Mortality After Traumatic Brain Injury in Elderly Patients: A New Scoring System

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■ BACKGROUND: Traumatic brain injury (TBI) remains a life-threatening condition characterized by growing incidence worldwide, particularly in the aging population, in which the primary goal of treatment appears to be avoidance of chronic institutionalization.

■ METHODS: To identify independent predictors of 30-day mortality or vegetative state in a geriatric population and calculate an intuitive scoring system, we screened 480 patients after TBI treated at a single department of neurosurgery over a 2-year period. We analyzed data of 214 consecutive patients aged ≥65 years, including demographics, medical history, cause and time of injury, neurologic state, radiologic reports, and laboratory results. A predictive model was developed using logistic regression modeling with a backward stepwise feature selection.

■ RESULTS: The median Glasgow Coma Scale (GCS) score on admission was 14 (interquartile range, 12–15), whereas the 30-day mortality or vegetative state rate amounted to 23.4%. Starting with 20 predefined features, the final prediction model highlighted the importance of GCS motor score (odds ratio [OR], 0.17; 95% confidence interval [CI], 0.09–0.32); presence of comorbid cardiac, pulmonary, or renal dysfunction or malignancy (OR, 2.86; 9 5% CI, 1.08–7.61); platelets ≤100 × 10^9 cells/L (OR, 13.60; 95% CI, 3.33–55.49); and red blood cell distribution width coefficient of variation ≥14.5% (OR, 2.91; 95% CI, 1.09–7.78). The discovered coefficients were used for nomogram development. It was further simplified to facilitate clinical use. The proposed scoring system, Elderly Traumatic Brain Injury Score (eTBI Score), yielded similar performance metrics.

■ CONCLUSIONS: The eTBI Score is the first scoring system designed specifically for older adults. It could constitute a framework for clinical decision-making and serve as an outcome predictor. Its capability to stratify risk provides reliable criteria for assessing efficacy of TBI management.

INTRODUCTION

Traumatic brain injury (TBI) remains a common and life-threatening condition characterized by growing incidence worldwide, particularly in the aging population.[1-5] Given the paucity of clear definitions and methodologic flaws in clinical evaluations, meta-analyses and epidemiologic studies in this field are often confounded.[6-8] Without any doubt, good recovery in elderly patients is rarely achieved,[9-12] hence the primary goal of treatment in this group appears to be avoidance of chronic institutionalization.[13]

The most common cause of TBI in older adults is falls, unlike in the younger population where traffic accidents are most common.[1,8,14] It implies different significance of primary and secondary injuries in these groups, and indicates that aging,

comorbidities, medications, and deficiency of rehabilitation services substantially contribute to poor prognosis.

The definition of elderly patient or geriatric population is relatively broad across the literature. Various authors set the threshold ranging from 50[1,13,15] to 70 years.[16] In numerous countries, the age of 65 years serves as normal retirement age and it also occurs to be the most commonly used in TBI studies.[2,5,9-11,17-21]

Based on the Monro-Kellie doctrine, decompressive craniectomy remains a considerable therapeutic opportunity for patients with increased intracranial pressure after TBI[22-24]; however, in older adults, it has been associated with an exceedingly high mortality rate.[18,25] In 2015, Yuan et al.[26] analyzed 14 studies concerning intracranial pressure monitoring and concluded that in terms of mortality, there is no evidence of its superiority in patients with TBI. Especially in older adults, this technique was deemed to be inutile,[27] therefore leaving sufficient room for experience-based decision-making.

There are numerous predictive factors of outcome after TBI discussed in the literature.[16,28-34] Despite that, there remains no widely used clinical grading scale for older adults after TBI.[32] Some authors endeavored to indicate patients in whom the mortality rate approached 100%[16,33] or advised surgery only in a preselected group,[3,16,35] therefore attempting to answer the question, who could actually benefit from neurosurgical treatment?

The aims of this study were to identify independent predictors of mortality in elderly patients after TBI and to calculate an intuitive scoring system for clinical use.

MATERIALS AND METHODS

We performed a retrospective case-control study of medical records of patients after TBI treated at the department of neurosurgery of Barlicki University Hospital. The study was carried out in compliance with the Helsinki Declaration, and ethics approval was acquired from the ethical committee at the Medical University of Lodz. A list of patients was generated by searching the hospital electronic health records database for discharge diagnosis code S06 (intracranial injury) according to the *International Statistical Classification of Diseases and Related Health Problems, 10th Revision*. Patients ≥65 years of age were included in the study (Figure 1), and there were no other exclusion criteria.

Data used for development of a scoring system were available at the time of evaluation at the accident & emergency department, including patient demographics, medical history, cause and time

Figure 1. Eligibility criteria: we identified 4307 patients treated at the department of neurosurgery over a 2-year period (between October 2016 and October 2018). We screened 480 patients with *International Statistical Classification of Diseases and Related Health Problems, 10th Revision* discharge diagnosis code S06 (intracranial injury), and included into the analysis data of 214 patients ≥65 years of age. DN, department of neurosurgery; LOS, length of stay at DN; PTS, patients; TBI, traumatic brain injury.

Table 1. Group Characteristics (N = 214)	
Characteristic	**Value**
Age	79 (69—85)
Male	137 (64)
LOS (days)	6 (3—10)
LOS ≥8 days	91 (42.5)
Conservative treatment	101 (47.2)
Surgical treatment	113 (52.8)
Burr-hole craniostomy	61 (28.5)
Decompressive craniectomy with or without clot evacuation	38 (17.8)
Craniotomy and clot evacuation	13 (6.1)
External ventricular drainage	1 (0.5)
Conservative treatment failure	26 (20.5)
Reoperations (% of surgical patients)	18 (15.9)
Mechanism of injury	
Fall	192 (89.7)
Traffic	18 (8.4)
Assault	4 (1.9)
Time of injury	
<24 hours	132 (61.7)
1 day—1 week	18 (8.4)
>1 week	64 (29.9)
GCS score	14 (12—15)
GCS score ≤8	27 (12.6)
Unresponsive pupil (1 or none reactive)	17 (7.9)
Hemiparesis	57 (26.6)
Laboratory results	
HGB (g/dL)	12.7 (10.8—14)
HCT (%)	37.2 (32.3—41.2)
MCV (fL)	89.7 (86.6—93.1)
MCH (pg)	30.4 (29.2—31.6)
RDW-CV (% CV)	13.4 (12.8—14.3)
RDW-SD (fL)	43.9 (41.4—47.4)
PLTs (g/L)	200 (156—251.5)
PCT (%)	0.2 (0.2—0.3)
MPV (fL)	10.3 (9.7—11.2)
PDW (fL)	11.7 (10.6—13.4)
WBC count (g/L)	9.2 (7.1—11.9)
PI (%)	90 (82.3—95)
INR	1.1 (1—1.2)
	Continues

Table 1. Continued	
Characteristic	**Value**
PT (seconds)	15.6 (14.7—17.1)
APTT (seconds)	30.7 (27.9—34.6)
TT	15.4 (14.5—16.3)
GLU (mg/dL)	131.5 (112—154)
Prognosis	
eTBI Score	5 (4—6)
14-day mortality according to CRASH Model (median %) (assessed only for patients with admission GCS score ≤14)	18.8 (11.8—37.8)
Outcome	
Extended Glasgow Outcome Scale score	5 (3—7)
14-day mortality	24 (11.2)
30-day mortality	41 (19.2)
30-day vegetative state	9 (4.2)
Discharged home	128 (59.8)

Values are number of patients (%) or median (interquartile range).
LOS, length of stay at the department of neurosurgery; GCS, Glasgow Coma Scale; HGB, hemoglobin; HCT, hematocrit; MCV, mean corpuscular volume; MCH, mean cell hemoglobin; RDW-CV, red blood cell distribution width coefficient of variation; CV, coefficient of variation; RDW-SD, red blood cell distribution width SD; PLT, platelet; PCT, plateletcrit; MPV, mean platelet volume; PDW, platelet distribution width; WBC, white blood cell; PI, prothrombin index; PT, prothrombin time; INR, international normalized ratio; APTT, activated partial thromboplastin time; TT, thrombin time; GLU, glucose; eTBI Score, Elderly Traumatic Brain Injury Score; CRASH, Corticosteroid Randomization After Significant Head injury.

of injury, neurologic state, radiologic reports, and laboratory results. We used the Glasgow Coma Scale (GCS) motor score instead of the total GCS score because it was previously suggested,[36] therefore avoiding the problem of miscoding in patients who were hearing impaired or intubated. Some data related to in-hospital treatment were also noted, including whether the patient was treated conservatively or surgically and whether the patient required immediate neurosurgical intervention or was operated on because of conservative treatment failure. The primary outcome measure was mortality or vegetative state (Extended Glasgow Outcome Scale [EGOS] score 1—2) at 30 days after hospital admission because no patient in vegetative state at that moment survived the in-hospital stay. Patients with favorable outcome at hospital discharge were assumed stable at 30 days after hospital admission.

Statistical analyses were performed using Statistica software (Version 13 [StatSoft, Inc., Tulsa, Oklahoma, USA]) and R programming language (R Core Team, R Foundation, Vienna, Austria). Quantitative data were tested for skewness and reported as mean with SD or median with interquartile range. Categorical data were presented as counts and frequencies. We compared continuous variables between 2 groups with the Mann-Whitney U test. The frequencies of categorical variables were compared using Pearson χ^2 test, χ^2 test with Yates correction, or 2-tailed Fisher

Table 2. Univariate Analysis of Data of 214 Patients ≥65 Years of Age after Traumatic Brain Injury

Characteristic	EGOS Score 1—2 (n = 50)	EGOS Score ≥3 (n = 164)	P Value	P Value	Not Discharged Home (n = 86)	Discharged Home (n = 128)
Age	81 (70.8—85.3)	78 (69—85)	0.232	0.003	82 (72—86)	74 (68.3—84)
Male	26 (52)	111 (67.7)	0.043	0.079	49 (57)	88 (68.8)
LOS (days)	6 (2—14.3)	6 (3—9.8)	0.994	0.005	8 (4—15)	5 (3—8.8)
LOS ≥8 days	22 (44)	69 (42.1)	0.809	0.008	46 (53.5)	45 (35.2)
Conservative treatment	7 (14)	94 (57.3)	<0.001	<0.001	25 (29.1)	76 (59.4)
Surgical treatment	43 (86)	70 (42.7)	<0.001	<0.001	61 (70.9)	52 (40.6)
Burr-hole craniostomy	11 (22)	51 (31.1)	0.214	0.556	23 (26.7)	39 (30.5)
Decompressive craniectomy	25 (50)	13 (7.9)	<0.001	<0.001	30 (34.9)	8 (6.3)
Craniotomy and clot evacuation	6 (12)	7 (4.3)	0.096	0.456	7 (8.1)	6 (4.7)
External ventricular drainage	1 (2)	0 (0)	0.234	0.402	1 (1.2)	0 (0)
Conservative treatment failure	10 (58.8)	16 (14.6)	<0.001	0.001	15 (37.5)	11 (12.6)
Reoperations (% of surgical patients)	6 (14)	12 (17.1)	0.793	>0.999	10 (16.4)	8 (15.4)
GCS score	8.5 (4—12)	15 (13—15)	<0.001	<0.001	12 (6—14)	15 (13—15)
GCS-M score	5 (2—5)	6 (6—6)	<0.001	<0.001	5 (4—6)	6 (6—6)
GCS score ≤8	25 (50)	2 (1.2)	<0.001	<0.001	26 (30.2)	1 (0.8)
Unresponsive pupil (1 or none reactive)	11 (22)	6 (3.7)	<0.001	<0.001	14 (16.3)	3 (2.3)
Hemiparesis	17 (34)	40 (24.4)	0.178	0.197	27 (31.4)	30 (23.4)
Any comorbidity	38 (76)	111 (67.7)	0.263	0.063	66 (76.7)	83 (64.8)
Hypertension	34 (68)	93 (56.7)	0.155	0.159	56 (65.1)	71 (55.5)
Cardiac dysfunction	28 (56)	63 (38.4)	0.028	0.017	45 (52.3)	46 (35.9)
Pulmonary dysfunction	7 (14)	13 (7.9)	0.311	0.484	10 (11.6)	10 (7.8)
Diabetes mellitus	6 (12)	23 (14)	0.896	0.79	11 (12.8)	18 (14.1)
Renal dysfunction	7 (14)	8 (4.9)	0.058	0.177	9 (10.5)	6 (4.7)
Gastrointestinal dysfunction	1 (2)	1 (0.6)	0.416	>0.999	1 (1.2)	1 (0.8)
Neurologic dysfunction	11 (22)	34 (20.7)	0.847	0.318	21 (24.4)	24 (18.8)
Venous insufficiency	2 (4)	8 (4.9)	>0.999	0.527	5 (5.8)	5 (3.9)
Malignancy	6 (12)	12 (7.3)	0.451	0.525	9 (10.5)	9 (7)
≥3 comorbidities	19 (38)	47 (28.7)	0.211	0.098	32 (37.2)	34 (26.6)
Comorbid cardiac, pulmonary, or renal dysfunction or malignancy	31 (62)	71 (43.3)	0.02	0.012	50 (58.1)	52 (40.6)
Antithrombotic agents	10 (20)	30 (18.3)	0.949	0.741	17 (19.8)	23 (18)
VKA or NOAC	7 (14)	19 (11.6)	0.833	0.983	11 (12.8)	15 (11.7)
Acenocoumarol	4 (8)	7 (4.3)	0.288	0.759	5 (5.8)	6 (4.7)
Warfarin	2 (4)	1 (0.6)	0.137	0.566	2 (2.3)	1 (0.8)
Dabigatran (Pradaxa)	0 (0)	9 (5.5)	0.121	0.32	2 (2.3)	7 (5.5)
Rivaroxaban (Xarelto)	2 (4)	2 (1.2)	0.233	0.305	3 (3.5)	1 (0.8)
Acetylsalicylic acid	2 (4)	11 (6.7)	0.737	>0.999	5 (5.8)	8 (6.3)
Clopidogrel	1 (2)	0 (0)	0.234	0.402	1 (1.2)	0 (0)
Enoxaparin (Clexane)	2 (4)	0 (0)	0.054	0.16	2 (2.3)	0 (0)
Preoperative prothrombin complex concentrate (Octaplex)	2 (4)	3 (1.8)	0.332	>0.999	2 (2.3)	3 (2.3)

Continues

Table 2. Continued

Characteristic	EGOS Score 1–2 (n = 50)	EGOS Score ≥3 (n = 164)	P Value	P Value	Not Discharged Home (n = 86)	Discharged Home (n = 128)
Radiologic findings						
Intracranial bleeding with mass effect	23 (46)	35 (21.3)	<0.001	0.002	33 (38.4)	25 (19.5)
Skull fracture	11 (22)	42 (25.6)	0.605	0.923	21 (24.4)	32 (25)
Acute subdural hematoma	39 (78)	63 (38.4)	<0.001	<0.001	54 (62.8)	48 (37.5)
Subacute subdural hematoma	1 (2)	13 (7.9)	0.197	0.412	4 (4.7)	10 (7.8)
Chronic subdural hematoma	11 (22)	54 (32.9)	0.141	0.734	25 (29.1)	40 (31.3)
Epidural hematoma	2 (4)	6 (3.7)	>0.999	0.48	2 (2.3)	6 (4.7)
Cerebral contusions	15 (30)	50 (30.5)	0.948	0.383	29 (33.7)	36 (28.1)
Infratentorial hemorrhage	3 (6)	3 (1.8)	0.142	0.04	5 (5.8)	1 (0.8)
Intravenous hemorrhage	0 (0)	4 (2.4)	0.575	0.65	1 (1.2)	3 (2.3)
Traumatic subarachnoid hemorrhage	11 (22)	36 (22)	0.994	0.524	17 (19.8)	30 (23.4)
Laboratory results						
HGB (g/dL)	10.8 (9.5–13.2)	12.9 (11.7–14.1)	<0.001	<0.001	11.4 (9.8–13.2)	13.1 (12–14.2)
HGB ≤10 g/dL	19 (38)	17 (10.4)	<0.001	<0.001	24 (27.9)	12 (9.4)
HCT (%)	32.4 (28.8–38.7)	38 (34.3–41.7)	<0.001	<0.001	34.6 (29.6–38.7)	39 (35–41.8)
MCV (fL)	89.7 (85.9–95.2)	89.7 (86.8–92.3)	0.359	0.700	89.3 (86.9–94)	90.2 (86.5–92.3)
MCH (pg)	30.1 (29.2–32.2)	30.5 (29.3–31.5)	0.958	0.428	30.1 (29.2–31.5)	30.7 (29.3–31.7)
RDW-CV (% CV)	14 (13.1–15.5)	13.2 (12.7–14)	<0.001	0.004	13.7 (13–14.8)	13.2 (12.7–14)
RDW-CV ≥14.5%	19 (38)	27 (16.5)	<0.001	0.027	25 (29.1)	21 (16.4)
RDW-SD (fL)	46.8 (42.1–50.2)	43.3 (41.3–46.6)	0.004	0.028	45.7 (41.9–49.1)	43.3 (41.3–46.5)
PLTs (g/L)	166 (110.8–239.5)	202.5 (167–255)	0.004	0.005	178 (119.8–239.8)	202 (175.5–256.3)
PLTs ≤100 g/L	10 (20)	5 (3)	<0.001	<0.001	13 (15.1)	2 (1.6)
PCT (%)	0.2 (0.1–0.3)	0.2 (0.2–0.3)	0.016	0.023	0.2 (0.1–0.2)	0.2 (0.2–0.3)
MPV (fL)	10.4 (9.8–11.7)	10.3 (9.7–10.9)	0.086	0.093	10.4 (9.8–11.4)	10.3 (9.5–10.8)
PDW (fL)	12 (10.8–14.4)	11.7 (10.5–13.3)	0.234	0.199	11.9 (10.7–13.9)	11.6 (10.5–13.1)
WBC count (G/L)	9.8 (7.7–13.8)	9.1 (6.7–11.7)	0.078	0.009	10 (7.4–13.1)	8.8 (6.5–11.3)
PI (%)	83 (72.8–89.8)	92 (85–96)	<0.001	<0.001	87 (78.5–93)	93 (86–97)
INR	1.2 (1.1–1.3)	1.1 (1–1.2)	<0.001	<0.001	1.1 (1.1–1.3)	1.1 (1–1.2)
INR ≥1.5	9 (18)	12 (7.3)	0.051	0.334	11 (12.8)	10 (7.8)
PT (seconds)	16.9 (15.6–19.3)	15.2 (14.6–16.5)	<0.001	<0.001	16.1 (15.1–17.9)	15.1 (14.5–16.3)
APTT (seconds)	34.2 (30.4–37)	29.9 (27.5–33.4)	<0.001	0.008	32.2 (29–36)	29.9 (27.6–33.2)
APTT ≥35 seconds	21 (42)	28 (17.1)	<0.001	0.006	28 (32.6)	21 (16.4)
TT	15.8 (14.9–17)	15.2 (14.4–16.1)	0.027	0.309	15.5 (14.5–16.6)	15.2 (14.6–16.1)
GLU (mg/dL)	145 (124–165.5)	128 (103–153)	0.154	0.127	137 (121.3–159.3)	126 (96.8–151)
Crea (mg/dL)	0.9 (0.7–1.2)	0.9 (0.7–1)	0.376	0.748	0.9 (0.7–1.1)	0.9 (0.7–1)

Values are number of patients (%) or median (interquartile range).

EGOS, Extended Glasgow Outcome Scale; LOS, length of stay at the department of neurosurgery; GCS, Glasgow Coma Scale; GCS-M, Glasgow Coma Scale motor; HGB, hemoglobin; HCT, hematocrit; MCV, mean corpuscular volume; MCH, mean cell hemoglobin; RDW-CV, red blood cell distribution width coefficient of variation; CV, coefficient of variation; RDW-SD, red blood cell distribution width SD; PLT, platelet; PCT, plateletcrit; MPV, mean platelet volume; PDW, platelet distribution width; WBC, white blood cell; PI, prothrombin index; INR, international normalized ratio; APTT, activated partial thromboplastin time; TT, thrombin time; GLU, glucose; eTBI Score, Elderly Traumatic Brain Injury Score; VKA, vitamin K antagonist; NOAC, novel oral anticoagulant; PT, prothrombin time; Crea, creatinine; UN, urea nitrogen; K, potassium; Na, sodium; TNT, troponin T; CRASH, Corticosteroid Randomization After Significant Head injury.

Table 2. Continued

Characteristic	EGOS Score 1—2 (n = 50)	EGOS Score ≥3 (n = 164)	P Value	P Value	Not Discharged Home (n = 86)	Discharged Home (n = 128)
UN (mg/dL)	43.5 (31.3—64.8)	38 (30—48)	0.106	0.310	41.5 (30—55.8)	38 (30.5—48.5)
K (mmol/L)	4.1 (3.6—4.5)	4 (3.7—4.3)	0.778	0.790	4.1 (3.7—4.4)	4 (3.8—4.3)
Na (mmol/L)	136 (133.3—140)	138 (135—140)	0.088	0.105	137 (134—140)	138 (135—140)
TNT (ng/L)	22 (12.3—46.3)	17 (10.3—23)	0.242	0.015	22 (15.5—35)	15 (7.8—21.5)
Ethanol (%)	0.7 (0.1—2.3)	1.4 (0.1—2.4)	0.309	0.039	0.1 (0.1—2.2)	1.6 (0.5—2.4)
Complications	28 (56)	61 (37.2)	0.018	0.041	43 (50)	46 (35.9)
Pulmonary	38 (76)	20 (12.2)	<0.001	<0.001	49 (57)	9 (7)
Cardiac	39 (78)	4 (2.4)	<0.001	<0.001	40 (46.5)	3 (2.3)
Renal	9 (18)	2 (1.2)	<0.001	<0.001	10 (11.6)	1 (0.8)
Infection	17 (34)	16 (9.8)	<0.001	<0.001	27 (31.4)	6 (4.7)
Neurologic deterioration	10 (20)	18 (11)	0.156	0.121	15 (17.4)	13 (10.2)
Prognosis						
eTBI Score	3 (2—4)	5 (5—6)	0.039	0.04	4 (3—5)	5 (5—6)
14-day mortality according to CRASH model (median %) (assessed only for patients with admission GCS score ≤14)	50.8 (22.3—78.4)	15.3 (10.2—25.2)	0.038	0.043	28.6 (16.4—69.7)	13.4 (9.1—23.2)

Values are number of patients (%) or median (interquartile range).

EGOS, Extended Glasgow Outcome Scale; LOS, length of stay at the department of neurosurgery; GCS, Glasgow Coma Scale; GCS-M, Glasgow Coma Scale motor; HGB, hemoglobin; HCT, hematocrit; MCV, mean corpuscular volume; MCH, mean cell hemoglobin; RDW-CV, red blood cell distribution width coefficient of variation; CV, coefficient of variation; RDW-SD, red blood cell distribution width SD; PLT, platelet; PCT, plateletcrit; MPV, mean platelet volume; PDW, platelet distribution width; WBC, white blood cell; PI, prothrombin index; INR, international normalized ratio; APTT, activated partial thromboplastin time; TT, thrombin time; GLU, glucose; eTBI Score, Elderly Traumatic Brain Injury Score; VKA, vitamin K antagonist; NOAC, novel oral anticoagulant; PT, prothrombin time; Crea, creatinine; UN, urea nitrogen; K, potassium; Na, sodium; TNT, troponin T; CRASH, Corticosteroid Randomization After Significant Head injury.

exact test, when appropriate. For all tests, $P < 0.05$ was deemed to be significant.

A predictive model was developed using logistic regression modeling with a backward stepwise feature selection with a likelihood ratio test and with $P < 0.05$ needed for stepwise feature removal. Prior to modeling, the completeness of the data was assured using predictive mean matching. Features with suspected predictive abilities according to univariate analysis were included in the modeling as continuous and after dichotomization with thresholds set based on a literature review to incorporate values
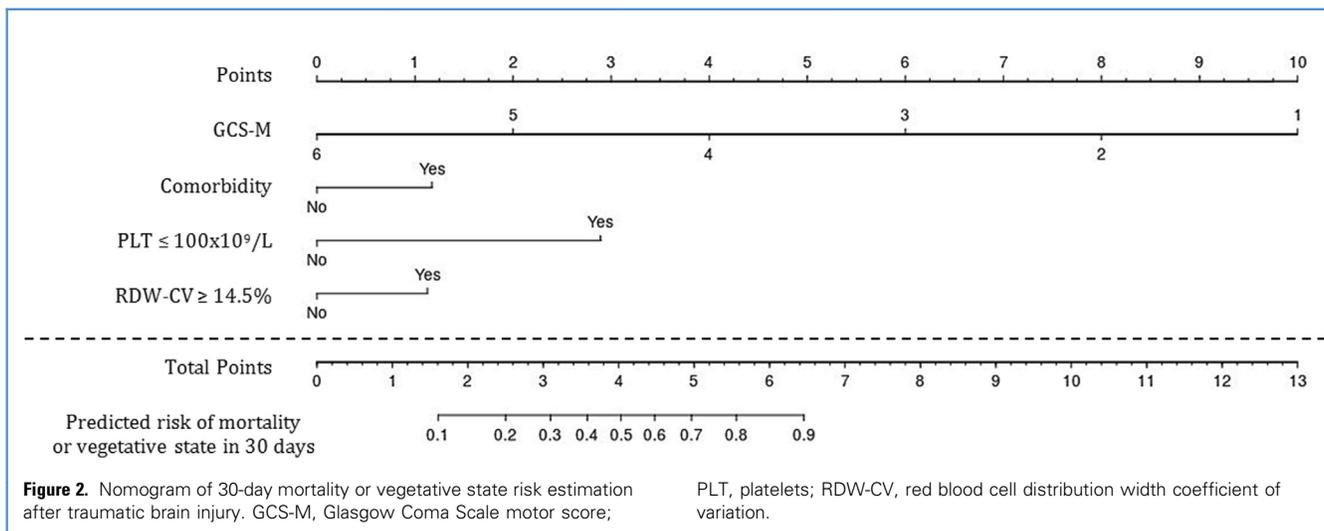

Figure 2. Nomogram of 30-day mortality or vegetative state risk estimation after traumatic brain injury. GCS-M, Glasgow Coma Scale motor score; PLT, platelets; RDW-CV, red blood cell distribution width coefficient of variation.

Table 3. Determination of the Elderly Traumatic Brain Injury Score

Component	eTBI Score Points
GCS-M score	
	1—6
PLTs	
$\leq 100 \times 10^9$ cells/L	−1
$>100 \times 10^9$ cells/L	0
RDW-CV	
$\geq 14.5\%$	−1
$<14.5\%$	0
Comorbid cardiac, pulmonary, or renal dysfunction or malignancy	
Yes	−1
No	0
Total eTBI Score	−2 to 6

GCS-M, Glasgow Coma Scale motor; PLT, platelet; RDW-CV, red blood cell distribution width coefficient of variation; eTBI Score, Elderly Traumatic Brain Injury Score.

Table 4. Thirty-Day Mortality or Vegetative State (Extended Glasgow Outcome Scale Score 1—2) Was Inversely Proportional to the Elderly Traumatic Brain Injury Score

eTBI Score	Number of Patients (%)	EGOS Score 1—2 (%)	Discharged Home (%)
All	214 (100)	23	60
−2	0 (0)	NA	NA
−1	0 (0)	NA	NA
0	5 (2)	100*	0
1	4 (2)	100*	0
2	11 (5)	91	0
3	16 (7)	69	19
4	37 (17)	30	51
5	77 (36)	10	69
6	64 (30)	2	83

eTBI Score, Elderly Traumatic Brain Injury Score; EGOS, Extended Glasgow Outcome Scale; NA, not applicable.

*All patients with an eTBI Score ≤ 1 died in the 30-day period; 83% of patients with an eTBI Score 6 were discharged home; no patient scored <0; however, this would be expected to be associated with mortality.

similar to those used in prior reports.[37-43] The resulting logistic regression model was evaluated for its predictive performance using accuracy, sensitivity, and specificity. Discovered coefficients were later used for nomogram development, which was further simplified to facilitate the clinical use of the proposed scoring
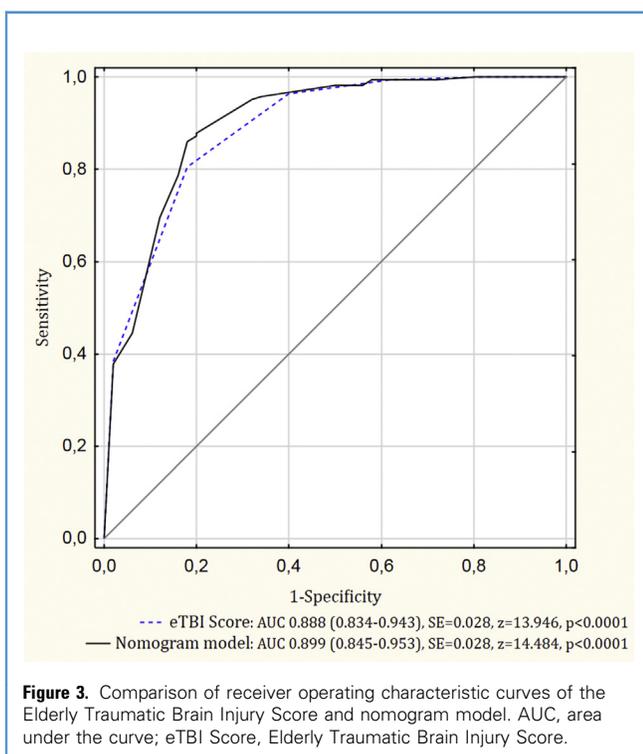
system. Variance inflation factors (VIFs) were used to assess the potential multicollinearity. Internal validity of the modeling method was assessed in leave-one-out cross-validation (LOOCV). The diagnostic abilities of models were also evaluated in receiver operating characteristic (ROC) curve analysis.
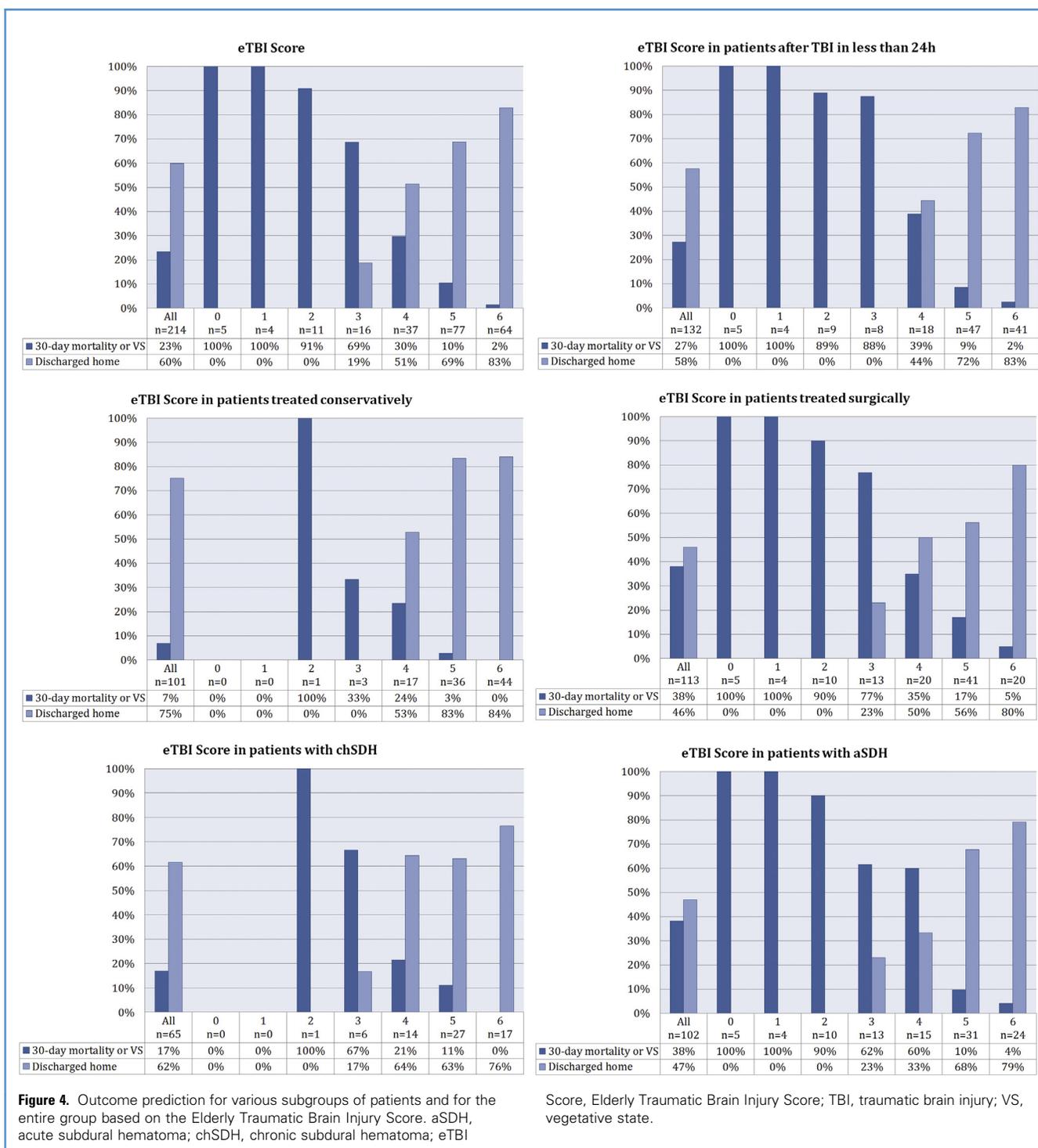
RESULTS

After duplicates removal, we identified 4307 patients treated at the department of neurosurgery over a 2-year period (between October 2016 and October 2018). We screened 480 patients with *International Statistical Classification of Diseases and Related Health Problems, 10th Revision* discharge diagnosis code S06 (intracranial injury), and included into the analysis data of 214 patients ≥ 65 years of age (**Figure 1**).

The median GCS score on admission was 14 (interquartile range, 12—15), with 68.7% of patients having a GCS score ≥ 13. The 30-day mortality or vegetative state rate amounted to 23.4% (**Table 1**). Characteristically, age was not associated with EGOS score 1—2; however, it had an impact on the rate of patients discharged home (**Table 2**). Anisocoria occurred in 17 patients (7.9%), and it was associated with mortality in the presence of acute subdural hematoma (aSDH) (P = 0.006), whereas 4 patients with anisocoria not having aSDH survived, and 2 of them were discharged home.

Patients requiring neurosurgical treatment (n = 113, 52.8%) were in worse neurologic state on admission (median GCS score 13 vs. 15, P < 0.001) and more frequently had coagulation abnormalities (P < 0.001), neurologic deficits (P < 0.001), and comorbidities (P = 0.026). On the other hand, patients presenting with skull fracture, cerebral contusion, or traumatic subarachnoid

Figure 3. Comparison of receiver operating characteristic curves of the Elderly Traumatic Brain Injury Score and nomogram model. AUC, area under the curve; eTBI Score, Elderly Traumatic Brain Injury Score.

Figure legend in chart:
--- eTBI Score: AUC 0.888 (0.834-0.943), SE=0.028, z=13.946, p<0.0001
— Nomogram model: AUC 0.899 (0.845-0.953), SE=0.028, z=14.484, p<0.0001

Figure 4. Outcome prediction for various subgroups of patients and for the entire group based on the Elderly Traumatic Brain Injury Score. aSDH, acute subdural hematoma; chSDH, chronic subdural hematoma; eTBI Score, Elderly Traumatic Brain Injury Score; TBI, traumatic brain injury; VS, vegetative state.

hemorrhage were usually treated conservatively (all P < 0.001). The 30-day mortality or vegetative state rate was associated with the need for neurosurgical intervention (P < 0.001), and particularly with decompressive craniectomy (P < 0.001), but not with the need for reoperation (Table 2).

Conservative treatment failed in 20.5% of patients (n = 26). They presented in somewhat worse neurologic condition (median GCS score 14 vs. 15), were slightly older (median age 81 vs. 76 years), and more often had cardiac (P = 0.032) or pulmonary dysfunction (P = 0.04). Their in-hospital stay was frequently

Figure 5. Comparison of outcome prediction between the Elderly Traumatic Brain Injury Score, Glasgow Coma Scale motor score, Head Injury Severity Scale score, and GCS score. EGOS, Extended Glasgow Outcome Scale; eTBI Score, Elderly Traumatic Brain Injury Score; GCS, Glasgow Coma Scale.
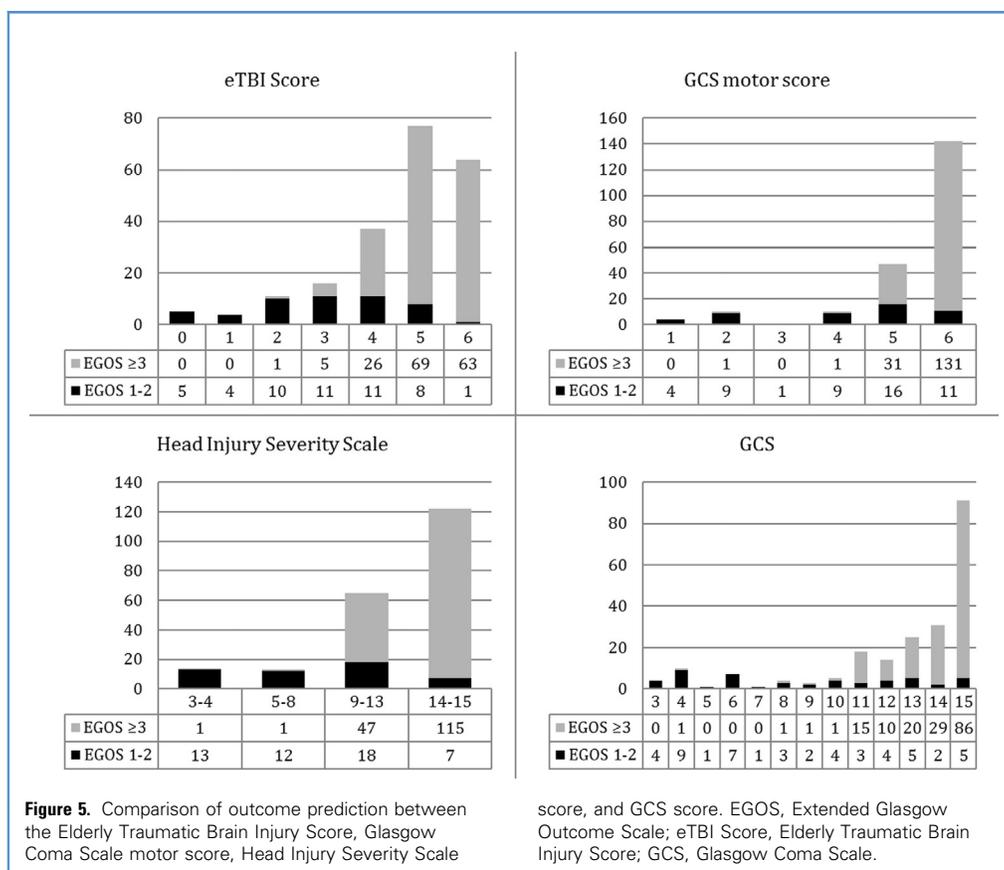
complicated by infection (P = 0.003). Conservative treatment failure was also associated with increased rate of 30-day mortality or vegetative state (P < 0.001).

Starting with 20 predefined features (**Supplementary Table S1**), after a backward stepwise procedure, the final model for prediction of death or vegetative state after TBI highlighted the importance of GCS motor score (odds ratio [OR], 0.17; 95% confidence interval [CI], 0.09−0.32, per increase in score); presence of comorbid cardiac, pulmonary, or renal dysfunction or malignancy (OR, 2.86; 95% CI, 1.08−7.61); platelets (PLTs) ≤100 × 10^9 cells/L (OR, 13.60; 95% CI, 3.33−55.49); and red blood cell distribution width coefficient of variation (RDW-CV) ≥14.5% (OR, 2.91; 95% CI, 1.09−7.78). GCS motor score was most strongly associated with outcome. Feature importance and its influence on death probability are shown in a developed nomogram (**Figure 2**). With threshold of probability >50% for death, the model accurately predicted 88.8% of outcomes (95% CI, 83.8%−92.7%), with sensitivity of 66% and specificity of 96%. Positive and negative predictive values of death prediction were 83% and 90%, respectively. The area under the ROC curve for estimated probabilities was calculated as 0.89. The VIF values for all included predictors ranged from 1.04 to 1.06. The averaged accuracy in LOOCV was calculated as 87.4%, with a mean area under the ROC curve equal to 0.9. Based on the nomogram (**Figure 2**), we have developed a simplified and intuitive clinical scoring system, Elderly Traumatic Brain Injury

Score (eTBI Score) (**Tables 3** and **4**), which yielded similar performance metrics in validation (**Figure 3**). We used the eTBI Score to predict outcome in various subgroups of patients and in the entire study cohort to assess whether it was predictive of outcome in different clinical scenarios and whether all patients with TBI ≥65 years of age could be considered in a single risk stratification scale (**Figure 4**).

DISCUSSION

Herein we present a novel scoring system for risk stratification for elderly patients after head injury. It features the importance of GCS motor score; the presence of comorbid cardiac, pulmonary, or renal dysfunction or malignancy; and specified laboratory results of RDW-CV ≥14.5% and PLTs ≤100 × 10^9 cells/L. Interestingly enough, the presence of aSDH either with or without mass effect was discarded in favor of the GCS motor score (**Supplementary Table S1**), possibly because of collinearity (P < 0.001). Although no external validation of the developed prediction model has been so far performed, the consistency showed in LOOCV suggests that the applied modeling method is robust and that the developed model is resilient to overfitting. A lack of multicollinearity was proven by low VIF values.

The result of the eTBI Score calculation ranges from −2 to 6 points as a derivative of the GCS motor score. Therefore, we aimed to investigate differences between the eTBI Score and various
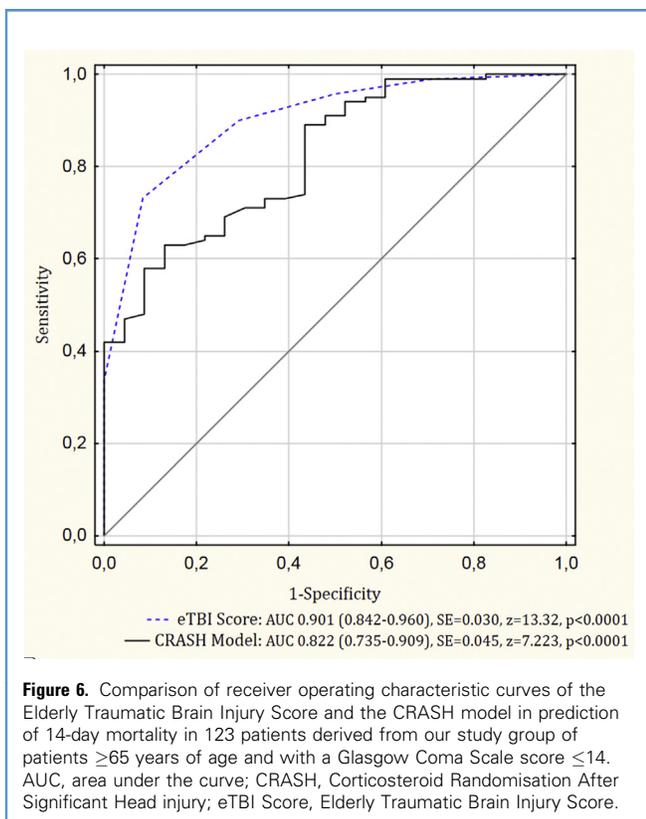
Figure 6. Comparison of receiver operating characteristic curves of the Elderly Traumatic Brain Injury Score and the CRASH model in prediction of 14-day mortality in 123 patients derived from our study group of patients ≥65 years of age and with a Glasgow Coma Scale score ≤14. AUC, area under the curve; CRASH, Corticosteroid Randomisation After Significant Head injury; eTBI Score, Elderly Traumatic Brain Injury Score.

variants of GCS score used in clinical practice (Figure 5). The most important clinically relevant finding was clear separation of patients with minimal mortality risk. In the group of patients with eTBI Score 6 (n = 64), this totaled 1.56%; however, 31.25% of them required neurosurgical intervention. It can therefore be suggested that the new scoring system will provide fine discrimination between patients with increasing mortality risk regardless of treatment modality.

In 2010, Schnüriger et al.[43] reported that PLTs ≤100 × 10⁹ cells/ L significantly increased risk of death in patients with traumatic intracranial hemorrhage and suggested further validation of early PLT transfusion. Notably, it is supposed that PLTs may have capacity for neuroprotection by means of neuroinflammation, decrease of hemorrhage, and stimulation of neuronal functions and synaptic plasticity after injury.[44] Still, studies on PLT transfusion for patients with TBI yielded ambiguous results.[45,46]

RDW-CV is a measure of anisocytosis and is used in differential diagnosis of anemia.[47] It is also an extensively studied mortality risk factor for various medical conditions, including head trauma.[40,48-56] We consider it might be an indirect measure of biological aging, becoming an even more significant biomarker than age in the geriatric population.

Scoring systems are widely used across medical disciplines provided that they incorporate the most important issues and are kept as simple as possible. On the other hand, there is an

on-going debate whether to support the clinical application of mortality risk scoring systems or not, because of the possible misuse. Various authors imply that poor outcome in critical care patients may be an effect of self-fulfilling prophecy after withdrawal of treatment in a preselected group.[57-64] With this in mind, we assume that the eTBI Score could well serve as an initial metric of outcome; nonetheless, it would totally fail to either indicate a treatment-limiting order or replace experience-based decision-making.

The CRASH (Corticosteroid Randomisation After Significant Head injury) model is one of the most recognizable scoring systems in TBI.[65] It was developed on a group of 10,008 patients with a GCS score ≤14 after TBI, to predict the risk of 14-day mortality and 6-month unfavorable outcome. It is noteworthy that the mean age of patients included in this trial was 37±17.1 years; therefore, its application in older adults may be less accurate. Furthermore, prediction of 6-month unfavorable outcome based on admission findings in this group of patients may be unreliable, as long as it is highly dependent on rehabilitation.[66-68] Our analysis showed that the CRASH model was less valuable than the eTBI Score despite the use of 14-day mortality as an outcome measure in the group of 123 patients ≥65 years of age derived from our study (Figure 6).

The methodology of a retrospective study design represents a potential source of bias caused by inconsistent clinical reporting and possible existence of unmeasured confounders. We identified some of them described in the literature (i.e., initial blood pressure, heart rate, glycemia), which are commonly assessed and managed during prehospital emergency care; hence, they are rarely available in hospital electronic records. We also suspect possible reporting bias regarding antithrombotic therapy and comorbidities, which would lead to underestimation of these risk factors. Furthermore, in the future, it would be expected to at least double the study cohort to increase the number of patients with poor prognosis and therefore more adequately prognosticate their outcome.

CONCLUSIONS

The eTBI Score is the first scoring system designed specifically for elderly patients after TBI. As a derivative of GCS motor score with added features that proved to be independent predictors of outcome, it constitutes an objective tool to help guide treatment. It could perform as a framework for clinical decision-making at the level of accident and emergency department and serve as an outcome predictor both for the patient and her or his family. Moreover, its capability to stratify risk for the patient provides reliable criteria for assessing efficacy of TBI management. More research using a prospective large cohort study is needed to validate the proposed scoring system on an independent dataset prior to its clinical application. It must be remembered that the current state of knowledge does not approve early treatment-limiting orders after TBI based on single tool assessment, and the intrinsic patient and injury characteristics remain to be examined carefully on a case-by-case basis.

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Supplementary Table S1. Statistics of Backward Stepwise Procedure in the Final Logistic Model Development					
Step	B	SE	Wald	Significance	OR
Step 1a					
GCS motor score	−2.001	0.47	18.127	0	0.135
aSDH	0.559	0.613	0.832	0.362	1.749
RDW-CV ≥14.5%	1.061	0.91	1.36	0.244	2.89
Comorbid cardiac, pulmonary, or renal dysfunction or malignancy	1.005	0.577	3.032	0.082	2.733
INR ≥1.5	2.377	1.369	3.014	0.083	10.775
aSDH with mass effect	0.366	0.693	0.279	0.597	1.443
Unresponsive pupil	−1.89	1.319	2.054	0.152	0.151
HGB ≤10 g/dL	−0.164	1.006	0.027	0.87	0.848
PLTs ≤100 g/L	2.709	1.043	6.742	0.009	15.017
APTT ≥35 seconds	0.444	0.929	0.228	0.633	1.558
Age	−0.024	0.035	0.466	0.495	0.976
Sex	−0.876	0.624	1.97	0.16	0.417
VKA or NOAC	−1.901	1.325	2.059	0.151	0.149
tSAH	−0.413	0.672	0.377	0.539	0.662
HGB	0.136	0.201	0.459	0.498	1.146
RDW-CV	0.049	0.169	0.084	0.772	1.05
PLTs	−0.001	0.004	0.082	0.775	0.999
INR	0.109	0.297	0.134	0.714	1.115
APTT	−0.004	0.058	0.005	0.946	0.996
Crea	0.223	0.309	0.521	0.47	1.25
Constant	7.938	5.741	1.912	0.167	2802.28
Step 2a					
GCS motor score	−2.002	0.47	18.158	0	0.135
aSDH	0.567	0.602	0.886	0.346	1.763
RDW-CV ≥14.5%	1.04	0.856	1.478	0.224	2.83
Comorbid cardiac, pulmonary, or renal dysfunction or malignancy	1.01	0.574	3.096	0.079	2.746
INR ≥1.5	2.398	1.338	3.211	0.073	10.997
aSDH with mass effect	0.365	0.693	0.278	0.598	1.441
Unresponsive pupil	−1.889	1.319	2.05	0.152	0.151
HGB ≤10 g/dL	−0.164	1.006	0.027	0.87	0.848
PLTs ≤100 g/L	2.713	1.041	6.786	0.009	15.076
APTT ≥35 seconds	0.407	0.756	0.289	0.591	1.502
Age	−0.024	0.035	0.474	0.491	0.976
Sex	−0.878	0.623	1.985	0.159	0.416
VKA or NOAC	−1.93	1.258	2.352	0.125	0.145
tSAH	−0.413	0.672	0.377	0.539	0.662
HGB	0.137	0.201	0.463	0.496	1.147
RDW-CV	0.052	0.162	0.103	0.748	1.053
PLTs	−0.001	0.004	0.08	0.777	0.999

OR, odds ratio; GCS, Glasgow Coma Scale; aSDH, acute subdural hematoma; RDW-CV, red blood cell distribution width coefficient of variation; INR, international normalized ratio; HGB, hemoglobin; PLT, platelet; APTT, activated partial thromboplastin time; tSAH, traumatic subarachnoid hemorrhage; VKA, vitamin K antagonist; NOAC, novel oral anticoagulant; Crea, Creatinine.

Continues

Supplementary Table S1. Continued					
Step	**B**	**SE**	**Wald**	**Significance**	**OR**
INR	0.102	0.282	0.132	0.716	1.108
Crea	0.209	0.22	0.9	0.343	1.232
Constant	7.805	5.401	2.089	0.148	2453.085
Step 3a					
GCS motor score	−1.987	0.459	18.778	0	0.137
aSDH	0.578	0.598	0.935	0.334	1.783
RDW-CV ≥14.5%	1.053	0.85	1.535	0.215	2.866
Comorbid cardiac, pulmonary, or renal dysfunction or malignancy	1.009	0.574	3.094	0.079	2.744
INR ≥1.5	2.349	1.301	3.257	0.071	10.475
aSDH with mass effect	0.358	0.691	0.269	0.604	1.431
Unresponsive pupil	−1.836	1.272	2.086	0.149	0.159
PLTs ≤100 g/L	2.716	1.041	6.807	0.009	15.123
APTT ≥35 seconds	0.41	0.755	0.295	0.587	1.506
Age	−0.023	0.035	0.456	0.499	0.977
Sex	−0.879	0.624	1.982	0.159	0.415
VKA or NOAC	−1.915	1.25	2.346	0.126	0.147
tSAH	−0.396	0.663	0.357	0.55	0.673
HGB	0.158	0.153	1.066	0.302	1.172
RDW-CV	0.048	0.16	0.09	0.764	1.049
PLTs	−0.001	0.004	0.068	0.794	0.999
INR	0.112	0.276	0.164	0.686	1.118
Crea	0.203	0.216	0.878	0.349	1.225
Constant	7.4	4.785	2.392	0.122	1635.711
Step 4a					
GCS motor score	−1.977	0.455	18.892	0	0.138
aSDH	0.604	0.59	1.046	0.306	1.829
RDW-CV ≥14.5%	1.098	0.834	1.733	0.188	2.998
Comorbid cardiac, pulmonary, or renal dysfunction or malignancy	1.023	0.572	3.2	0.074	2.781
INR ≥1.5	2.392	1.296	3.407	0.065	10.94
aSDH with mass effect	0.376	0.688	0.3	0.584	1.457
Unresponsive pupil	−1.823	1.262	2.086	0.149	0.162
PLTs ≤100 g/L	2.859	0.89	10.317	0.001	17.437
APTT ≥35 seconds	0.386	0.746	0.268	0.605	1.471
Age	−0.023	0.035	0.438	0.508	0.977
Sex	−0.84	0.605	1.926	0.165	0.432
VKA or NOAC	−1.919	1.255	2.338	0.126	0.147
tSAH	−0.4	0.664	0.363	0.547	0.67
HGB	0.158	0.153	1.06	0.303	1.171
RDW-CV	0.041	0.158	0.067	0.796	1.042
INR	0.118	0.276	0.181	0.67	1.125
					Continues

Step	B	SE	Wald	Significance	OR
Supplementary Table S1. Continued					
Crea	0.209	0.215	0.942	0.332	1.232
Constant	7.092	4.629	2.348	0.125	1202.82
Step 5a					
GCS motor score	−1.978	0.457	18.746	0	0.138
aSDH	0.601	0.59	1.039	0.308	1.825
RDW-CV ≥14.5%	1.238	0.632	3.838	0.05	3.45
Comorbid cardiac, pulmonary, or renal dysfunction or malignancy	1.03	0.571	3.253	0.071	2.802
INR ≥1.5	2.381	1.297	3.368	0.066	10.811
aSDH with mass effect	0.367	0.686	0.286	0.593	1.444
Unresponsive pupil	−1.803	1.262	2.039	0.153	0.165
PLTs ≤100 g/L	2.874	0.884	10.558	0.001	17.705
APTT ≥35 seconds	0.357	0.739	0.233	0.629	1.429
Age	−0.022	0.034	0.404	0.525	0.978
Sex	−0.823	0.601	1.878	0.171	0.439
VKA or NOAC	−1.903	1.251	2.312	0.128	0.149
tSAH	−0.402	0.664	0.366	0.545	0.669
HGB	0.151	0.151	1.002	0.317	1.163
INR	0.12	0.276	0.187	0.665	1.127
Crea	0.203	0.212	0.918	0.338	1.226
Constant	7.639	4.116	3.445	0.063	2077.346
Step 6a					
GCS motor score	−2.015	0.454	19.694	0	0.133
aSDH	0.572	0.586	0.952	0.329	1.772
RDW-CV ≥14.5%	1.225	0.635	3.721	0.054	3.404
Comorbid cardiac, pulmonary, or renal dysfunction or malignancy	1.034	0.571	3.279	0.07	2.813
INR ≥1.5	2.537	1.233	4.236	0.04	12.645
aSDH with mass effect	0.346	0.687	0.254	0.614	1.414
Unresponsive pupil	−1.868	1.257	2.21	0.137	0.154
PLTs ≤100 g/L	2.922	0.882	10.986	0.001	18.585
APTT ≥35 seconds	0.373	0.735	0.258	0.611	1.453
Age	−0.022	0.034	0.417	0.518	0.978
Sex	−0.841	0.6	1.968	0.161	0.431
VKA or NOAC	−1.778	1.199	2.197	0.138	0.169
tSAH	−0.426	0.661	0.416	0.519	0.653
HGB	0.155	0.151	1.054	0.305	1.167
Crea	0.205	0.213	0.931	0.335	1.228
Constant	7.972	4.061	3.853	0.05	2898.501

OR, odds ratio; GCS, Glasgow Coma Scale; aSDH, acute subdural hematoma; RDW-CV, red blood cell distribution width coefficient of variation; INR, international normalized ratio; HGB, hemoglobin; PLT, platelet; APTT, activated partial thromboplastin time; tSAH, traumatic subarachnoid hemorrhage; VKA, vitamin K antagonist; NOAC, novel oral anticoagulant; Crea, Creatinine.

Step	B	SE	Wald	Significance	OR
Supplementary Table S1. Continued					
Step 7a					
GCS motor score	−2.072	0.445	21.646	0	0.126
aSDH	0.689	0.535	1.655	0.198	1.991
RDW-CV ≥14.5%	1.252	0.632	3.916	0.048	3.496
Comorbid cardiac, pulmonary, or renal dysfunction or malignancy	1.027	0.569	3.258	0.071	2.792
INR ≥1.5	2.488	1.231	4.082	0.043	12.036
Unresponsive pupil	−1.899	1.255	2.289	0.13	0.15
PLTs ≤100 g/L	2.988	0.875	11.663	0.001	19.856
APTT ≥35 seconds	0.39	0.735	0.282	0.595	1.477
Age	−0.02	0.034	0.346	0.556	0.98
Sex	−0.823	0.6	1.883	0.17	0.439
VKA or NOAC	−1.711	1.199	2.036	0.154	0.181
tSAH	−0.395	0.651	0.369	0.543	0.673
HGB	0.16	0.15	1.139	0.286	1.173
Crea	0.202	0.214	0.891	0.345	1.224
Constant	8.033	4.064	3.907	0.048	3081.574
Step 8a					
GCS motor score	−2.121	0.438	23.492	0	0.12
aSDH	0.687	0.536	1.64	0.2	1.987
RDW-CV ≥14.5%	1.248	0.632	3.901	0.048	3.484
Comorbid cardiac, pulmonary, or renal dysfunction or malignancy	1.049	0.566	3.439	0.064	2.855
INR ≥1.5	2.787	1.127	6.114	0.013	16.24
Unresponsive pupil	−1.964	1.278	2.363	0.124	0.14
PLTs ≤100 g/L	2.914	0.856	11.591	0.001	18.433
Age	−0.019	0.034	0.298	0.585	0.982
Sex	−0.819	0.599	1.867	0.172	0.441
VKA or NOAC	−1.742	1.22	2.039	0.153	0.175
tSAH	−0.387	0.645	0.36	0.549	0.679
HGB	0.14	0.144	0.953	0.329	1.151
Crea	0.221	0.212	1.09	0.296	1.247
Constant	8.47	3.977	4.535	0.033	4768.017
Step 9a					
GCS motor score	−2.125	0.438	23.506	0	0.119
aSDH	0.704	0.533	1.742	0.187	2.022
RDW-CV ≥14.5%	1.25	0.635	3.871	0.049	3.49
Comorbid cardiac, pulmonary, or renal dysfunction or malignancy	0.987	0.553	3.182	0.074	2.683
INR ≥1.5	2.76	1.145	5.807	0.016	15.795
Unresponsive pupil	−1.97	1.29	2.333	0.127	0.139
					Continues

Supplementary Table S1. Continued

Step	B	SE	Wald	Significance	OR
PLTs ≤100 g/L	2.833	0.839	11.397	0.001	16.989
Sex	−0.673	0.533	1.59	0.207	0.51
VKA or NOAC	−1.687	1.228	1.886	0.17	0.185
tSAH	−0.368	0.639	0.332	0.564	0.692
HGB	0.153	0.142	1.171	0.279	1.166
Crea	0.219	0.206	1.13	0.288	1.245
Constant	6.81	2.496	7.444	0.006	906.868
Step 10a					
GCS motor score	−2.099	0.432	23.564	0	0.123
aSDH	0.699	0.531	1.737	0.188	2.012
RDW-CV ≥14.5%	1.221	0.633	3.723	0.054	3.389
Comorbid cardiac, pulmonary, or renal dysfunction or malignancy	0.993	0.553	3.225	0.073	2.7
INR ≥1.5	2.699	1.118	5.829	0.016	14.858
Unresponsive pupil	−1.882	1.279	2.163	0.141	0.152
PLTs ≤100 g/L	2.82	0.845	11.141	0.001	16.783
Sex	−0.648	0.531	1.488	0.223	0.523
VKA or NOAC	−1.658	1.207	1.888	0.169	0.19
HGB	0.139	0.139	1.008	0.315	1.149
Crea	0.212	0.206	1.056	0.304	1.236
Constant	6.778	2.509	7.295	0.007	878.212
Step 11a					
GCS motor score	−2.065	0.426	23.485	0	0.127
aSDH	0.716	0.529	1.831	0.176	2.047
RDW-CV ≥14.5%	1.228	0.625	3.861	0.049	3.413
Comorbid cardiac, pulmonary, or renal dysfunction or malignancy	1.056	0.546	3.735	0.053	2.875
INR ≥1.5	2.661	1.111	5.738	0.017	14.311
Unresponsive pupil	−1.905	1.279	2.22	0.136	0.149
PLTs ≤100 g/L	2.798	0.838	11.15	0.001	16.418
Sex	−0.581	0.52	1.249	0.264	0.559
VKA or NOAC	−1.712	1.196	2.049	0.152	0.18
HGB	0.103	0.132	0.615	0.433	1.109
Constant	7.197	2.471	8.48	0.004	1335.011
Step 12a					
GCS motor score	−1.976	0.406	23.722	0	0.139
aSDH	0.675	0.525	1.651	0.199	1.964
RDW-CV ≥14.5%	0.962	0.527	3.331	0.068	2.617
Comorbid cardiac, pulmonary, or renal dysfunction or malignancy	1.073	0.547	3.847	0.05	2.923

OR, odds ratio; GCS, Glasgow Coma Scale; aSDH, acute subdural hematoma; RDW-CV, red blood cell distribution width coefficient of variation; INR, international normalized ratio; HGB, hemoglobin; PLT, platelet; APTT, activated partial thromboplastin time; tSAH, traumatic subarachnoid hemorrhage; VKA, vitamin K antagonist; NOAC, novel oral anticoagulant; Crea, Creatinine.

Continues

Supplementary Table S1. Continued					
Step	B	SE	Wald	Significance	OR
INR ≥1.5	2.611	1.109	5.546	0.019	13.612
Unresponsive pupil	−1.77	1.26	1.975	0.16	0.17
PLTs ≤100 g/L	2.609	0.797	10.727	0.001	13.592
Sex	−0.536	0.513	1.094	0.296	0.585
VKA or NOAC	−1.784	1.192	2.239	0.135	0.168
Constant	8.061	2.253	12.803	0	3168.872
Step 13a					
GCS motor score	−2.006	0.407	24.24	0	0.135
aSDH	0.748	0.518	2.085	0.149	2.113
RDW-CV ≥14.5%	0.941	0.524	3.229	0.072	2.563
Comorbid cardiac, pulmonary, or renal dysfunction or malignancy	1.112	0.547	4.138	0.042	3.04
INR ≥1.5	2.514	1.089	5.33	0.021	12.354
Unresponsive pupil	−1.81	1.255	2.081	0.149	0.164
PLTs ≤100 g/L	2.559	0.799	10.259	0.001	12.917
VKA or NOAC	−1.519	1.14	1.776	0.183	0.219
Constant	7.831	2.238	12.248	0	2518.29
Step 14a					
GCS motor score	−2.043	0.406	25.339	0	0.13
aSDH	0.643	0.504	1.627	0.202	1.902
RDW-CV ≥14.5%	0.999	0.518	3.723	0.054	2.716
Comorbid cardiac, pulmonary or renal dysfunction or malignancy	0.897	0.524	2.932	0.087	2.451
INR ≥1.5	1.394	0.678	4.226	0.04	4.032
Unresponsive pupil	−1.919	1.246	2.37	0.124	0.147
PLTs ≤100 g/L	2.683	0.797	11.326	0.001	14.625
Constant	8.144	2.221	13.445	0	3441.647
Step 15a					
GCS motor score	−2.15	0.397	29.283	0	0.117
RDW-CV ≥14.5%	1.049	0.513	4.183	0.041	2.854
Comorbid cardiac, pulmonary, or renal dysfunction or malignancy	0.899	0.522	2.966	0.085	2.458
INR ≥1.5	1.352	0.673	4.038	0.044	3.864
Unresponsive pupil	−1.917	1.192	2.587	0.108	0.147
PLTs ≤100 g/L	2.97	0.781	14.455	0	19.49
Constant	9.022	2.11	18.284	0	8283.67
Step 16a					
GCS motor score	−1.861	0.351	28.048	0	0.156
RDW-CV ≥14.5%	0.998	0.504	3.928	0.047	2.714
Comorbid cardiac, pulmonary, or renal dysfunction or malignancy	0.943	0.513	3.383	0.066	2.568
INR ≥1.5	1.173	0.66	3.161	0.075	3.232
PLTs ≤100 g/L	2.806	0.732	14.684	0	16.547
Constant	7.392	1.862	15.751	0	1622.34
					Continues

Supplementary Table S1. Continued					
Step	B	SE	Wald	Significance	OR
Step 17a					
GCS motor score	−1.803	0.332	29.527	0	0.165
RDW-CV ≥14.5%	1.068	0.502	4.532	0.033	2.909
Comorbid cardiac, pulmonary, or renal dysfunction or malignancy	1.052	0.498	4.457	0.035	2.864
PLTs ≤100 g/L	2.61	0.718	13.226	0	13.596
Constant	7.172	1.77	16.408	0	1301.9
OR, odds ratio; GCS, Glasgow Coma Scale; aSDH, acute subdural hematoma; RDW-CV, red blood cell distribution width coefficient of variation; INR, international normalized ratio; HGB, hemoglobin; PLT, platelet; APTT, activated partial thromboplastin time; tSAH, traumatic subarachnoid hemorrhage; VKA, vitamin K antagonist; NOAC, novel oral anticoagulant; Crea, Creatinine.					