results underwent exploratory laparotomy due to a 3-cm stab wound to the left upper quadrant (LUQ), which violated the fascia; however, no intra-abdominal injuries were identified during surgery.

Of the total patients, two underwent exploratory laparotomy, while 26 were admitted for observation and eventually discharged with negative follow-up outcomes, without readmission or mortality. Fifteen patients were discharged from the Emergency Department after a 6-hour observation period, with non-significant follow-up findings. All patients survived up to the 7-day follow-up.

The results summarized in Table 2 indicate that SSLOW exhibited 100% sensitivity (95% CI 5–100%) and 97% specificity (95% CI 74–96%). The positive predictive value was 80% (95% CI 1.0–64% 95% CI), while the negative predictive value was 100% (95% CI 88–100%). Furthermore, the positive likelihood ratio was 8.4 (95% CI 3.69–19.1), with a negative likelihood ratio of 0.

Table 1. Demographics

Demographics	Number (Percentage)
Male	38 (88%)
Female	5 (12%)
Age Groups	Percentage
16–20	16%
21–30	49%
31–40	19%
41–50	9%
51–60	7%
Time of Injury	Number (Percentage)
AM	15 (35%)
PM	28 (65%)
Time of Presentation	Number (Percentage)
AM	12 (28%)
PM	31 (72%)
Mechanism of Injury	Number (Percentage)
Knife	19 (44%)
Ice pick	12 (28%)
Scissors	8 (19%)
GSW	1 (2%)
Other	3 (7%)
Location of Injuries	Number (Percentage)
RUQ	15 (35%)

RLQ	2 (5%)
LUQ	25 (58%)
LLQ	1 (2%)
Self-inflicted	Number (Percentage)
Yes	0
No	43 (100%)
Disposition	Number (Percentage)
Operating theatre	2 (5%)
Admission for observation	26 (60%)
Discharge	15 (35%)
Deceased	0

Table 2 Categorical values

	True	False	Total
Positives	5	1	6
Negatives	37	0	37
Total	42	1	43

Discussion:

This preliminary study highlights the utility of the SSLOW examination as an effective tool in the assessment of penetrating abdominal injuries. Among the enrolled patients, six positive SSLOW examinations were recorded, with subsequent confirmation of injuries in five cases through laparotomy or other established imaging modalities. The challenges associated with evaluating patients with abdominal injuries, particularly in regions with limited access to advanced imaging , underscore the importance of early detection of occult penetrating bowel wounds to prevent complications like peritonitis, which carry significant morbidity and mortality. (Walcher et al., 2006)

While previous studies have demonstrated the efficacy of high-frequency ultrasound following the traditional FAST in improving sensitivity, particularly in blunt trauma cases, there has been a paucity of research evaluating its use specifically in penetrating injuries. Victims of penetrating injuries often present differently, being more likely to be upright or seated rather than in spinal precautions, and they are also more prone to isolated bowel injuries, potentially leading to variations in the accumulation of free fluid. (Ma, 2014)

In this small-scale study, the SSLOW examination emerged as a valuable tool for detecting occult abdominal injuries. Its implementation could serve as an adjunct to aid surgeons in the early detection of isolated bowel or solid organ injuries, potentially enhancing patient outcomes and reducing the risk of complications associated with delayed diagnosis and treatment. Further research on a larger scale is warranted to validate these findings and ascertain the broader applicability and efficacy of the SSLOW examination in diverse clinical settings. (RajabzadehKanaf et al., 2014)

Conclusion:

In conclusion, despite the limitations outlined above, the SSLOW examination emerges as a promising tool in the evaluation of penetrating abdominal injuries at the Emergency Department of the Georgetown Public Hospital Corporation. This modality demonstrates high sensitivity and specificity in detecting isolated bowel injuries and solid organ injuries in patients with penetrating abdominal trauma, serving as a valuable adjunct to the current standard of care. Further research with larger sample sizes and diverse patient populations is warranted to confirm and expand upon these findings.

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