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Injury Severity Scoring in the Resuscitation Room—Is Preliminary Injury Severity Score Accurate?

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ABSTRACT

Background: The Injury Severity Score (ISS) is a commonly used trauma assessment tool. An accurately calculated ISS is fundamental when used for the classification of the injury severity of trauma patients and subsequent evaluation of a trauma center's performance. This study aimed to analyze the accuracy of a preliminary ISS of trauma patients in the resuscitation room.

Methods: A preliminary ISS assessed by clinicians during the primary assessment of trauma patients at the Trauma Center of Rigshospitalet, Denmark in the time period January 2019–May 2024 was recorded in a trauma database and compared with definitive ISS assessed by certified Abbreviated Injury Scale (AIS) coders. Clinicians were not AIS-certified. All trauma patients were clinically assessed by a trauma team. The primary outcome of the study was the interrater agreement of the preliminary and definitive ISS, evaluated using Cohen's Kappa and a Bland–Altman plot for visual representation. Cases with missing or invalid data were excluded.

Results: In total, 3623 trauma patients with preliminary and definitive ISS were registered. The majority of trauma patients were adult 2858 (79%), and male 2433 (67%). Penetrating trauma was sustained by 588 (16%) patients while 3032 (84%) suffered blunt trauma. The Cohen's Kappa between the preliminary and the definitive ISS value was 0.51 (95% CI 0.50–0.53), suggesting a moderate overall agreement. The lowest agreement was found in the subgroup of seriously (ISS 15–24) injured patients, 0.31 (95% CI 0.27–0.35). The Bland–Altman plot showed acceptable agreement, although it seemed there was an increasing difference in ISS with increasing mean ISS. No indication of other bias or systematic mistakes was identified.

Conclusion: This study found a moderate but overall acceptable level of agreement between preliminary and definitive ISS in trauma patients. In the most severe cases, the preliminary ISS showed a tendency to underestimate injury severity. These findings suggest that the accuracy of preliminary ISS diminishes in cases of severe trauma, highlighting the need for cautious interpretation in critically injured patients. Preliminary ISS remains a valuable tool in clinical settings for trauma severity classification.

1 | Introduction

Accurate and consistent injury severity assessment plays a crucial role in the outcome prediction of trauma patients, quality assurance, patient safety, benchmarking, and strategic planning of trauma systems [1, 2]. The Abbreviated Injury Scale (AIS) was developed in 1971 and provides a standardized system to classify injuries based on their anatomic location

[3]. The AIS scores can be combined in several ways to determine a total trauma score, for example, in Injury Severity Score (ISS), New Injury Severity Score (NISS), or Anatomic Profile (AP) scores.

The ISS is the most commonly used trauma score [4]. All identified injuries are scored on a ranked scale of 1–6 according to the AIS in six specified anatomical regions, and the ISS is derived by the sum of the three highest AIS scores squared in three different regions [4]. The ISS is an ordinal scale with restricted values ranging between 0 and 75 with a number of mathematically impossible scores. Any injury with an AIS score of 6 per definition results in a maximal ISS of 75.

The ISS has several weaknesses and limitations for clinical use. Being a purely anatomical score, the ISS does not consider the patient's physiological status, comorbidities, or time from injury [5]. An accurate AIS coding requires considerable time and available results of paraclinical investigations such as computed tomography (CT) scans. Therefore, at our center, we have implemented a preliminary AIS scoring system to aid initial clinical decision-making regarding intrahospital triage and the possible need for admission to an intensive care unit (ICU).

While a preliminary ISS may provide valuable information in the early phases of patient care, it may underestimate or overestimate injuries. That may lead to suboptimal triage decisions. Only a few studies investigating the accuracy of a preliminary ISS [6, 7]. exist, revealing an evidence gap in trauma centers using ISS in patient assessment.

This study aimed to assess the accuracy of a preliminary ISS performed during or immediately after the trauma call compared to the definitive ISS of trauma patients. We hypothesized that the preliminary ISS estimated by orthopedic surgeons during the initial patient examination would demonstrate an acceptably accurate agreement with the definitive ISS coded post-discharge by certified AIS coders.

2 | Methods

2.1 | Study Design and Setting

This observational quality assurance study was based on prospectively collected data from the local trauma quality assurance database of the major trauma center at Copenhagen University Hospital, Rigshospitalet, Capital Region of Denmark. According to Danish law, approval for quality assurance projects was issued by the department management with no further approvals necessary [8].

The healthcare system in Denmark is divided into five demographic regions, and access to healthcare is free of charge [9]. The Capital Region and Region Zealand cover the eastern part of Denmark, which accounts for approximately 2.75 million inhabitants. Rigshospitalet serves as the only major trauma center, and 17 referral hospitals with lower-level facilities also receive and admit trauma patients. The emergency medical services in Denmark consist of ambulances staffed by paramedics or emergency medical technicians, supplemented by physician-staffed rapid response vehicles and emergency medical helicopters [10].

2.2 | Participants and Data Collection

The study population comprised all patients admitted with trauma team activation from January 1, 2019, to May 31, 2024. As standard practice, demographic and trauma-related variables were systematically recorded in the local trauma quality assurance database. The preliminary ISS was calculated as a standard practice in our hospital shortly after the preliminary trauma assessment. The assigned orthopedic surgeon is responsible for the AIS assessment and ISS calculation. The highest AIS score per body region was estimated using a simplified reference sheet of AIS-coded lesions from common clinical findings and, if performed, initial findings of a trauma CT scan. The clinicians performing the preliminary scoring were not required to have AIS certification or specific AIS training and were introduced to the assessment and calculation by senior colleagues from the department. There was no formal training program. The definitive AIS coding and derived ISS of the same case occurred after discharge from the hospital, 30 days, or death. This definitive ISS was calculated using information derived from the hospital medical records by healthcare personnel certified in AIS coding in an Onsite Course led by an AIS instructor. The AIS 2005 Update 2008 version was used for the whole duration of data collection [11].

2.3 | Outcomes

The primary outcome of the study was the interrater agreement between the preliminary and definitive ISS. The agreement was assessed as the difference between the two types of ISS by statistical analysis using Cohen's Kappa. Cohen's Kappa measures the rate of interrater agreement, which provides a measure of agreement between the preliminary ISS compared to the definitive ISS scores. Cohen's Kappa was interpreted as follows, proposed by the original Landis and Koch: <0.2 as poor agreement, 0.21–0.4 as weak, 0.41–0.6 as moderate, 0.61–0.8 as good, and >0.8 as very good agreement [12].

As a secondary outcome, the preliminary and definitive ISS were divided into three severity groups: mild (ISS <15), serious (ISS 15–24), and severe (ISS >24), and the agreement was assessed using Cohen's Kappa.

A Bland–Altman plot was created to visually assess agreement between the preliminary and definitive ISS and identify systemic bias by plotting differences between two measurements against their averages [13].

Exclusion criteria consisted of a missing or invalid ISS score.

2.4 | Statistics

Baseline data for the study population were summarized using the median and interquartile range (IQR) for continuous variables, and

frequencies with percentages for categorical variables. Agreement between the preliminary and definitive ISS was evaluated through Cohen's Kappa value and Bland–Altman plot representation with a visual inspection alongside calculations of bias (mean difference) and limits of agreement, representing the range within which 95% of data points are expected to fall.

A subgroup analysis of agreement between preliminary versus definitive ISS divided by injury severity groups is presented in the current study. All statistical calculations were performed using Excel 2013. The chosen level of statistical significance of a p value is set at $p < 0.05$ in the current study.

3 | Results

Data from 5090 consecutive trauma patients were obtained from the local trauma quality assurance database. Cases with invalid or missing ISS, 1467 (28%), were excluded, resulting in 3623 cases (Figure 1). The number of cases that were missing preliminary ISS was 975, and 394 cases were missing definitive ISS. Several cases, 94, had both variables missing from the data set. Four cases, all of which were the preliminary ISS, had an invalid ISS score, defined as ISS < 0 or > 75. The scoring was not repeated for invalid cases because the resulting score would no longer qualify as preliminary. The mean ISS values for cases with missing data, derived from the single available score, were 13 for the definitive-only ISS and 12 for the preliminary-only ISS.

The study population consisted of 2433 (67%) males, 888 (25%) females, and 302 (8%) missing. A total of 588 (16%) suffered penetrating trauma, while 3032 (84%) sustained blunt trauma, and three cases (~0%) were missing. The study group consisted of 2858 (79%) adult patients, 505 (14%) pediatric patients, and 260 (7%) missing (Table 1).

Total number of patients in the subgroups of preliminary ISS was 2392 for ISS < 15, 728 for ISS 15–24, and 503 for ISS > 24. For the definitive ISS, the total was 2407 for ISS < 15, 685 for ISS 15–24, and 531 for ISS > 24 (Table 2). Of the 2407 patients with a definitive ISS < 15, 2112 (88%) were initially categorized as ISS < 15 in preliminary assessment, 254 (11%) were initially assigned a higher severity score of ISS 15–24, and 41 (2%) were assigned a higher severity score of ISS > 24. For the 685 patients categorized as ISS 15–24 in the definitive scoring, 216 (32%) were categorized as ISS < 15 in the preliminary ISS, 317 (46%) were correctly scored as ISS 15–24, and 152 (22%) were assigned a higher severity score of ISS > 24 initially. Among the 531 patients with a definitive ISS > 24, 64 (12%) were initially assigned to ISS < 15, 157 (30%) were initially categorized as ISS 15–24, and 310 (58%) were correctly identified as ISS > 24.

The primary outcome was the overall Kappa value of 0.51 ± 0.015 (0.50–0.53). The secondary outcomes, consisting of injury severity subgroups analysis, showed respective Kappa values of 0.65 (0.62–0.67) for the subgroup of ISS < 15, 0.31 (0.27–0.35) for ISS 15–24, and 0.52 (0.48–0.56) for ISS > 24 (Table 3). The mean difference between preliminary versus definitive ISS was 3 ($p = 0.02$) for the subgroup of ISS < 15, 6 ($p = 0.02$) for ISS 15–24, and 11 ($p = 0.02$) for ISS > 24. For the subgroup of elderly (age ≥ 65 years), the overall Kappa value was 0.40 ± 0.014 (0.39–0.42).

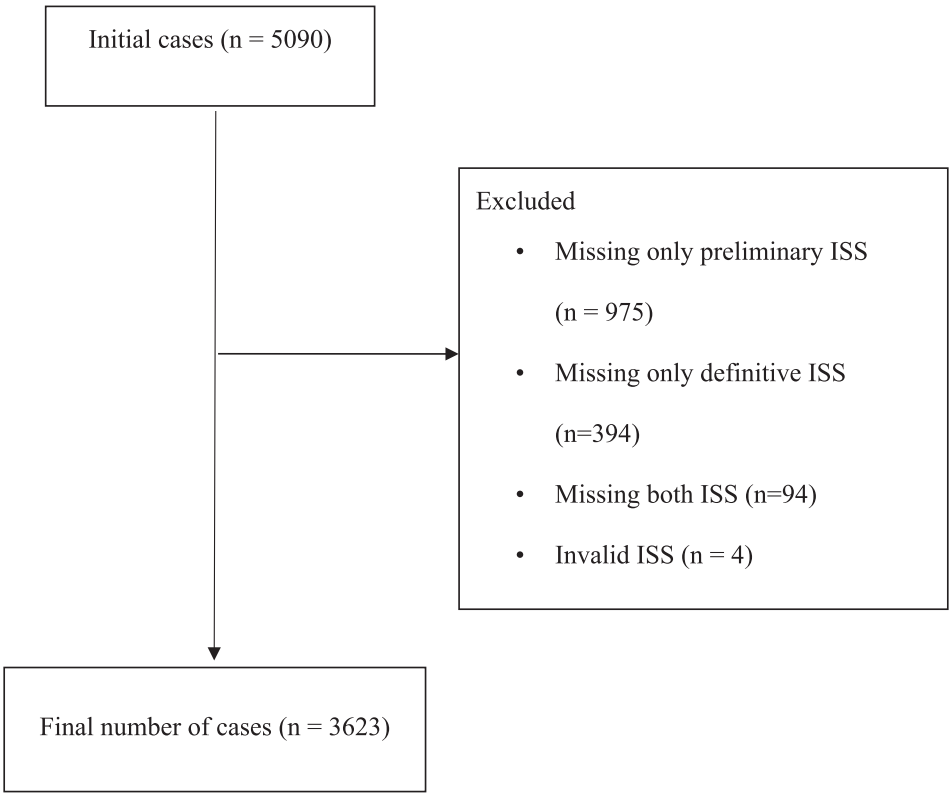

FIGURE 1 | Flow diagram of the case inclusion process. Flow diagram of case inclusion process from obtained data points from the database to included cases. ISS, Injury Severity Score.

TABLE 1 | Descriptive characteristics of the trauma population.

Sample characteristics	*N* = xxxx, %
Sex	
Male	2661, 73%
Missing data	0
Age	
Adult (≥18 years old)	3083, 85%
Missing data	0
Trauma mechanism	
Penetrating	588, 16%
Missing data	3, ~0%
Survived until discharge	
Yes	2497, 69%
Missing data	914, 25%
Trauma call type[a]	
Primary trauma call	2952, 82%
Secondary trauma call	670, 19%
Missing data	1, ~0%
Injury Severity Score	
Definitive, median (IQR)	10 (4–17.5)[b]

Abbreviation: IQR, interquartile range.
[a]Primary trauma call refers to a patient arriving directly from the incident site. Secondary trauma call patients have been assessed in a different hospital prior to transportation to the trauma center at Rigshospitalet.
[b]Median (Q1–Q3).

The Bland–Altman plot of all included cases (Figure 2) showed acceptable agreement between preliminary and definitive ISS, although it seemed there was an increasing difference in ISS with increasing mean ISS. The mean difference is calculated at +0.31, the upper limit at +15.8 (±1.96 SD), and the lower limit at −15.8. No indication of other bias or systematic mistakes was identified.

4 | Discussion

This study investigated the accuracy of preliminary versus definitive ISS assessments in trauma patients, revealing a moderate overall agreement. The lowest agreement was found in the subgroup of seriously (ISS 15–24) injured trauma patients. The Bland–Altman plot supported these results, and no indication of other systematic differences was apparent. A substantial number of cases were excluded from analysis due to missing data in either one or both ISS values. The mean values of missing data, however, did not suggest a bias towards high or low injury score registrations, as the mean of the single present value was similar to the overall mean.

Two studies investigate preliminary ISS using a similar method. A study by Mlaver et al. found a fair agreement between the two ISS with the least difference in the mild (ISS < 9) and critical (ISS > 25) severity subgroups in 112 trauma cases preliminarily scored by surgeons within 24 h from admission compared to definitive ISS [7]. A study by Bågenholm et al. validated data from 144 patients in a Norwegian trauma center and found a moderate overall agreement between the registered and the validated ISS in 43.1% of patients [6]. The registered ISS score was, however, coded by trauma registry coders and is not a preliminary ISS.

Several studies investigate interrater reliability by externally validating the registered ISS. Horton et al. and Neal et al. selected

TABLE 2 | Preliminary versus definitive Injury Severity Score for severity subgroups.

		Preliminary ISS			
		ISS <15	ISS 15–24	ISS >24	Total
Definitive ISS	ISS <15	2112	254	41	2407
	ISS 15–24	216	317	152	685
	ISS >24	64	157	310	531
	Total	2392	728	503	3623

Note: Comparison of preliminary and definitive Injury Severity Score (ISS) in all included trauma cases. ISS divided into three subgroups: ISS < 15, ISS 15–24, and ISS > 24. The outlined cells in diagonal row show matching preliminary and definitive ISS. Off-diagonal cells show misclassifications where preliminary ISS under- or overestimated the severity of injury.
Abbreviation: ISS, Injury Severity Score.

TABLE 3 | Analysis of preliminary versus definitive Injury Severity Score (ISS).

ISS score severity (definitive ISS group)	Mean points of difference	*p* for mean difference	Kappa values
ISS < 15	3.10	0.02	0.65 (0.62–0.67)
ISS 15–24	6.02	0.02	0.31 (0.27–0.35)
ISS > 24	10.76	0.02	0.52 (0.48–0.56)

Note: Comparison of mean between preliminary vs definitive ISS and the corresponding *p* values for three injury severity subgroups of ISS. The corresponding Kappa values with standard interval are listed in right column.

FIGURE 2 | Bland–Altman plot for preliminary vs. definitive Injury Severity Score (ISS). Bland–Altman Plot for preliminary versus definitive ISS showing all included cases. Mean difference is calculated at +0.31, upper limit at +15.8 (±1.96 SD) and lower limit at −15.8.

a blinded group to redo the ISS on several trauma cases [14, 15]. The setup in the current study is different—the preliminary ISS scoring is not performed by a certified AIS professional and the AIS coding manual is only used in the latter ISS scoring. Since the conditions for the two assessments are different, it is neither possible nor necessary for the preliminary and the definitive scores to be identical in all cases. The current study can therefore not be weighed against the standard inter-rater agreement studies.

The results of the current study showed that in the more severe injury subgroups, the average disagreement between the two ISS values grows from 3.1 mean points for the ISS < 15 group to 6.0 for ISS 15–24 to 10.8 for the ISS > 25 group. As the formula for calculating ISS involves taking the square values of the highest scores, higher discordance is mathematically forced for higher trauma score subgroups. When accounted for chance agreement using Cohen's Kappa, the interrater agreement is calculated to be 0.65 for the ISS < 15 group (good), 0.31 for ISS 15–24 (weak) and 0.52 for the ISS > 24 group (moderate). Thus, the results suggest that patients with serious injuries are the most difficult to correctly assess in the preliminary ISS. Clinicians performing the preliminary ISS should also be cautious when categorizing most injured patients as the injury severity group was underestimated in 41% of the patients with a definitive ISS of > 24. In the subgroup of elderly trauma patients in our study, the overall Kappa suggests a moderate agreement, which was lower than in the total group.

The "good" and "moderate" overall agreement in the two other ISS groups—the mild and severe injuries—assures the usefulness and overall acceptable accuracy of the preliminary ISS for clinical use. It suggests that the preliminary ISS can provide useful information about the overall severity of the current trauma case and the expected mortality of the patient. It may be routinely implemented in clinical settings, as the alternative would be the omission of any anatomical injury classification. Nonetheless, interpretation of the definitive ISS should be approached with appropriate caution due to its inherent limitations. Initially inaccurate ISS can lead to inadequate observation, further clinical investigations, and timely follow-up. Possible consequences of underestimating preliminary ISS include an insufficient level of patient monitoring and admission of critically injured trauma patients to a non-ICU ward. Contrary, an overestimation of ISS can lead to overtriage, illustrated by an ICU admission that was not necessarily required.

The preliminary ISS is calculated using the immediate clinical findings and results from the trauma CT scan. By the time the definitive ISS is calculated, additional clinical findings from surgical intervention and reassessment of the CT scan are available, which may change the AIS scores and contribute to a further difference between preliminary and definitive ISS.

Versions of the AIS scoring manual used can differ between respective trauma centers, introducing systematic errors in AIS coding which influence the comparability of results [16]. Furthermore, the coding of the AIS can be somewhat subjective, leading to variations in ISS scoring based on the observer's interpretation and therefore subject to inter-observer bias [17, 18]. To counteract that, continuous quality control and a uniform, formalized education must be ensured.

A strength of this study is the large database of trauma cases available for analysis compared to previous studies constructed similarly, providing data on thousands of patients over 5 years. A limitation of this study lies in the coders performing the definitive ISS calculation not being blinded to the preliminary ISS. The definitive ISS may therefore have been biased by the completed preliminary ISS. Moreover, the current study only uses data from a single trauma center and 28% of cases were excluded due to missing data.

Further studies in major trauma centers are recommended to investigate if the correlation in our data is representative of other Danish and Nordic trauma centers. The current study does not address possible suggestions for improvement of preliminary ISS accuracy. ISS is purely an anatomical trauma score, and including physiological data may benefit outcome prediction, as done in other combined trauma scores, such as Trauma Score and Injury Severity Score (TRISS) or A Severity Characterization of Trauma (ASCOT) [19, 20]. In order to improve the approach and

accuracy of preliminary trauma outcome prediction for the clinician, further research and testing in the field must be ensured to benefit overall trauma patient care.

5 | Conclusion

This study evaluated the accuracy of a preliminary versus a definitive ISS in trauma patients and identified a moderate overall agreement, which is acceptable for implementation in a clinical setting. The subgroups with serious and severe ISS showed the lowest levels of agreement and a tendency to underestimate injury severity, suggesting the need for cautious interpretation in critically injured patients. Preliminary ISS may be less appropriate for research applications, but it remains a valuable tool in clinical settings, where physicians need to classify trauma severity into mild, moderate, or severe categories.

Author Contributions

Sofia King: conceptualization, formal analysis, visualization, writing – original draft. **Jacob Steinmetz:** conceptualization, methodology, supervision, writing – review and editing. **Søren Steemann Rudolph:** software, writing – review and editing. **Oscar Rosenkrantz:** software, writing – review and editing. **Peter Muhareb Udby:** conceptualization, methodology, supervision, writing – review and editing.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that support the findings of this study are available to researchers from third party. Restrictions apply to the availability of these data, which were used under license for this study. The data that support the findings of this study are not publicly available due to legal restrictions on sharing identifiable data from Danish quality assurance projects.

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