EXPERT ASSESSMENT OF DIAGNOSTIC DEFECTS IN TRAUMATIC BRAIN INJURY WITH DAILY FATALITY RATES DEPENDING ON THE DURATION OF TREATMENT AND PATIENTS' HOSPITAL STAY

[a]ALINA PLETENETSKA, [b]IVAN DEMCHENKO, [c]YEVHENII VARFOLOMEIEV

[a-c]Bogomolets National Medical University, 5, Mechnikova Str., 01133, Kyiv, Ukraine
email: [a]fantasyalinka@gmail.com, [b]demchenkoivan@gmail.com, [c]war.fall.ev@gmail.com

Abstract: One common diagnostic error in traumatic brain injury (TBI) assessment is the failure to recognize and properly evaluate the initial injury. The aim of our study was to find out diagnostic defects in traumatic brain injury with daily fatality rates depending on the duration of treatment and patients' hospital stay by analyzing the medical records of patients in Kyiv City Clinical Emergency Hospital. 102 cases of fatalities that occurred within 24 hours after admission to KCCEH (2012-2019 years) in cases of TBI were analyzed. Medical histories of the deceased and data from the forensic autopsy had been analyzed. It was found that the highest number of defects in diagnostic procedures, such as the absence of a complete description of the local status of head injuries, the lack of comprehensive assessment and objectification of hemodynamics and respiratory function, and the absence of neurovisualization, were found among patients who stayed in the hospital for up to 3 hours. There was a higher percentage of cases with discrepancies in diagnoses between forensic medical workers and clinicians as the duration of patients' hospital stay increased. The departments where the highest number of deaths occurred varied based on the duration of stay and treatment. The neurosurgical department had the highest number of deaths with a duration of 6 to 12 hours, while the polytrauma department had the highest number of deaths within the first 3 hours. The neurological department had the highest number of deaths with a duration of stay in the hospital from 6 to 12 hours.

Keywords: traumatic brain injury; acute blood loss; diagnosis defects; forensic-medical examination.

1 Introduction

One common diagnostic error in traumatic brain injury (TBI) assessment is the failure to recognize and properly evaluate the initial injury. Capizzi et al. [3] emphasize the importance of understanding the epidemiology and pathophysiology of TBI to ensure accurate diagnosis. Diagnostic errors may arise from inadequate knowledge or misinterpretation of the signs and symptoms associated with TBI. In emergency settings, where time is of the essence, healthcare providers may face challenges in making accurate diagnoses due to the complexity and variability of TBI presentations [1; 2]. Another significant diagnostic error is the failure to detect subtle or delayed manifestations of TBI. Fernholm et al. [6] highlight the importance of addressing diagnostic errors in primary healthcare and emergency departments to prevent harm to patients. TBI symptoms can sometimes be non-specific or present with delayed onset, leading to underdiagnosis or misdiagnosis. These errors may result from a lack of awareness or reliance on initial assessments that do not capture the full extent of the injury [6; 7; 9].

In emergency conditions, the time-sensitive nature of TBI diagnosis introduces additional challenges. Diagnostic errors may occur due to time constraints, limited access to comprehensive diagnostic tools, or reliance on incomplete information. Hautz et al. [9] demonstrate that diagnostic errors in emergency rooms can lead to increased mortality rates and prolonged hospital stays. Kafor et al. [10] further emphasize the importance of learning from voluntary reports of diagnostic errors to enhance diagnostic accuracy in emergency medicine. Furthermore, the prevalence of diagnostic errors in TBI assessment is a significant concern. Gunderson et al. [8] conducted a systematic review and meta-analysis, revealing a high prevalence of harmful diagnostic errors in hospitalized adults. These errors can stem from a range of factors, including cognitive biases, inadequate communication among healthcare providers, and system-level issues [8]. To address these diagnostic errors, it is essential to foster a culture of continuous learning and improvement in TBI assessment. Majdan et al. [11] conducted a cross-sectional analysis of TBI epidemiology in Europe, highlighting the need for a comprehensive understanding of the regional burden. Newman-Toker et al. [12] emphasize the importance of systematic reviews to gain insights into diagnostic errors in the emergency department, enabling the development of effective strategies for improvement.

In conclusion, the accurate diagnosis of TBI, particularly in emergency conditions, is crucial for optimal patient outcomes. It should be noted that diagnostic defects in TBI can significantly worsen the forensic assessment of TBI later. Diagnostic defects reduce the quality of medical care, so they require a detailed analysis, which can be done as part of a forensic medical examination.

The aim of our study was to find out diagnostic defects in traumatic brain injury with daily fatality rates depending on the duration of treatment and patients' hospital stay by analyzing the medical records of patients in Kyiv City Clinical Emergency Hospital (KCCEH).

2 Method

102 cases of fatalities that occurred within 24 hours after admission to KCCEH (2012-2019) in cases of traumatic brain injury (TBI) were analyzed. During the study, we examined the archived medical records of the deceased, including their inpatient cards, as well as the accompanying documentation from the Ambulance crew, and the findings from medical reports containing data from forensic autopsies (which were documented in the inpatient cards). Data processing and analysis were carried out in OpenOffice software packages (Base, Calc, Writer, Draw, Math), GNU Octave with saving of source documents in *.doc, *.xls format. This is open source software and its use is governed by the GPL (GNU General Public License) and the IBM SPSS trial. The following statistical indicators were determined: arithmetic mean (M), standard deviation (SD), number of cases (N, n), frequency (P) of occurrence and 95% confidence interval (95% CI). The statistical significance of the differences between the two compared values was assessed by the Student's test (t). The level of statistical significance for the study is $p \leq 0.05$.

3 Results

The analyzed cases were divided into the following groups: isolated TBI –62 cases (60,8 ± 9,5%) and combined TBI – 40 (39,2±9,5%).

The duration of treatment until the occurrence of a fatal case was divided into the following groups (from the moment of admission): up to 3 hours – 30 cases (29.4%), from 3 to 6 hours – 14 cases (13.7%), from 6 to 12 hours – 32 cases (31.4%), from 12 to 24 hours – 26 cases (25.5%). When distinguishing patients depending on the causes of death:

- In patients who died from TBI (64): up to 3 hours - 13 (20.3±9.9%) observations, from 3 to 6 hours - 9 (14.1±8.5%) cases, from 6 to 12 hours - 19 (29.7±11.2%) observations, from 12 to 24 hours - 23 (35.9±11.8%) cases;

- In patients with TBI who died from acute blood loss (38): up to 3 hours – 17 (44.7±15.8%) observations, from 3 to 6 hours – 12 (31.6±14.8%) cases, from 6 to 12 hours - 6 (15.8±11.6%) observations, from 12 to 24 hours - 3 (7.9±8.6%) cases (Figure. 1)

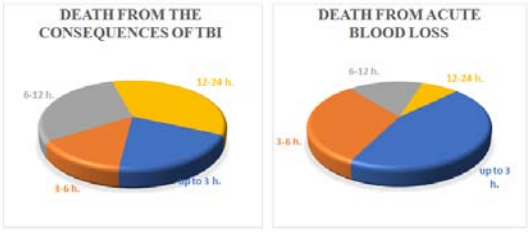

Figure 1. Distribution of deaths per day from the consequences of TBI and from acute blood loss depending on the duration of treatment before the occurrence of a fatal event, %.

In the group of patients who died within 3 hours, the average age was 40.7±12.5 years. The average age of patients who died within the time frame of 3-6 hours was 38.9±11.3 years. In the group of patients who died within the time frame of 6-12 hours, the average age was 42.9±12.4 years. The average age of patients who died within the time frame of 12-24 hours was 41.5±11.7 years. The age difference did not reach statistical significance ($p > 0.05$).

Fatal outcomes in males were observed in 18 cases (60.0±17.5%) within 3 hours, and in 12 cases (85.7±18.3%) within the 3-6 hours period. Fatal outcomes in females were observed in 10 cases (33.3±16.9%) within 3 hours, and in 8 cases (57.1±25.9%) within the 3-6 hours period ($p<0.05$). Fatal outcomes in males within the 6-12 hours period were observed in 22 cases (68.8±16.1%), and in the 12-24 hours period, they were observed in 16 cases (61.5±18.7%). Fatal outcomes in females within the 6-12 hours period were observed in 8 cases (25.0±15.0%), and in the 12-24 hours period, they were observed in 8 cases (30.8±17.7%).

Alcohol intoxication was observed in 30 patients (90.0±10.7%) with a treatment duration of up to 3 hours, and in 12 patients (85.7±18.3%) - with a treatment duration of 3-6 hours. It was observed in 17 patients (53.1±17.3%) with a treatment duration of 6-12 hours, and in 18 patients (69.2±17.7%) with a treatment duration of 12-24 hours. The difference did not reach statistically significant levels ($p > 0.05$).

Divergence between the diagnosis established by the EMC (emergency medical care) workers at the pre-hospital stage and the forensic-medical diagnosis was observed in patients with treatment durations of up to 3 hours and 3-6 hours, with 2 cases (6.7±8.9%) and 4 cases (28.6±23.7%) respectively. Divergence in diagnosis occurred in 10 cases (31.3±16.1%) during treatment durations of 6-12 hours, and in 12 cases (46.2±19.2%) during treatment durations of 12-24 hours. The frequency of this discrepancy reached its maximum value during treatment durations of 12-24 hours, but the difference did not reach statistical significance ($p > 0.05$).

The absence or incomplete description of the local status of external head injuries was observed in 29 patients (96.7±6.4%) who died within 3 hours, and in 13 patients (92.9±13.5%) in whom fatal events occurred within the 3-6 hours period following hospitalization. The absence/incomplete description of the local status was also observed in 29 patients (90.6±10.1%) who died within the 6-12 hours period, and in 21 patients (80.8±15.1%) in whom fatal events occurred within the 12-24 hours period following hospitalization. The difference did not reach statistical significance ($p > 0.05$).

The absence of assessment and objectification of hemodynamics and external respiration using laboratory indicators and ECG (electrocardiography) was observed in 19 (63.3±17.2%) patients who died within 3 hours of hospitalization and in 6 (42.9±25.9%) patients who died within the 3-6 hours period after hospitalization. The absence of assessment and objectification of hemodynamics and external respiration using laboratory indicators and ECG was observed in 24 (75.0±15.0%) patients who died within the 6-12 hours period and in 15 (57.7±19.0%) patients who died within the 12-24 hours period after hospitalization. The difference does not reach statistical significance ($p > 0.05$).

The absence of examination by a neurologist/neurosurgeon with clinical-neurological assessment according to standards and international scales (such as Glasgow and others) was observed in patients with fatal outcomes within 3 hours in 28 cases (93.3±8.9%) and in cases where fatal consequences occurred within the 3-6 hours period after hospitalization - in 12 cases (85.7±18.3%). The absence of examination by a neurologist/neurosurgeon with clinical-neurological assessment according to standards and international scales was also observed in patients who later died within the 6-12 hours period in 21 cases (65.6±16.5%) and in cases where fatal consequences occurred within the 12-24 hours period after hospitalization in 17 cases (65.4±18.3%). The frequency of this deficiency reaches its maximum value within treatment durations of up to 3 hours, but the difference does not reach statistical significance ($p > 0.05$).

The absence of neurovisualization (CT/MRI, radiography, etc.) was found in 27 patients (90.0±10.7%) in whom fatal events occurred within the period up to 3 hours after hospitalization and in 12 patients (85.7±18.3%) in whom fatal events occurred within the 3-6 hours period after hospitalization. The absence of neurovisualization (CT/MRI, radiography, etc.) was observed in 24 patients (75.0±15.0%) in whom fatal events occurred within the 6-12 hours period after hospitalization and in 7 patients (26.9±17.0%) in whom fatal events occurred within the 12-24 hours period after hospitalization. The defects were statistically significantly more frequent ($p < 0.05$) in patients who died within 3 hours of hospitalization.

The maximum number of daily deaths among patients who stayed in the hospital for up to 3 hours was observed in the III quarter of the year, at 46.7±17.8%. For patients who stayed in the hospital for 3-6 hours, the maximum number of daily deaths was observed in the IV quarter of the year, at 57.1±17.7%. For patients who stayed in the hospital for 6-12 hours, the maximum number of daily deaths was observed in the II and IV quarters of the year, at 31.3±16.5% each. The maximum number of daily deaths among patients who stayed in the hospital for 12-24 hours was observed in the I quarter of the year, at 38.5±18.7%. The difference does not reach statistical significance ($p > 0.05$).

As seen from Figure 2, the diagnostic measures conducted for patients vary depending on the duration of treatment and their stay in the hospital. The maximum number of diagnostic deficiencies (specifically, the absence of a complete description of the local status with external head injuries, lack of a comprehensive and qualitative assessment and objectification of hemodynamics and external respiration using laboratory indicators and ECG, and absence of neurovisualization) occurs during the period of treatment and patient stay in the hospital up to 3 hours. However, the highest percentage of cases where patients were not fully examined by a neurologist/neurosurgeon with clinical-neurological assessment according to standards and international scales (such as Glasgow) was found during the 6-12 hours period of patients' stay in the hospital. Regarding the comprehensive and qualitative assessment and objectification of hemodynamics and external respiration using laboratory indicators and ECG, the absence (or poor quality) of it was more frequently observed during the 6-12 hours period compared to the 3-6 hours period. The percentage of cases with a discrepancy between the diagnoses of the medical staff and the forensic medical staff increased with the increase of the patient's stay in hospital (Figure 2).

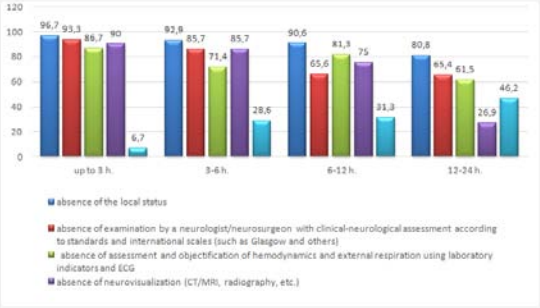

Figure 2. Distribution of diagnostic defects in patients who died with TBI per day depending on the duration of treatment and stay of patients in the hospital, %.

Analyzing the departments where patients died daily based on the duration of their stay and treatment in the hospital, it was found that the highest number of deaths occurred in the neurosurgical department with a duration of 6 to 12 hours (34.5±19.0%). In the polytrauma department, the highest number of deaths occurred within the first 3 hours (37.5±17.3%). In the neurological department, the highest number of deaths occurred with a duration of stay in the hospital from 6 to 12 hours (66.66±16.3%) (Table 1).

Table 1: The frequency of hospitalization in departments depending on the duration of treatment and stay of patients in the hospital

Interval time to death	N, abs.	Neurosurgical			Polytrauma			Neurological		
		N, abs.	P, %	CI, %	N, abs.	P, %	CI, %	N, abs.	P, %	CI, %
Up to 3 h.	30	14	467	179	16	533	179		00	00
3-6 h.	14	12	857	183	2	143	183		00	00
6-12 h.	32	20	625	168	8	250	150	4	125	115
12-24 h.	26	12	462	192	6	231	162	8	308	177
In total	102	58			32			12		

4 Discussion

Our research findings on traumatic brain injury (TBI) with acute blood loss are consistent with the previously cited sources [1; 3; 5; 9; 11]. The high mortality rate observed within 3 hours of hospital admission highlights the critical nature of acute blood loss in TBI, emphasizing the urgent need for timely interventions to improve patient outcomes [1; 11]. This aligns with the global incidence of TBI and its association with increased mortality rates [5].

Our study identifies common defects in diagnostic procedures, particularly among patients with shorter hospital stays [1]. These defects include the absence of a complete description of the local status of head injuries, the lack of comprehensive assessment and objectification of hemodynamics and respiratory function, and the absence of neurovisualization [1, 3]. These findings coincide with the importance of accurate and thorough diagnostic assessments in TBI management [3]. By addressing these defects, healthcare professionals can improve the quality of TBI diagnosis and subsequently enhance patient care and outcomes.

Regarding discrepancies in diagnoses, our study aligns with previous research, revealing an increased percentage of cases with discrepancies between diagnoses made by forensic medical workers and clinicians as the duration of hospital stay increases [2]. This emphasizes the challenges in achieving consistent and accurate diagnoses throughout the patient's journey and highlights the need for effective communication and collaboration among healthcare professionals to ensure optimal TBI management [2].

Furthermore, the variation in departments where the highest number of deaths occurred based on the duration of stay and treatment is consistent with the findings of other studies [3]. The neurosurgical department recorded the highest number of deaths with a duration of 6 to 12 hours, while the polytrauma department had the highest number of deaths within the first 3 hours [3]. Additionally, the neurological department had the highest number of deaths with a duration of stay in the hospital from 6 to 12 hours [3]. These departmental variations highlight the importance of specialized care and tailored interventions for different phases of TBI management [3].

The alignment of our findings with previous research highlights the significance of detecting and addressing diagnostic errors in TBI assessment. By improving diagnostic procedures, reducing discrepancies in diagnoses, and implementing specialized care strategies, healthcare providers can enhance the quality of TBI diagnosis and improve patient outcomes. The insights gained from comparing our results with existing research highlight the ongoing need for standardized protocols, interdisciplinary collaboration, and continuous quality improvement efforts in TBI diagnosis and management.

5 Conclusion

1. The highest number of defects in diagnostic procedures, such as the absence of a complete description of the local status of head injuries, the lack of comprehensive assessment and objectification of hemodynamics and respiratory function, and the absence of neurovisualization, were found among patients who stayed in the hospital for up to 3 hours.
2. There was a higher percentage of cases with discrepancies in diagnoses between forensic medical workers and clinicians as the duration of patients' hospital stay increased.
3. The departments where the highest number of deaths occurred varied based on the duration of stay and treatment. The neurosurgical department had the highest number of deaths with a duration of 6 to 12 hours, while the polytrauma department had the highest number of deaths within the first 3 hours. The neurological department had the highest number of deaths with a duration of stay in the hospital from 6 to 12 hours.

These findings suggest the need for improvements in diagnostic procedures, particularly in assessing hemodynamics and respiratory function using laboratory indicators and ECG in Ukraine. Additionally, efforts should be made to enhance the quality of clinical assessments and neurovisualization for patients who have shorter hospital stays. The discrepancies in diagnoses between forensic medical workers and clinicians should also be addressed to ensure accurate and effective patient care.

Diagnostic defects affect the assessment of the quality of medical care provided within the forensic-medical examination in Ukraine. These defects can result in improper treatment and negatively impact patient outcomes. Recognizing and addressing these defects are crucial steps towards improving the quality of medical care in Ukraine.

Literature:

1. Aaronson, E., Borczuk, P., Benzer, T., Shum, L., Hughes, L. (2018). 72h returns: A trigger tool for diagnostic error. American *Journal of Emergency Medicine, 36*(3), 359-361. doi:10.1016/j.ajem.2017.08.019.

2. Burke, L.G., Epstein, S.K., Burke, R.C., Schuur, J.D., Kocher, K.E. (2020). Trends in Mortality for Medicare Beneficiaries Treated in the Emergency Department From 2009 to 2016. *JAMA Internal Medicine, 180*(1), 80-88. doi:10.1001/jamainternmed.2019.4866.

3. Capizzi, A., Woo, J., Verduzco-Gutierrez, M. (2020). Traumatic brain injury: an overview of epidemiology, pathophysiology, and medical management. *Medical Clinics of North America, 104*(2), 213-238. doi:10.1016/j.mcna.2019.11.001.
4. Centers for Disease Control and Prevention. Traumatic Brain Injury & Concussion. Accessed June 6, 2023. https://www.cdc.gov/traumaticbraininjury/index.html.
5. Dewan, M.C., Rattani, A., Gupta, S., et al. (2019). Estimating the global incidence of traumatic brain injury. *Journal of Neurosurgery, 130*, 1080-1097. doi:10.3171/2018.11.JNS182858.
6. Fernholm, R., Pukk Härenstam, K., Wachtler, C., Nilsson, G.H. (2019). Diagnostic errors reported in primary healthcare and emergency departments: A retrospective and descriptive cohort study of 4830 reported cases of preventable harm in Sweden. *European Journal of General Practice, 25*(3), 128-135. doi:10.1080/13814788.2019.1625886.
7. Gleason, K.T., Peterson, S., Dennison Himmelfarb, C.R., Wu, A.W., Newman-Toker, D.E. (2020). Feasibility of patient-reported diagnostic errors following emergency department discharge: a pilot study. Diagnosis (Berl). doi:10.1515/dx-2020-0014. PMID:33006949.
8. Gunderson, C.G., Bilan, V.P., Holleck. J.L., et al. (2020). Prevalence of harmful diagnostic errors in hospitalized adults: a systematic review and meta-analysis. *BMJ Quality & Safety, 29*, 1008-1018. doi:10.1136/bmjqs-2019-010822. PMID:32269070.
9. Hautz, W.E., Kämmer, J.E., Hautz, S.C., et al. (2019). Diagnostic error increases mortality and length of hospital stay in patients presenting through the emergency room. *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine, 27*(1), 54. doi:10.1186/s13049-019-0629-z. PMID:31068188.
10. Kafor, N., Payne, V.L., Chathampally, Y., Singh, H. (2016). Using voluntary reports from physicians to learn from diagnostic errors in emergency medicine. *Emergency Medicine Journal, 33*(4), 245-252. doi: 10.1136/emermed-2014-204604. PMID:26531860.
11. Majdan, M., Plancikova, D., Brazinova, A., Rusnak, M., Nieboer, D., Maas, A.I. (2016). Epidemiology of traumatic brain injuries in Europe: a cross-sectional analysis. *Lancet Public Health, 1*(2), e76-e83.
12. Newman-Toker, D.E., Peterson, S.M., Badihian, S., et al. (2022). Diagnostic Errors in the Emergency Department: A Systematic Review. AHRQ Comparative Effectiveness Reviews. Rockville (MD): Agency for Healthcare Research and Quality (US). PMID: 36574484. https://www.ncbi.nlm.nih.gov/books/NBK588118/

Primary Paper Section: F

Secondary Paper Section: FE, FH

Given that the study was conducted on archival material of deceased patients, informed consent wasn't taken. The study was approved by the local Commission for Bioethical Expertise and Research Ethics of Bogomolets National Medical University.

This scientific work is an individual research work "Expert-diagnostic system of objectification of forensic medical examination of traumatic brain injury" (state registration number: 0123U101528, term: 2023–2026) and was carried out on the basis of the Department of Forensic Medicine and Medical Law of Bogomolets National Medical University.