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Perspectives of Turkish Neurosurgeons on Concussion/Mild Traumatic Brain Injury: A National Survey

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ABSTRACT

AIM: To evaluate the adherence to and awareness of current concussion/mild traumatic brain injury (mTBI) guidelines among Turkish neurosurgeons.

MATERIAL and METHODS: A cross-sectional electronic survey was administered to all members of the Turkish Neurosurgical Society (n=1875 neurosurgeons) between January and February 2024. The 208 respondents (11.1%) were categorized based on years of neurosurgery specialization, type of current institution, residency program accreditation, and current institution accreditation.

RESULTS: The majority of the participants (66.3%) were employed in Tertiary-level Healthcare (TLH) institutions. In TLH settings, Emergency Medicine Practitioners (EMPs) were primarily responsible for the initial computed tomography (CT) scan for pediatric patients, while this decision was also made by EMPs for adult patients, regardless of years of experience in neurosurgery specialization. Participants enrolled in residencies at accredited institutions were more likely to obtain detailed patient histories. The rates of adherence to current guidelines were comparable across institutions, regardless of their accreditation status.

CONCLUSION: This pioneering study evaluating neurosurgeons' adherence to and awareness of concussion/mTBI guidelines revealed a uniformity in compliance among Turkish practitioners, irrespective of years of experience, institutional type, or accreditation status.

KEYWORDS: Trauma, Neurosurgeon, Guideline, Concussion

ABBREVIATIONS: mTBI: Mild traumatic brain injury, **ED:** Emergency department, **EMP:** Emergency medicine practitioner, **CT:** Computed tomography, **SLH:** Secondary-level healthcare, **TLH:** Tertiary-level healthcare, **S100B:** S100 Beta protein, **UCH-L1:** Ubiquitin C-terminal hydrolase-L-1, **GFAP:** Glial fibrillary acidic protein, **NSE:** Neuron-specific enolase, **PGDS:** Prostaglandin-D2 synthetase, **PCS:** Post-concussion syndrome, **PPCS:** Persistent post-concussion syndrome

INTRODUCTION

Concussion, also known as mild traumatic brain injury (mTBI), is an acute neurophysiological event caused by the application of mechanical energy on the head region. While all concussions are classified as mTBI, distinctions arise when neuroimaging reveals lesions or persistent neurological deficits (25). mTBI typically presents with a Glasgow Coma Scale (GCS) score of 13–15. Notably, 5–10% of patients with mTBI may develop intracranial lesions necessitating medical or surgical intervention (37). Within this subgroup, 3.5% will require neurosurgical surgery, and 1.4% will die (24).

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The global burden of mTBI poses a significant public health challenge, with over 60 million cases presenting to emergency departments (EDs) worldwide annually (8). These concussive injuries have far-reaching consequences, affecting not only athletic and academic performance, but also social interactions (20,30). Effective management of mTBI requires a multidisciplinary approach, involving neurosurgeons, anesthesiologists, and emergency medicine practitioners (EMPs). Their collaborative expertise is crucial during the diagnosis, management, follow-up, and rehabilitation phases to ensure optimal patient outcomes. The last two decades have witnessed a proliferation of guidelines for TBI, with over 30 published to date (10,19). This trend is driven by the rising global incidence of mTBI and the concerted effort to minimize morbidity and mortality and expedite patients' return to normal daily activities.

This study aimed to evaluate the adherence to and awareness of current concussion/mTBI guidelines among Turkish neurosurgeons, spanning the continuum of care from initial diagnosis to successful reintegration of patients into their routine lives.

MATERIAL and METHODS

Online Survey

Based on two previous studies (11,40), we compiled recommendations for patients with mild head injuries to create an online survey. The survey comprised 16 questions, including demographic information (age, sex, years of expertise, hospital type, and the accreditation status of the institution where the respondent is currently working or completed their residency), clinical inquiry questions for patient history-taking, brain imaging protocols for pediatric and adult patients, identification of medium and high-risk factors in patients with head trauma, serum biomarkers used to preempt recurrent CT scans, criteria for selecting patients requiring follow-up CT scans, the need for anticoagulant and antiplatelet neutralization, transition stages for returning to active life/sport participation, potential challenges upon returning to school, and recommended intervals for reevaluation in cases of persistent symptoms in pediatric and adult patients. The complete survey questionnaire is presented in Table I.

A total of 1875 neurosurgeons registered with the Turkish Neurosurgical Society received an invitation to participate in the online survey. The response rate was 11.1% (n=208). Prior to initiating the survey, participants were assured of the confidentiality of their responses. All data were collected in an online database and subsequently exported to Microsoft Excel for analysis. To ensure optimal understanding, the survey was conducted in Turkish, the participant's native language.

Subgrouping of Questions and Institutions

The survey questions were categorized into two domains: 1) baseline characteristics (including personal and institutional details) and 2) clinical recommendations for initial assessment, follow-up, and return to everyday life, aligned with current studies. Participants were stratified into subgroups based on four principal dimensions: 1) years of neurosurgery specialization; 2) type of current institution; 3) accreditation status of residency program; and 4) accreditation status of current institution. Institutional classification adhered to the Turkish Ministry of Health's directives. Accordingly, the state and private hospitals were classified as Secondary-level Healthcare (SLH) institutions, whereas state and private universities, training and research hospitals, and city hospitals were designated as Tertiary-level Healthcare (TLH) institutions.

Statistical Analysis

Data analysis was performed using the SPSS 11.5 program. Quantitative variables were presented as mean ± standard deviation or median (range), while categorical variables were presented as frequency (percentage). To compare quantitative variables across categories of qualitative variables, non-parametric tests were employed due to the non-normal distribution of the data. Mann-Whitney U test was used to assess differences between two categories while Kruskal-Wallis H test was used to assess differences across three categories. *P* values <0.05 were considered indicative of statistical significance.

RESULTS

Baseline Characteristics

The survey respondents were predominantly male (90.4%), aged over 45, and neurosurgery specialists with 1–4 years of experience (31.7%). In terms of institutional affiliation, 66.3% of respondents were employed at TLH institutions. The accreditation rates (national or international) for the participants' residency institutes and their current institutions were 76.9% and 51.4%, respectively. The demographic and institutional data are summarized in Table II.

Adherence to and Awareness of Current Guidelines

EMPs were significantly (p=0.035) more likely to be responsible for the decision to perform brain CT scans in adult patients presenting to the ED with concussion/mTBI, regardless of neurosurgery experience (Table III).

Similarly, in TLHs, EMPs were significantly (p=0.028) more likely to be responsible for the decision to perform brain CT scans in pediatric patients presenting to ED with concussion/mTBI. Participants working in SLHs demonstrated significantly greater accuracy (p=0.034) in determining the need for follow-up CT scans in specific scenarios outlined in question 12 (Table IV).

Participants from accredited (national or international) residency institutes were significantly more likely (p=0.006) to inquire about relevant questions in patients' histories (Table V). However, no significant difference was observed in adherence to concussion/mTBI management guidelines between participants from currently accredited institutions and those without accreditation (Table VI).

A comprehensive analysis was conducted to investigate potential associations between various clinical practices and professional factors. The clinical practices evaluated included

Table I: All Questions Included in the Online Survey on Mild Traumatic Brain Injury. The Correct Answers or Classifications of Questions are Provided within Parentheses in the Question or Response

1. How old are you?	• 24-29 • 29-34 • 34-39 • 40-44 • 45+:
2. Your gender?	• Female • Male
3. How many years have you been a neurosurgery specialist?	• 1-4 • 5-8 • 9-12 • >12
4. What type of hospital do you work at?	• State University (TLH) • State Hospital (SLH) • Training and Research Hospital (TLH) • City Hospital (TLH) • Private University (TLH) • Private Hospital (SLH)
5. Was your residency institution accredited?	• No • Yes, National/International
6. Is the institution where you currently work accredited?	• No • Yes, National/International
7. During patient history-taking, which of the following questions do you ask? Please select. (All should be queried.)	• I inquire about the presence of a concussive force (for example, did your head move back and forth?) and its intensity (for example, from what height did you fall?). • Do you remember the moment of the trauma and the moments immediately afterward? • Has anyone seen you lying still and unresponsive immediately after the accident? • Were you confused or unsure about your location and what was happening? • Were you able to think clearly about what to do after the accident? • Were you able to answer the questions appropriately and follow the instructions of people at the scene? • Has anyone mentioned that your speech was inconsistent or nonsensical? • Were you using alcohol or drugs immediately before the accident? • Did you witness the impact? Did you think you or others were seriously injured or in danger of dying? Did you feel panic or fear? • Did you sustain injuries elsewhere on your body? Did you experience severe pain?
8. How do you decide whether a brain CT is necessary for pediatric head trauma?	• EMPs take a CT and consult • Clinical experience • International guidelines (PECARN Rule, etc.)
9. How do you decide whether a brain CT is necessary for adult head trauma?	• EMPs take a CT and consult • Clinical experience • International guidelines (Canadian head CT Rule, etc.)
10. Mark the following conditions as high (H) or intermediate (I) risk.	• Hemostatic disorders: the use of anticoagulants, dual antiplatelet therapy, or congenital bleeding disorders (hemophilia, von Willebrand disease, etc.) (H) • Multiple episodes of vomiting (H) • Clinical signs suggestive of basilar or cranial skull fracture (otorrhea or rhinorrhea, mastoid ecchymosis, periorbital ecchymosis, hemotympanum or bleeding from the auditory canal, palpable irregularity of the cranial convexity, suspected open or depressed skull fracture) (H)

	• Focal neurological deficit (H) • Patients over 65 years of age using antiplatelet therapy (I) • High-energy trauma (I) • Amnesia occurring 30 minutes after the traumatic event (I) • Post-traumatic seizure (H) • GCS score of less than 15 occurring within 2 hours of trauma in the absence of poisoning (H) • GCS score of less than 15 occurring within 2 hours of trauma in a patient with symptoms of poisoning (I)
11. Mark the serum biomarkers used to prevent recurrent CT scans. (All markers can be used.)	• S100B, UCH-L1, GFAP • None
12. For patients presenting with intracranial traumatic findings (contusion, linear SAH, etc.) on their initial CT scan, when do you perform follow-up CT scans? (All needs follow-up CT)	• In patients with neurological deterioration • Patients over 65 years of age • Using antiplatelet/anticoagulant other than aspirin • None
13. Which of the following are correct for neutralizing oral anticoagulants and antiplatelets in mild traumatic brain injury? (All are correct.)	• In patients with mild traumatic brain injury presenting with intracranial hemorrhagic lesions, immediate neutralization of non-vitamin K antagonist oral anticoagulants should be performed. • For patients using oral anticoagulants and presenting with mild traumatic brain injury with intracranial hemorrhagic lesions, oral anticoagulants should be immediately neutralized. • Consultation among peers should be made for measures to be applied to patients with mechanical heart valves. • After a mild traumatic brain injury with intracranial hemorrhagic lesions in a patient under aspirin treatment, neutralization of aspirin is not necessary.
14. What is recommended for the stepwise return to active life/sports? Please mark. (All are recommended.)	• For each phase of progression, a minimum of 24 hours (or longer) should be allowed. If any symptoms worsen during exercise, the athlete should regress to the previous phase. • Symptom-limited activity • Mild aerobic exercise • Sport-specific exercises • Non-contact training • Combat sports • Return to sport
15. Which of the following conditions may be experienced upon returning to school? Please mark. (All may be experienced.)	• Attention deficit/poor concentration • Difficulty in memory recall • Decrease in processing speed • Cognitive fatigue • Emotional symptoms (anxiety or depression) • Headache • Sensitivity to light and sound • Increase in current symptoms
16. When should additional imaging and examinations be performed for patients experiencing moderate symptoms or unable to resume their normal activities immediately?	• 1-2 weeks (Adult) • >2-4 weeks (Pediatric)

__CT:__ Computed tomography, __PECARN:__ Pediatric emergency care applied research network, __S100B:__ S100 beta protein, __UCH-L1:__ Ubiquitin C-terminal hydrolase-L-1, __GFAP:__ Glial fibrillary acidic protein, __SAH:__ Subarachnoid hemorrhage, __SLH:__ Secondary Level Healthcare, __TLH:__ Tertiary-level healthcare, __GCS:__ Glasgow coma scale, __EMP:__ Emergency medicine practitioner.

Table II: Demographic and Institutional Data of the Participants

Variables		
Age, n (%)	24-29	5 (2.4)
	29-34	38 (18.3)
	34-39	52 (25.0)
	40-44	56 (26.9)
	≥45	57 (27.4)
Gender, n (%)	Male	188 (90.4)
	Female	20 (9.6)
Years of Neurosurgery Specialty, n (%)	1-4 years	66 (31.7)
	5-8 years	40 (19.2)
	9-12 years	38 (18.3)
	>12 years	64 (30.8)
Hospital Classification, n (%)	SLH	70 (33.7)
	TLH	138 (66.3)
Accreditation of the Residency Institution, n (%)	No	48 (23.1)
	National	92 (44.2)
	International	68 (32.7)
Accreditation of the Institution where Employed, n (%)	No	101 (48.6)
	National	73 (35.1)
	International	34 (16.3)

***SLH:** Secondary level healthcare, **TLH:** Tertiary-level healthcare.*

evaluation of trauma characteristics and risk stratification (question 10), use of serum biomarkers to avoid repeated CT scans, management of oral anticoagulants and antiplatelets, gradual return to active life/sport/school, and additional imaging and examination protocol for pediatric/adult patients with moderate symptoms or those unable to resume normal activities immediately. These clinical practices were compared across professional factors such as years of neurosurgery specialization, type of current hospital (TLH vs SLH), and accreditation status of residency and current ınstitution. No statistically significant differences were observed across these comparisons (Tables III-VI).

Expert recommendations for the diagnosis, management, and follow-up of mTBI in the current literature (11) are summarized in Figure 1.

■ DISCUSSION

Concussion/mTBI can result in immediate health problems and, in some cases, persistent symptoms (23,31). Adherence to current guidelines is crucial for optimizing outcomes, encompassing diagnosis, medical/surgical management, follow-up, and return to life and sports. This study addresses a significant knowledge gap by investigating neurosurgeons' adherence to and awareness of current concussion/mTBI guidelines, specifically examining the influence of demographic, academic, and institutional factors (11,40). Notably, this is the first study to focus exclusively on neurosurgeons' practices and perspectives, building upon existing literature.

Sarigul et al. investigated adherence to TBI guidelines among neurosurgeons, anesthesiologists, and EMPs in Türkiye. The results showed that 61% of participants adhered to TBI guidelines, although the specific adherence rate for neurosurgeons was not reported (39). A separate study in New Zealand surveyed 96 concussion clinicians and found that 70% were familiar with and had utilized at least one concussion guideline (7). Another study conducted in Swedish emergency hospitals revealed a 74% adherence rate (34). In contrast to previous studies (7,39), our research employed a survey-based approach to evaluate participants' knowledge levels. Notably, our study's methodology differed from prior research, as we evaluated each guideline recommendation individually, precluding the calculation of an overall adherence rate. Our findings diverged from those of Derbyshire et al. (7), who observed a positive correlation between clinicians' experience levels and guideline awareness. In contrast, our study did not detect a significant difference in guideline adherence and awareness across varying levels of clinical experience.

Current guidelines (11) outline certain clinical/radiological and patient-specific conditions as high or intermediate risk factors in patients with concussion/mTBI (Table I). We categorized participants into four groups to evaluate their knowledge of these risk levels. Notably, no significant differences were observed in their knowledge of these risk levels. However, the median correct response rate of 70% for this question suggests that a substantial proportion of participants incorrectly assess patient risk. This finding has significant implications, as inaccurate risk assessment may lead to either excessive investigations or inadequate follow-up care. However, on questioning the decision for a follow-up CT scan for patients with intracranial traumatic findings on the initial CT scan, the correct response rate was significantly higher in participants from SLHs compared to those from TLHs. We speculate that specialists in SLHs may be younger and more familiar with current literature due to their recent completion of residency training. In Türkiye, SLHs typically serve as the initial employment setting for specialists following residency, exposing them to contemporary practices and guidelines.

Monitoring plasma concentrations of specific serum biomarkers is a valuable tool for excluding the development of intracranial lesions after traumatic brain injury. Key relevant biomarkers include S100 Beta protein (S100B), Ubiquitin C-Terminal Hydrolase-L-1 (UCH-L1), and Glial Fibrillary Acidic Protein (GFAP) (11). In particular, a plasma S100B concentration below 0.1 mg/L within three hours of the trauma event can effectively rule out the presence of a significant intracranial lesion detectable by a CT scan. Following a traumatic incident, there is a surge in plasma concentrations of UCH-L1 and GFAP due to the former's neuron-specific nature and the latter's role as a prominent component of the astrocytic cyto-

Table III: Accuracy Rates of Answering Questions Based on Years of Neurosurgery Specialization

Variables		1-4 Years	5-8 Years	9-12 Years	>12 Years	p-value
The percentage of questions that need to be asked during patient history-taking, %	Mean±SD	53.18±23.74	60.00±19.87	54.21±23.78	50.94±26.11	0.252[a]
	Median (Min.-Max.)	55.00 (10.00-100.00)	60.00 (20.00-100.00)	50.00 (10.00-100.00)	50.00 (0.00-100.00)	
Decision to perform pediatric brain CT scan, n (%)	EMPs Perform CT and Consults	41 (62.1)	27 (67.5)	23 (60.5)	37 (57.8)	0.932[b]
	Clinical Experience	17 (25.8)	7 (17.5)	9 (23.7)	18 (28.1)	
	International Guidelines	8 (12.1)	6 (15.0)	6 (15.8)	9 (14.1)	
Decision to perform adult brain CT scan, n (%)	EMPs Perform CT and Consults	53 (81.5)	31 (77.5)	28 (73.7)	39 (60.9)	**0.035**[b]
	Clinical Experience	10 (15.4)	6 (15.0)	3 (7.9)	16 (25.0)	
	International Guidelines	2 (3.1)	3 (7.5)	7 (18.4)	9 (14.1)	
Evaluating the characteristics of trauma and the patient as high or intermediate risk, % (Question 10)	Mean±SD	66.67±16.76	69.50±19.47	71.05±17.98	69.68±20.87	0.543[a]
	Median (Min.-Max.)	70.00 (40.00-100.00)	70.00 (10.00-100.00)	70.00 (20.00-100.00)	70.00 (30.00-100.00)	
Serum biomarkers used to prevent recurrent CT scans, n (%)	False	44 (66.7)	29 (72.5)	24 (63.2)	46 (71.9)	0.744[b]
	True	22 (33.3)	11 (27.5)	14 (36.8)	18 (28.1)	
Decision for follow-up CT scan, % (Question 12)	Mean±SD	2.26±0.86	2.38±0.70	2.37±0.88	2.31±0.83	0.886[a]
	Median (Min.-Max.)	3.00 (0.00-3.00)	2.00 (0.00-3.00)	3.00 (0.00-3.00)	3.00 (0.00-3.00)	
Neutralization of oral anticoagulants and antiplatelets, %	Mean±SD	52.27±24.70	52.50±23.89	50.66±22.87	46.88±22.05	0.635[a]
	Median (Min.-Max.)	50.00 (25.00-100.00)	50.00 (25.00-100.00)	50.00 (25.00-100.00)	50.00 (0.00-100.00)	
Stepwise return to active life/sport, %	Mean±SD	35.50±22.45	37.14±21.89	28.57±16.94	27.90±17.53	0.057[a]
	Median (Min.-Max.)	28.57 (14.29-100.00)	28.57 (14.29-100.00)	28.57 (14.29-71.43)	28.57 (0.00-71.43)	
Stages of returning to school, %	Mean±SD	74.81±28.21	82.81±23.12	76.31±26.44	66.80±29.90	0.044[a]
	Median (Min.-Max.)	87.50 (12.50-100.00)	100.00 (25.00-100.00)	87.50 (12.50-100.00)	68.75 (0.00-100.00)	
Additional imaging and examination time for pediatric patients experiencing moderate symptoms or unable to resume normal activities immediately, n (%)	False	52 (78.8)	35 (87.5)	31 (81.6)	58 (90.6)	0.259[b]
	True	14 (21.2)	5 (12.5)	7 (18.4)	6 (9.4)	
Additional imaging and examination time for adult patients experiencing moderate symptoms or unable to resume normal activities immediately, n (%)	False	24 (36.4)	13 (32.5)	13 (34.2)	30 (46.9)	0.403[b]
	True	42 (63.6)	27 (67.5)	25 (65.8)	34 (53.1)	

***SS:** Standard Deviation, **Min:** Minimum, **Max:** Maximum, **a:** Kruskal Wallis H test, **b:** Chi-square test, **CT:** Computed tomography, **EMP:** Emergency medicine practitioner.*

skeleton. Monitoring strategies leveraging the biological half-lives of biomarkers can enhance assessment (11,13). Many other biomarkers have been identified in the literature (1,26). The neuron-specific enolase (NSE)/prostaglandin-D2 synthetase (PGDS) and S100B/PGDS ratios offer greater diagnostic accuracy for severe TBI compared to individual biomarker measurements (1). Similar to many countries worldwide, these biomarkers are not used routinely in Türkiye. In our study, 68.8% of the participants (143/208) were not aware of the use of these biomarkers.

Table IV: Accuracy Rates of Answering Questions Based on the Type of Hospital where Participants Currently Work

Variables		SLH	TLH	p-value
The percentage of questions that need to be asked during patient history-taking, %	Mean ± SD	54.14±23.62	53.91±24.09	0.999[a]
	Median (Min.-Max.)	50.00 (0.00-100.00)	50.00 (10.00-100.00)	
Decision to perform pediatric brain CT scan, n (%)	EMPs Perform CT and Consults	37 (52.9)	91 (65.9)	**0.028**[b]
	Clinical Experience	25 (35.7)	26 (18.9)	
	International Guidelines	8 (11.4)	21 (15.2)	
Decision to perform adult brain CT scan, n (%)	EMPs Perform CT and Consults	47 (68.2)	104 (75.4)	0.415[b]
	Clinical Experience	15 (21.7)	20 (14.5)	
	International Guidelines	7 (10.1)	14 (10.1)	
Evaluating the characteristics of trauma and the patient as high or intermediate risk, % (Question 10)	Mean ± SD	70.00±15.72	68.41±20.15	0.681[a]
	Median (Min.-Max.)	70.00 (40.00-100.00)	70.00 (10.00-100.00)	
Serum biomarkers used to prevent recurrent CT scans, n (%)	False	46 (65.7)	97 (70.3)	0.501[b]
	True	24 (34.3)	41 (29.7)	
Decision for follow-up CT scan, % (Question 12)	Mean ± SD	2.43±0.91	2.26±0.78	**0.034**[a]
	Median (Min.-Max.)	3.00 (0.00-3.00)	2.00 (0.00-3.00)	
Neutralization of oral anticoagulants and antiplatelets, %	Mean ± SD	49.64±22.32	50.72±23.96	0.947[a]
	Median (Min.-Max.)	50.00 (0.00-100.00)	50.00 (25.00-100.00)	
Stepwise return to active life/sport, %	Mean ± SD	30.82±19.09	32.92±20.83	0.532[a]
	Median (Min.-Max.)	28.57 (0.00-71.43)	28.57 (14.29-100.00)	
Stages of returning to school, %	Mean ± SD	69.82±30.43	76.36±26.41	0.110[a]
	Median (Min.-Max.)	81.25 (0.00-100.00)	87.50 (12.50-100.00)	
Additional imaging and examination time for pediatric patients experiencing moderate symptoms or unable to resume normal activities immediately, n (%)	False	56 (80.0)	120 (87.0)	0.189[b]
	True	14 (20.0)	18 (13.0)	
Additional imaging and examination time for adult patients experiencing moderate symptoms or unable to resume normal activities immediately, n (%)	False	27 (38.6)	53 (38.4)	0.981[b]
	True	43 (61.4)	85 (61.6)	

***SLH:** Secondary Level Healthcare, **TLH:** Tertiary-level healthcare, **SS:** Standard Deviation, **Min:** Minimum, **Max:** Maximum, **a:** Kruskal Wallis H test, **b:** Chi-square test, **CT:** Computed tomography, **EMP:** Emergency medicine practitioner.*

Table V: Accuracy Rates of Answering Questions Based on the Accreditation of the Residency Institution

Variables		No	Yes	p-value
The percentage of questions that need to be asked during patient history-taking, %	Mean ± SD	45.00±23.16	56.69±23.49	**0.006**[a]
	Median (Min.-Max.)	50.00 (10.00-100.00)	60.00 (0.00-100.00)	
Decision to perform pediatric brain CT scan, n (%)	EMPS Perform CT and Consults	35 (72.9)	93 (58.1)	0.141[b]
	Clinical Experience	7 (14.6)	44 (27.5)	
	International Guidelines	6 (12.5)	23 (14.4)	
Decision to perform adult brain CT scan, n (%)	EMPs Perform CT and Consults	39 (81.3)	112 (70.4)	0.191[b]
	Clinical Experience	4 (8.3)	31 (19.5)	
	International Guidelines	5 (10.4)	16 (10.1)	
Evaluating the characteristics of trauma and the patient as high or intermediate risk, % (Question 10)	Mean ± SD	69.79±19.84	68.68±18.49	0.787[a]
	Median (Min.-Max.)	70.00 (10.00-100.00)	70.00 (20.00-100.00)	
Serum biomarkers used to prevent recurrent CT scans, n (%)	False	32 (66.7)	111 (69.4)	0.723[b]
	True	16 (33.3)	49 (30.6)	
Decision for follow-up CT scan, % (Question 12)	Mean ± SD	2.31±0.93	2.32±0.80	0.707[a]
	Median (Min.-Max.)	3.00 (0.00-3.00)	3.00 (0.00-3.00)	
Neutralization of oral anticoagulants and antiplatelets, %	Mean ± SD	51.56±23.86	50.00±23.29	0.757[a]
	Median (Min.-Max.)	50.00 (25.00-100.00)	50.00 (0.00-100.00)	
Stepwise return to active life/sport, %	Mean ± SD	32.74±18.16	32.05±20.87	0.516[a]
	Median (Min.-Max.)	28.57 (14.29-85.71)	28.57 (0.00-100.00)	
Stages of returning to school, %	Mean ± SD	76.56±29.13	73.44±27.61	0.276[a]
	Median (Min.-Max.)	100.00 (12.50-100.00)	87.50 (0.00-100.00)	
Additional imaging and examination time for pediatric patients experiencing moderate symptoms or unable to resume normal activities immediately, n (%)	False	39 (81.2)	137 (85.6)	0.461[b]
	True	9 (18.8)	23 (14.4)	
Additional imaging and examination time for adult patients experiencing moderate symptoms or unable to resume normal activities immediately, n (%)	False	20 (41.7)	60 (37.5)	0.603[b]
	True	28 (58.3)	100 (62.5)	

***SS:** Standard Deviation, **Min:** Minimum, **Max:** Maximum, **a:** Kruskal Wallis H test, **b:** Chi-square test, **CT:** Computed tomography, **EMP:** Emergency medicine practitioner.*

Table VI: Accuracy Rates of Answering Questions Based on the Accreditation of the Current Institution

Variables		No	Yes	p-value
The percentage of questions that need to be asked during patient history-taking, %	Mean±SD	52.18±22.65	55.70±24.96	0.309[a]
	Median (Min.-Max.)	50.00 (10.00-100.00)	60.00 (0.00-100.00)	
Decision to perform pediatric brain CT scan, n (%)	EMPs Perform CT and Consults	70 (69.3)	58 (54.2)	0.077[b]
	Clinical Experience	19 (18.8)	32 (29.9)	
	International Guidelines	12 (11.9)	17 (15.9)	
Decision to perform adult brain CT scan, n (%)	EMPs Perform CT and Consults	78 (77.2)	73 (68.8)	0.300[b]
	Clinical Experience	13 (12.9)	22 (20.8)	
	International Guidelines	10 (9.9)	11 (10.4)	
Evaluating the characteristics of trauma and the patient as high or intermediate risk, % (Question 10)	Mean±SD	68.22±19.10	69.62±18.51	0.678[a]
	Median (Min.-Max.)	70.00 (10.00-100.00)	70.00 (30.00-100.00)	
Serum biomarkers used to prevent recurrent CT scans, n (%)	False	67 (66.3)	76 (71.0)	0.466[b]
	True	34 (33.7)	31 (29.0)	
Decision for follow-up CT scan, % (Question 12)	Mean±SD	2.31±0.86	2.33±0.80	0.978[a]
	Median (Min.-Max.)	3.00 (0.00-3.00)	3.00 (0.00-3.00)	
Neutralization of oral anticoagulants and antiplatelets, %	Mean±SD	52.23±22.94	48.50±23.75	0.238[a]
	Median (Min.-Max.)	50.00 (25.00-100.00)	50.00 (0.00-100.00)	
Stepwise return to active life/sport, %	Mean±SD	32.39±20.19	32.04±20.38	0.852[a]
	Median (Min.-Max.)	28.57 (14.29-100.00)	28.57 (0.00-100.00)	
Stages of returning to school, %	Mean±SD	75.62±28.25	72.78±27.68	0.436[a]
	Median (Min.-Max.)	87.50 (12.50-100.00)	75.00 (0.00-100.00)	
Additional imaging and examination time for pediatric patients experiencing moderate symptoms or unable to resume normal activities immediately, n (%)	False	86 (85.1)	90 (84.1)	0.836[b]
	True	15 (14.9)	17 (15.9)	
Additional imaging and examination time for adult patients experiencing moderate symptoms or unable to resume normal activities immediately, n (%)	False	41 (40.6)	39 (36.4)	0.539[b]
	True	60 (59.4)	68 (63.6)	

EMP: *Emergency medicine practitioner,* ***SS:*** *Standard Deviation,* ***Min:*** *Minimum,* ***Max:*** *Maximum,* ***a:*** *Kruskal Wallis H test,* ***b:*** *Chi-square test,* ***CT:*** *Computed tomography.*

Definitions and criteria for mTBI:

1. The presence of one or more of the following symptoms:
   - Disorientation or confusion
   - Loss of consciousness lasting less than 30 minutes
   - Post-traumatic amnesia lasting less than 24 hours
   - Other temporary neurological issues, including focal deficits, seizures, or intracranial injuries that do not require surgical treatment
2. A GCS score ranging from 13 to 15, measured 30 minutes after the injury or later during the evaluation for treatment.

The patients with mTBI should not be referred to the ED for evaluation:

In the absence of the following conditions, these patients may not need to be directed to the emergency service, provided they can be monitored by a third party:

- Existing coagulation disorders, including those receiving anticoagulant therapy
- Individuals over 65 years of age who are also on antiplatelet medications
- Intoxication (due to substances such as medications, alcohol, etc.)
- Symptoms beyond headaches (such as vomiting, loss of consciousness, amnesia lasting more than 30 minutes, seizures, focal neurological deficits, or decreased awareness);
- Evidence of trauma (like eyelid hematoma, depressed skull fracture, signs of a basilar skull fracture, or mastoid hematoma).

Clinical and anamnesis criteria indicating the risk of intracranial lesions following mTBI:

High Risk Factors

Anamnesis Factors: Coagulation disorders, such as those treated with anticoagulants, dual antiplatelet therapy, or congenital bleeding conditions (e.g., hemophilia, von Willebrand disease).

Clinical Factors:

- Signs indicative of a basilar or cranial skull fracture, including: csf leakage from the nose or ears (otorrhea or rhinorrhea), mastoid bruising, periorbital bruising, hemotympanum or bleeding visible from the ear canal, palpable discontinuity of the cranial vault, suspected open or closed depressed skull fracture, more than one episode of vomiting
- Post-traumatic seizures
- Presence of focal neurological deficits
- GCS score of less than 15 two hours post-trauma in the absence of intoxication.

Intermediate Risk Factors

Anamnesis Factors: Age over 65 years while on single antiplatelet therapy, gcs score less than 15 two hours after the injury in the context of intoxication, high-energy trauma, which may include situations such as: ejection of the occupant from a vehicle, pedestrian or cyclist who is not wearing a helmet struck by a vehicle, rollover of a vehicle or falls from a height greater than five stairs or over two meters

Clinical Factors: Amnesia regarding events occurring more than 30 minutes following the traumatic incident.

The role of biomarkers:

- S100B (Within the three hours following mTBI in patients identified as being at intermediate risk, the aim is to reduce the number of brain scans performed.)
- UCH-L1 and/or GFAP (Within the 12 hours after mild traumatic brain injury in patients considered to be at intermediate risk, the goal is to minimize the number of brain scans performed.)

The optimal timeframe for performing a brain scan to exclude intracranial lesions is as follows:

- Ideally, within one hour of admission to emergency facilities for patients at high risk of clinical deterioration or intracranial lesions.
- At the latest, within the first eight hours for patients identified as being at intermediate risk of clinical deterioration or intracranial lesions.

Patients with a transcranial lesion on the initial CT scan should have follow-up imaging conducted within the first 48 hours under the following circumstances:

- Neurological deterioration
- Age over 65 years
- Coagulation disorders not solely related to aspirin use

In patients treated with oral anticoagulant, the indications and modalities for reversal of these therapies (expert recommendations):

- The immediate reversal of vitamin K antagonists and direct oral anticoagulants in mTBI patients who present with an intracranial hemorrhagic lesion identified through imaging, aiming to reduce the risk of neurological aggravation.
- A collaborative discussion regarding the management strategies for patients with a mechanical heart valve.
- Not to neutralize aspirin in patients who have an intracranial hemorrhagic lesion and are being treated with aspirin following mTBI, the objective being to limit the risk of neurological aggravation.

Criteria for discharge from the ED:

Even if patients are receiving anticoagulants or antiplatelet medications, experts recommend that they be allowed to return home from the emergency facility as long as at least one of the following criteria is met:

- The patient is assessed to be at low risk for bleeding
- Serum biomarker tests are negative (when applicable)
- No brain lesions are detected on the initial imaging studies

When should additional imaging and examinations be performed for patients experiencing moderate to severe symptoms or those unable to resume their usual activities immediately?

- Adults: 1-2 weeks
- Pediatrics: >2-4 weeks

Figure 1: Expert recommendations for the diagnosis, management, and follow-up of mild traumatic brain injury (11) utilized for developing our survey. (**mTBI:** mild traumatic brain injury, **ED:** emergency department, **GCS:** Glasgow Coma Scale, **CT:** computed tomography, **CSF:** cerebrospinal fluid, **S100B:** S100 Beta protein, **UCH-L1:** Ubiquitin C-Terminal Hydrolase-L-1, **GFAP:** Glial fibrillary acidic protein)

Management of patients with concussion/mTBI requires careful consideration of anticoagulant and antiplatelet therapy. In cases of concurrent intracranial lesions post-trauma, neutralizing oral anticoagulants is imperative, whereas aspirin neutralization is unnecessary (11). Research indicates that aspirin does not worsen the prognosis, and platelet transfusions are not beneficial in patients with expanding intracranial hemorrhage (2). Patients receiving clopidogrel therapy are at a higher risk of bleeding and surgical intervention post-trauma (17), with platelet transfusion potentially mitigating the risk of further bleeding, neurosurgery, and mortality (15). Although prasugrel and ticagrelor are associated with a higher bleeding risk compared to clopidogrel, there has been no assessment of neutralizing their effects (11). The correct response rate for this question ranged from 46.8% to 52.2% among participants, varying by years of neurosurgery specialization. This finding further underlines inadequate knowledge of the guidelines among the participants.

TBI can lead to post-concussion syndrome (PCS), with a persistent PCS (PPCS) linked to negative outcomes such as reduced community reintegration, increased healthcare utilization, higher economic costs, heightened cognitive strain, and exacerbation of psychiatric symptoms (18). PPCS is characterized by headaches, dizziness, cognitive impairments, balance issues, behavioral changes, and disruptions in sleep (21,22,29,33,41). The prevalence of depressive disorders remains notably high and debilitating, particularly in the chronic phases following TBI (14). Despite this, the guidelines are not widely known or effectively disseminated (3,19). Recent research emphasizes the importance of initiating PCS treatment promptly, preferably in the ED, advocating for a multidisciplinary approach (9). While children and youth may exhibit similar post-concussion symptoms to adults, researchers stress the need for a more careful approach for managing concussions in pediatric patients due to their unique physiological characteristics (4,5,28,35,38). For pediatric patients with acute concussion, current guidelines recommend 24–48 hours of relative rest, followed by gradual reintroduction of non-contact activities, ensuring symptoms do not worsen. Prolonged periods of complete rest are discouraged in pediatric concussion rehabilitation, as it may exacerbate symptoms or prolong recovery time during the acute phase (6). In the context of higher education, current recommendations for PPCS have been criticized as inadequate and/or impractical. This highlights the need for a multidisciplinary and individually tailored care approach involving medical and academic stakeholders (12,27,32). In our study population, adherence to recommendations for a gradual return to active life/sport ranged from 27.9% to 35.5%, while adherence to recommendations for returning to school ranged from 68.7% to 100%, depending on the years of neurosurgery experience. The notably low awareness, particularly regarding the return to active life/sport perpetuates the increasing prevalence of PCS in the community. This knowledge gap also imposes a significant economic burden on healthcare systems.

For adult patients experiencing moderate symptoms or unable to resume normal activities immediately, additional imaging and examination time was 1–2 weeks. In contrast, pediatric patients in similar circumstances had an additional time frame of >2–4 weeks. The incorrect response rate for adults was 38.5%, whereas the pediatric group demonstrated a significantly higher rate of 84.6%. Because of the greater malleability or plasticity of pediatric brain tissue (16), it is common for symptoms to endure for longer periods before necessitating further evaluation in adults. However, we attributed the high rate of incorrect responses from participants in the pediatric group not only to a lack of familiarity with guidelines but also to parental pressure and concerns regarding potential malpractice. While guidelines eventually categorize concussion management by age, the lack of evaluation based on gender differences remains an oversight. In a recent study (36), females were found more susceptible to concussions, especially sports-related concussions. Given this knowledge gap, our study intentionally avoided querying participants about gender-specific considerations, recognizing the need for further investigation into this critical aspect of concussion care.

Some limitations of this study need to be acknowledged. The 11% response rate in this survey limits the generalizability of the findings to the national context. Additionally, the uneven participation rate, with TLHs contributing twice as many respondents as SLHs, may have skewed the results in favor of or against TLHs. Notably, EMPs are often responsible for deciding on the initial CT scan for patients in both SLHs and TLHs, highlighting another limitation due to the study's lack of a multidisciplinary design. Considering the need for a distinct survey for EMPs and the prospective complexities in statistical analysis, the survey was exclusively administered to neurosurgeons. Furthermore, the intrinsic nature of the survey raises concerns about the precision and authenticity of the participants' responses. Lastly, due to a participant providing an incomplete response to question 8, Tables III-VI display 207 participants for the relevant question.

CONCLUSION

Despite the proliferation of guidelines for the diagnosis, management, and rehabilitation of concussion/mTBI, a pressing public health issue affecting all age groups, consensus remains elusive. Our study is the first such study to exclusively include neurosurgeons for assessing adherence to and awareness of current concussion/mTBI guidelines. No significant differences were observed based on the participants' expertise level, affiliations, or institutional accreditations. However, significant knowledge gaps were identified, particularly regarding the use of serum biomarkers, neutralization of antiplatelet/anticoagulant medications, awareness of stepwise return to active life/school protocols, and management of persistent symptoms. Our findings highlight the need for organizing national workshops to address these knowledge gaps.

Declarations

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Availability of data and materials: The datasets generated and/or analyzed during the current study are available from the corresponding author by reasonable request.

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AUTHORSHIP CONTRIBUTION

Study conception and design: SC, BB, FY

Data collection: SC, BB, ÇT, ÇE, EE, UAD

Analysis and interpretation of results: BB, BA, MET, MEC, FY

Draft manuscript preparation: SC, FY, EE

All authors (SC, BB, CT, CE, EE, UAD, BA, MET, MEC, FY) reviewed the results and approved the final version of the manuscript.

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