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Diagnostic accuracy of TRISS, GAP score, and KTS in predicting survival of traumatic brain injury patients

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ABSTRACT

Background: *Traumatic brain injury (TBI) is one of the leading causes of morbidity and mortality worldwide, often resulting in long-term disability or death. The critical period for survival is within the first 6–12 hours after trauma, when secondary brain injury may occur due to hypoxia, hypotension, and systemic complications. To assist clinicians in predicting patient outcomes, several trauma scoring systems have been developed, including the Trauma and Injury Severity Score (TRISS), Glasgow Coma Scale–Age–Systolic Pressure (GAP) Score, and Kampala Trauma Score (KTS).*
Objectives: *This study aims to evaluate the accuracy of these three scoring systems in predicting survival outcomes in TBI patients.*
Methods: *This research employed a quantitative observational analytic design with a cohort approach involving 212 patients who presented to the Emergency Department (ED) with TBI. Patients were assessed using TRISS, GAP Score, and KTS, and survival status was observed for up to 6 hours. Data were collected by trained ED nurses using standardized procedures, including measurement of Glasgow Coma Scale (GCS), age, respiratory rate, neurological status, systolic blood pressure, and the number of severe injuries. Data analysis included diagnostic tests such as sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and overall accuracy.*
Results: *The results indicate that GAP Score had the highest sensitivity (99,5%), while GAP score demonstrated the highest specificity (85,7%). The highest PPV was found in TRISS and GAP score (97,1%), whereas KTS had the highest NPV (71,4%). GAP Score achieved the highest accuracy (96,7%), making it the most effective method for predicting TBI patient survival.*
Conclusions: *The GAP Score is recommended as the most accurate and practical tool for predicting survival in traumatic brain injury patients presenting to the emergency department, especially in clinical environments that require rapid decision-making.*

KEYWORD*: GAP score; KTS; survival; traumatic brain injury; TRISS*

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INTRODUCTION

Traumatic brain injury (TBI) is an alteration in brain function or other brain pathology caused by external forces, which may result in more complex disturbances such as neurological dysfunction, disability, and death (1,2). Globally, the average hospital admission for TBI cases is 28,750 patients, with mortality rates ranging from 6% to 30.4% (average mortality of 24.1%) (3,4). In Indonesia, the average monthly TBI cases amount to 127 patients, with a mortality rate of 35.93% and a survival rate of 64.07% (5,6).

Survival in TBI patients is the final outcome analyzed based on the duration of observation from the time of injury and the resulting events (death, relapse, or recovery)(7). TBI patients have lower survival chances compared to other injuries, particularly within the first 6-12 hours post-trauma. During this time, the brain enters an initial systemic phase characterized by drops in blood pressure, oxygenation, body temperature, blood glucose control, fluid status, and potential infections that lead to early death (68). Scoring systems such as RTS, TRISS, MGAP, GAP, and KTS are used to predict trauma severity (9,10). Currently, Indonesia does not have a nationally accepted scoring system specifically tailored for TBI, and the choice of prognostic tools often depends on physician preference and hospital protocol (6,11). Emergency nurses play a crucial role in monitoring TBI patients based on trauma scores, which aligns with the Symptom Management Theory. This theory emphasizes the importance of continuous monitoring and responding to symptoms holistically, including physical, emotional, and psychosocial aspects. Nurses not only rely on initial assessments but also monitor patient condition development to deliver timely and adaptive interventions, thus improving clinical outcomes and patient survival (12). In the context of TBI, nurses are not only responsible for initial assessments but also for tracking the patient's clinical progress. By doing so, they can deliver timely and adaptive interventions, ultimately improving survival outcomes.

Despite the existence of multiple trauma scoring systems, there is limited evidence comparing the diagnostic performance of TRISS, GAP Score, and KTS in predicting survival among TBI patients in Indonesian hospitals. This research seeks to fill that gap by evaluating and comparing the diagnostic accuracy of these three scoring systems, thereby identifying the most reliable and practical tool for predicting survival in TBI patients presenting to the emergency department.

MATERIALS AND METHODS

This study used a quantitative analytic observational design with a cohort approach, conducted at two private hospitals from September 24, 2024, to November 8, 2024. The study population

was determined based on the average number of traumatic brain injury (TBI) patient visits to the Emergency Department (ED), with a total sample of 212 respondents. The sample size was calculated using a cohort study formula by comparing three trauma scoring assessment proportions (2). The sampling technique used was quota sampling, with inclusion criteria of patients who sustained injuries due to traffic accidents and falls from a height, and who were observed for up to 6 hours, because it represents the early critical period during which secondary brain injury mechanisms such as cerebral edema, increased intracranial pressure, ischemia, and excitotoxicity evolve most rapidly (13,14).

Data collection was carried out by preparing a research proposal, obtaining ethical clearance, securing research permits, and selecting eight enumerators (ED nurses with five years of ED experience and holding a bachelor's degree in nursing). Training was provided to enumerators through online and offline methods. Informed consent was obtained. The researchers/enumerators measured GCS, age, respiratory rate, neurological status, systolic blood pressure, and the number of severe injuries experienced, and assessed patient survival status within the first 6 hours post-admission was defined as the patient being alive without progression to cardiac arrest or brain death in the ED. Data processing was performed by the researchers. Data were processed using frequency tables and diagnostic test procedures, with TRISS interpretation Poor: Ps < 50%, Moderate: Ps 50-75%, Good: Ps > 75%. GAP score interpretation Severe: GAP $\leq$ 18, Moderate: GAP 19-23, Mild: GAP 24-27. KTS interpretation Severe: KTS $\leq$ 8, Moderate: KTS 9-13, Mild: KTS $\geq$ 14 and including determining the ROC (Receiver Operating Characteristic), AUC (Area Under Curve), cut-off points, TP (true positive), TN (true negative), FP (false positive), and FN (false negative) to calculate sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy.

This study has met the ethical feasibility standards from the Health Research Ethics Committee, Faculty of Health Sciences, Universitas Brawijaya, under ethical clearance number 12643/UN10.F17.10.4/TU/2024.

RESULTS AND DISCUSSION

The respondents in this study totaled 212 traumatic brain injury (TBI) patients in the Emergency Department (ED). The characteristics of the respondents include age, gender, injury mechanism, and TBI classification. Categorical data were analyzed by calculating frequency distribution. The characteristics of the respondents are shown in **Table 1**.

Table 1 shows that most respondents were male (137 respondents or 64.6%), and the most common age group was young

adults aged 19–35 years (67 respondents or 31.6%).

Table 1. Characteristic responden

Characteristics	f	%
Gender		
Male	137	64.6
Female	75	35.4
Age		
0-11 years	14	6.6
12-18 years	27	12.7
19-35 years	67	31.6
36-45 years	20	9.4
46-60 years	47	22.2
>60 years	37	17.5
Mechanism of injury		
Traffic accident	169	79.7
Fall from height	43	20.3
Head injury classification		
Minor	155	73.1
Moderate	25	11.8
Severe	32	15.1

The majority of injury mechanisms were due to traffic accidents (169 respondents or 79.7%). Most TBI respondents were classified as having minor injuries (155 respondents or 73.1%). Respondents were assessed using trauma scores (TRISS, GAP Score, and KTS) and survival rates, as presented in **Table 2.**

Table 2 shows that based on the GAP Score, almost all respondents had favorable scores (200 respondents or 94.3%). Based on the KTS, most respondents had mild injury severity (148 respondents or 69.8%). Based on the TRISS score, almost all respondents had mild severity (192 respondents or 90.6%).

Table 2. Characteristics of traumatic head injury respondents based on TRISS trauma score, GAP score, KTS, and survival

Characteristics	f	%
TRISS		
Poor	6	2.8
Moderate	14	6.6
Good	192	90.6
GAP Score		
Severe	3	1.4
Moderate	9	4.2
Mild	200	94.3
KTS		
Severe	37	17.5
Moderate	27	12.7
Mild	148	69.8
Survival		
Survival	205	96.7
Non survival	7	3.3

Table 3. Sensitivity, specificity, positive predictive value, negative predictive value, and accuracy

Parameter	Formula	TRISS	GAP score	KTS
Sensitivity	TP/(TP+FN)	0.975	0.995	0.989
Specificity	TN/(FP+TN)	0.25	0.857	0.385
Positive Predictive Value (PPV)	TP/(TP+FP)	0.971	0.971	0.961
Negative Predictive Value (NPV)	TN/(FN+TN)	0.25	0.857	0.714
Accuracy	(TP + TN) / (TP + TN + FP + FN)	0.948	0.967	0.953

Regarding survival outcomes, almost all patients survived (205 respondents or 96.7%). The results of the sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy tests are shown in **Table 3.**

Table 3 show **TRISS**: sensitivity = 0.975, specificity = 0.250, PPV = 0.971, NPV = 0.250, accuracy = 94.8%. This means TRISS has a 97.5% ability to correctly identify patients who survived and a 25% ability to correctly identify those who did not survive. **GAP Score**: sensitivity = 0.995, specificity = 0.857, PPV = 0.971, NPV = 0.50, accuracy = 96.7%. This indicates GAP Score has the highest sensitivity and accuracy among the three scoring systems. **KTS**: sensitivity = 0.989, specificity = 0.385, PPV = 0.961, NPV = 0.714, accuracy = 95.3%. KTS has the highest NPV, meaning it performs best at identifying patients who will not survive.

Table 4. Analysis of survival

Variabel	*Valid (N)(listwise)*	AUC	*Std. Error*	*p-value*	IK 95 %		*COT*
					LB	UB	
TRISS	*Positive* [a]205 *Negative* 7	0.922	0.034	0	0.855	0.99	85.7
GAP Score	*Positive* [a] 205 *Negative* 7	0.96	0.017	0	0.926	0.993	87.2
KTS	*Positive* [a] 205 *Negative* 7	0.979	0.012	0	0.955	1	84.2

Table 4 presents the analysis of survival prediction using ROC curves: The prevalence of survival in TBI patients was 96.7% (205 out of 212 patients). **TRISS**: AUC = 92.2% (95% CI: 85.5–99), cut-off = 85.7. **GAP Score**: AUC = 96% (95% CI: 92.6-99.3), cut-off = 87.2. **KTS**: AUC = 97.9% (95% CI: 95.5-100), cut-off = 84.2.

DISCUSSION

Characteristic TBI pastients

Table 1 shows majority of respondents were male (64.6%), while females accounted for only 35.4%. This finding is consistent with previous studies reporting that men are at higher risk of sustaining TBI compared to women, mainly due to greater exposure to risk factors such as road traffic accidents and high-risk occupations (3,6,38). Basak et al. (2023) also reported that 66.5% of TBI patients were male, supporting the notion that gender is a significant factor in the epidemiology of TBI (6).

According to **Table 1**, the largest proportion of patients was in the 19–35 years age group (31.6%), followed by the 46-60 years group (22.2%) and those over 60 years (17.5%). Young adults are particularly vulnerable due to high mobility, driving activity, and risk-taking behavior (38,47). Kim et al. (2021) found that the

average age of TBI patients was 46.3 years, with the peak incidence in the productive age group (47). Furthermore, elderly patients (>60 years) represented a substantial proportion in this study, consistent with findings by Demlie et al. (2023), who emphasized that older age is a major risk factor for mortality in TBI because of physiological decline and comorbidities (38).

Most TBIs in **Table 1** resulted from traffic accidents (79.7%), while falls from height accounted for 20.3%. This aligns with WHO reports identifying traffic accidents as the leading cause of head injury, particularly in low- and middle-income countries (3,4,41). In Indonesia, local studies also confirm this trend. Fatimah et al. (2022) both found that more than 70% of TBI cases were due to road traffic accidents (8,10).

In terms of severity, most patients presented with minor head injury (73.1%), while moderate cases accounted for 11.8% and severe cases 15.1% at **Table 1**. This distribution is consistent with the findings of Wikantama et al. (2020), who reported that the majority of TBI patients at Dr. Sardjito Hospital were classified as minor head injuries (40). The predominance of minor TBI may be attributed to patients with mild neurological disturbances or decreased consciousness who still seek medical evaluation at the ED. Nevertheless, the proportion of moderate to severe cases (about 27%) remains significant and requires intensive management, as these cases are strongly associated with higher risks of mortality and complications (15,38,42).

The respondent profile in this study reflects the global epidemiological pattern of TBI: it occurs predominantly in men of productive age, is most commonly caused by road traffic accidents, and is largely classified as minor head injury. However, the considerable proportion of moderate and severe cases highlights the importance of accurate trauma scoring systems such as TRISS, GAP Score, and KTS to guide prognosis and inform timely interventions in the ED setting.

Characteristics of TBI patients based on TRISS, GAP Score, KTS, and survival

Table 2 shows that 90.6% of respondents had good TRISS scores, while only 2.8% had poor outcomes. This suggests that the majority of patients were categorized as low risk according to TRISS. TRISS integrates the Revised Trauma Score (RTS), Injury Severity Score (ISS), and age, which allows for a multifactorial assessment (15,16). Previous studies have highlighted TRISS as a reliable predictor of trauma outcomes, although its specificity in isolated head injury may be lower. Tianda et al. (2024) reported that TRISS demonstrated high sensitivity (91.8–96.3%) at different observation times (6, 24, and 48 hours) (24). Similarly, Yousefi et al. (2024) found TRISS to be superior in predicting

mortality compared to RTS in trauma patients (23). However, the relatively high percentage of good TRISS scores in this study may also reflect the dominance of mild head injury cases (73.1% in **Table 1**).

Almost all respondents (94.3%) were categorized as “good” according to the GAP Score (Table 2). This finding underscores the practicality and accuracy of GAP Score in TBI cases. The GAP Score, which combines only three parameters (GCS, age, and systolic blood pressure), has been proven effective in rapid ED assessments (29,30). Mohammed et al. (2022) showed that GAP Score maintained good predictive power even in resource-limited settings (31). Farzan et al. (2022) also confirmed that GAP outperformed RTS and ISS in predicting mortality in trauma patients (32). The dominance of good GAP scores in this study is consistent with the high proportion of survivors (96.7% in **Table 2**), reflecting the score's strong prognostic value.

According to **Table 2**, the majority of patients (69.8%) were classified as having mild severity based on KTS, while 17.5% were categorized as severe. KTS has been widely used in low-resource settings due to its reliance on simple parameters such as age, systolic BP, respiratory rate, and neurological status (33,34). Studies by Hakimzadeh et al. (2024) and Usman et al. (2023) demonstrated that KTS had good predictive value for trauma outcomes, although sometimes with lower specificity compared to GAP or TRISS (33,35). The high proportion of mild KTS cases in this study again reflects the predominance of minor head injuries (73.1% in **Table 1**), but the 17.5% severe category underscores the importance of monitoring high-risk patients closely.

Table 2 shows that 96.7% of patients survived, while only 3.3% did not survive within the first 6 hours of observation. This high survival rate may be explained by the predominance of mild TBI cases in this study population. Similar results were found by Basak et al. (2023), where GCS-based trauma scores, including GAP, showed high accuracy in predicting survival among TBI patients (6). Moreover, Tianda et al. (2024) emphasized that trauma scoring systems, when applied early, can significantly improve the identification of high-risk patients and optimize emergency interventions (24).

Sensitivity of TRISS, GAP Score, and KTS

Table 3 shows that the sensitivity values TRISS = 97.5%, GAP Score = 99.5%, and KTS = 98.9%. This generally indicates that all three trauma scoring systems have high sensitivity in assessing the survival of traumatic brain injury (TBI) patients. shows TRISS sensitivity was reported to be 99.8% (14). Other studies reported TRISS sensitivity as 77.52% (17), and in another study, TRISS sensitivity was 91.8% at 6 hours, 92.2% at 24 hours, and 96.3% at 48 hours (18). The Trauma and

Injury Severity Score (TRISS) combine three assessment components: Revised Trauma Score (RTS), Injury Severity Score (ISS), and the Brier coefficient. It includes evaluations of GCS, systolic blood pressure, respiratory rate, abbreviated injury scores in six body regions, and adjusts based on age and injury type. TRISS is influenced by physiological factors (GCS, systolic BP), anatomical factors (ISS, injury location), demographic factors (age, sex), clinical management, and methodology (19,20).

Table 3 according GAP Score sensitivity of 99.5% indicates it is a simple, accurate trauma scoring system using GCS, age, and systolic BP (21,22). It provides a quick overview of injury severity and survival potential (23). In Basak's study (2023), GAP Score showed higher sensitivity than GCS at 93.5%. Another study found GAP Score sensitivity was 100% (24), while another showed 72% sensitivity (22). Shows KTS sensitivity was 98.9%, indicating practicality in low-resource settings with basic data like age, consciousness level, and vital signs. Hakimzadeh et al. (2024) reported KTS sensitivity of 92.3% (25); Damurila et al. (2024) reported 70,4% (26); and Usman et al. (2022) reported 81.82% (27). Basak et al. (2023) showed KTS sensitivity in TBI patients was 81% (3).

The high sensitivity values from ROC analysis in **Table 4** (AUC values of 0.922 for TRISS, 0.960 for GAP, and 0.979 for KTS) further confirm that all three tools had strong discriminative power. KTS even showed the largest AUC (97.9%), though GAP remained more consistent when both sensitivity and specificity were considered (33,34). The GAP Score integrates GCS, age, and systolic blood pressure, offering a comprehensive picture of neurological and hemodynamic status, critical in TBI cases (28,29). GCS is key to consciousness assessment, while age is a significant risk factorolder patients tend to have worse outcomes. Most TBI cases in this study occurred in the 19–35 age group (32.1%), aligning with other studies (16,30,31). Systolic BP reflects hemodynamic status lower BP suggests shock or hemorrhage, worsening outcomes. Previous research shows TBI patients' systolic BP ranges from 104–130 mmHg (32,33), with a median of 122 mmHg (34). GAP Score's simplicity and speed make it ideal for emergency settings.

Spesificity of TRISS, GAP Score, and KTS

The specificity results in **Table 3** were value of TRISS was 25%, the specificity of the GAP score was 85.7%, and the specificity of KTS was 38.5%. meaning that only 25% of patients who did not die could be correctly identified by TRISS as not at risk. Previous studies showed that the specificity of TRISS was 69%-96.5% (16,33,35). Research conducted by Tianda et al (2024) showed that the specificity value of TRISS within 6 hours was 91.5%, within 24 hours was 92.2%, and within 48

hours was 96.3% (18). Other studies have produced TRISS specificity values of 92.8% (17) and 63.6% (14). TRISS, with a specificity of 25%, has the power to detect high-risk patients but tends to give false-positive results for patients who should have a good prognosis. This is due to: The complexity of the TRISS model, which combines RTS, ISS, and age, making it more sensitive to multisystem injuries but less specific to single injuries such as TBI, Research shows that TRISS is more effective in assessing severe trauma cases involving more than one organ than a single brain injury.

Table 3 shows specificity value of the GAP score is 85.7%. in line with research conducted by Merchant et al (2023) the specificity value of the GAP score in cases of neuro trauma patients was 80.0% (16). Research by Farzan et al (2022) found that the specificity of the GAP score was 80.56% (24). Other studies found that the specificity of the GAP score in geriatric traumatic brain injury patients was 80.7% (36). The GAP score means that 85.7% of patients who did not die could be correctly identified by the GAP score as not at risk. The GAP score shows that it is able to predict patients who are not at high risk of mortality. The advantages of the GAP score include: The simplicity of the three-parameter-based model (GCS, age, and systolic blood pressure), which makes it ideal for rapid evaluation in the ED, Studies have shown that the GAP score is very effective in cases of mild to moderate TBI, reducing the risk of misclassification, indicating that the GAP score is quite effective in reducing the number of patients misclassified as high risk, thus providing more accurate results in assessing the risk of death. The specificity value of the KTS is 38.5%. The KTS showed quite low specificity in table 3, which means that this tool produces false positive results. This provides sufficient confidence in assessing the risk of death and helps in better clinical decision making. Based on previous studies, the KTS has a specificity of 92.3% and 73.7% of the 95% CI between 56.9-86.6% (25).

Positive Predictive Value of TRISS, GAP Score, and KTS

According to **Table 3**, the positive predictive value of TRISS was 97.1%, the positive predictive value of GAP score was 97.1%, and the positive predictive value of KTS was 961%. It can be interpreted in general that these three trauma scores have good positive predictive value in assessing the survival of traumatic brain injury patients. The positive predictive value of TRISS reached 97.1%, indicating its very high ability to identify patients who will survive. In line with research conducted by Tianda et al (2024), the positive predictive value of TRISS in trauma patients in the ER was 94.9%, at 24 hours it was 95.7% and at 48 hours it was 97.2% (18). Another study explained that the PPV results on TRISS

were 92.83% (17). Previous research found that the PPV value of TRISS in head trauma patients was 97.1% (14). The TRISS score is calculated based on clinical parameters such as age, gender, and mechanism of injury. Studies have shown that these factors significantly affect the accuracy of prediction. Older patients tend to have worse outcomes, thus increasing the positive predictive value (37,38).

Based on **Table 1**, patients aged >60 years were 17%, male gender was 65.8%, and traumatic brain injury was caused by traffic accidents was 79.7%. Based on research by Kim et al (2021), it can be explained that the average age of traumatic brain injury patients is 64.1 years, traumatic brain injury patients caused by traffic accidents are 96.2% (Kim et al., 2021). Another study found that traumatic brain injury patients have an average age of 46.3 years, most of them are male gender is 66.5% and traumatic brain injury due to traffic accidents is 80.8% '(40). Tabel 3 shows GAP Score has a positive predictive value of 97.1%, the GAP score in predicting the survival of TBI patients is easy to apply in an emergency environment because it only requires three parameters (GCS, age, and systolic blood pressure) (41). In line with the research conducted by Joksic et al (2023) the PPV value of the GAP score was 87.5% Jokšić-Mazinjanin et al., 2023). Another study showed that the PPV results of the GAP score for head injury patients were 92% (23). The GAP score is very suitable for use in the ER with a high patient volume because it provides fast results without losing accuracy. With a positive predictive value of 99%, the GAP Score shows excellent ability to predict patients who really need intensive medical attention or are at risk of poor outcomes (11).

In **Table 3** KTS has a specificity and PPV of 96.1%, indicating that there are still 3.9% of patients who are predicted to survive but experience mortality. In line with research conducted by Damulira et al (2024), the PPV value of the KTS score is 78,4% (26). The PPV value of the KTS score is 100% in traumatic brain injury patients with a score of >10 (27). Another study found that the PPV value in patients less than 24 hours was 99% and the PPV value of brain injury patients after 30 days was 89% (3).The highest value in positive predictive value in traumatic brain injury patients is the GAP score and TRISS with a value of 97.1%. The GAP score was designed for resource-limited settings, making it ideal for rural areas or developing countries. Although it has a high PPV, the sensitivity of the KTS is often lower than that of the GAP, so it should be used with caution in cases of severe trauma.

Negative Predictive Value of TRISS, GAP Score, and KTS

The NPV in **Table 3** was TRISS is 25%. A negative predictive value of 25% indicates that only 25% of patients who are declared not to have serious injuries based

on a low TRISS score, actually do not have serious injuries. This means that there is a 75% chance that patients who are declared not to have serious injuries may actually have undetected injuries. In contrast to the study conducted by Jojczuk et al (2022) the negative predictive value of TRISS was 88.9%. Another study showed a negative predictive value of TRISS of 28% (17)and at 6 hours the NPV TRISS results were 83.7%, at 24 hours 84.3% and at 48 hours 96.6% (18).

Table 3 shows negative predictive value of GAP score 85,7%, The negative predictive value (NPV) was 85.7%, indicating that 85.7% of patients predicted not to survive did survive. This value is more consistent with the observed overall survival rate of 96.7%, in which only 3.3% of patients did not survive. This means that there is a 85,7% chance that a patient who is declared not to have a serious injury may actually have an undetected injury. In line with research conducted by mohammed (2022) the negative predictive value of the GAP score in head injury patients is 45% (23). In contrast to research by Joksic et al (2023) that the negative predictive value of the GAP score in brain injury patients is 89.8% (42).

The negative predictive value of the KTS in **Table 3** was 71.4%. In line with the study conducted by Shafiei et al (2024) The results showed that the negative predictive value (NPV) of the eTBI score was 71.4%, indicating that 71.4% of patients who were declared not seriously injured based on the score actually did not experience serious injury (43). Other studies have shown that patients with a GCS score of 3 or 4 have poor outcomes, with a low NPV in predicting survival (44). The trauma score with the highest negative predictive value was the KTS at 71.4%. The KTS had the highest NPV (71.4%), indicating that this tool is more effective in identifying patients who did not experience serious injury. This means that the KTS can provide greater confidence that patients with low scores actually do not have serious injuries. Low NPV can lead to doubt in clinical decision making, which can result in inappropriate treatment.

Accuracy of TRISS, GAP Score, and KTS

Table 3 shows overall accuracy values of TRISS was 94.8%. In line with research conducted by Tianda et al (2024) TRISS has good accuracy in predicting mortality in patients with trauma within 6 hours of 91.6%, within 24 hours of 92.2% and within 48 hours of 97% (18). Other studies show that the accuracy of TRISS in head injury patients in the ER is 93.4% (17). Research by Jojczuk et al (2022) shows the accuracy of TRISS in predicting mortality of 96.9% (14). GAP score accuracy 96.7%. GAP score is a scoring system used to predict mortality in trauma patients, especially those with traumatic brain injury (TBI). The GAP score combines three main parameters: Glasgow Coma

Scale (GCS), age, and systolic blood pressure (SBP). With an accuracy of 96.7%, the GAP score shows a high ability to predict clinical outcomes of trauma patients. In line with the research of Mohammed et al (2022) the accuracy value of the GAP score in head injury patients was 95% (23). The research of Fatima et al (2022) the accuracy value of the GAP score in head injury patients was 94.2% (6).

The accuracy of the Kampala Trauma Score (KTS) in **Table 3** is 95.3%. The Kampala Trauma Score (KTS) is a scoring system used to predict mortality in trauma patients, including traumatic brain injury (TBI). With an accuracy of 95.3%, the KTS shows good ability to predict clinical outcomes in trauma patients. The KTS combines several parameters, including GCS, age, and mechanism of injury. The quality and accuracy of measuring these parameters greatly affect the final outcome of the KTS (45). The type and mechanism of injury (eg, road traffic accident vs. fall) can affect the outcome.

More severe injuries are usually associated with worse outcomes (46). In line with the study by Haac et al (2020), the KTS showed good ability to predict mortality in resource-limited settings, with an accuracy approaching 84% (47). Another study showed that the KTS had an accuracy of 84% in predicting mortality in the emergency department in Ghana, focusing on brain injury (44). The KTS showed good accuracy in predicting mortality, with ROC values showing comparable performance to other scoring systems (48). Another study showed that the KTS had an area under curve (AUC) for predicting mortality in the ED of 0.857, indicating good accuracy in predicting patient outcomes (26).

KTS and GAP Score showed higher accuracy compared to TRISS, making them a better choice in situations where complete and accurate data are available. Both can provide better information about the prognosis of patients with brain injury by providing continuous monitoring. Traumatic brain injury patients are monitored using trauma scores, allowing nurses to consistently assess the patient's condition and adjust the care plan based on changes in clinical condition. Symptom Management Theory emphasizes the importance of continuous and responsive monitoring of emerging symptoms, as well as holistic symptom management that includes physical, emotional, and psychosocial aspects. Thus, nurses do not only rely on the initial assessment but also monitor the development of the patient's condition to provide adaptive and timely interventions, which contribute to improving clinical outcomes and patient survival (49,50).

GCS is the primary indicator of a patient's level of consciousness. A lower GCS score indicates a poorer level of consciousness, which is directly related to an increased risk of death (15,51). A lower systolic blood pressure indicates worse

hemodynamics, which may increase the risk of death.

Decreased SBP is often associated with more severe injuries (24,44). Age is a significant risk factor in trauma. Older patients tend to have worse outcomes due to physiological decline and possible comorbidities (3,33). The GAP score has been validated in a variety of populations and clinical settings, including in resource-limited countries, demonstrating its reliability across contexts (23,44). GAP score can be adjusted to changing injury patterns by becoming a determinant of post-injury health conditions 6,28).

The use of trauma scores in traumatic brain injury patients can assist medical personnel in making treatment decisions, and resource planning in improving trauma management. Nurses act as supporters of patients and families in dealing with the physical and psychosocial impacts of head trauma.

Counseling and education to patients and families about the patient's condition, treatment procedures, and warning signs to watch for can help improve understanding and independence in managing symptoms. Nurses can also facilitate collaboration between members of the multidisciplinary care team in planning coordinated and comprehensive care. By considering these aspects, nurses can provide holistic support to head trauma patients, maximize the recovery process, and improve the quality of life of patients and families (52,53).

CONCLUSION AND RECOMMENDATION

The conclusion of this study is that the GAP score is the best tool in predicting traumatic brain injury patients with the potential to survive, the most effective tool in predicting traumatic brain injury patients with a low risk of death, and has the ability of trauma scores to predict correctly, both in determining survival and non-survival of patients. KTS assesses that there are patients who do not experience serious injuries may actually have injuries that are not detected in the assessment of traumatic brain injury patient survival, and TRISS and GAP scores can assess patients who are categorized as high-risk patients almost always need intensive care. We specifically recommend that the GAP Score be integrated into the Standard Operating Procedures (SOPs) of ED nurses in Indonesia for Traumatic Brain Injury (TBI) patients, to serve as a rapid triage and monitoring tool.

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