EXPERT AND CLINICAL ASSESSMENT OF DEFICIENCIES IN PROVIDING CARE TO PATIENTS WITH TRAUMATIC BRAIN INJURY AND HEMORRHAGIC STROKE DUE TO THE RUPTURE OF CEREBRAL ANEURYSM

Alina O. Pletenetska¹, Svitlana O. Lytvak², Maksym V. Yamkovyi², Oleksandr O. Sadovskyi², Tetyana M. Lukash², Lilija V. Chobitko³

¹ – Bogomolets National Medical University, Kyiv, Ukraine
² – Shupyk National Healthcare University of Ukraine, Kyiv, Ukraine
³ – State Institution «Romodanov Neurosurgery Institute» of the National Academy of Medical Sciences of Ukraine, Kyiv, Ukraine

Summary

Introduction. The relevance of conducting this study is determined by the necessity to create organizational conditions and optimize the clinical-diagnostic aspect of medical care for patients with traumatic brain injury (TBI) and acute stroke. This aims to improve patients’ quality of life by enhancing the effectiveness of medical care provision in Ukraine. This improvement is based on identifying the causes and analyzing deficiencies in medical care for these conditions.

The aim of the research is to investigate the specificity of deficiencies in providing medical care to patients with isolated traumatic brain injury and acute hemorrhagic stroke due to the rupture of cerebral arterial aneurysms based on a retrospective analysis of medical documentation, as well as the results of patient treatment in cases of discrepancies between clinical and forensic diagnoses concerning the primary, concomitant diseases, and their complications.

Materials and methods. Clinical assessment of the results of providing care to patients with traumatic brain injury and stroke was conducted through a retrospective analysis of medical documentation of patients who were hospitalized with these pathologies. The applied methods include clinical and laboratory investigations of homeostasis and metabolism parameters, and instrumental techniques.

Results. In the identified influence of the timing of the operation (within the first few days) and the breakthrough of blood in the subarachnoid space of the brain, including with intracranial hemorrhage as a result of a re-rupture of a cerebral arterial aneurysm, on the risk of lethal outcomes of surgical treatment, a rationale for searching ways to optimize therapeutic tactics in this category of patients was provided. This includes identifying defects and shortcomings in the organizational aspect of medical care.

Conclusions. Based on the analysis and identification of the most informative factors influencing the results of surgical treatment of cerebral aneurysms, a prediction system has been developed that allows calculating the probability of its outcome. The application of the forecast is advisable to consider in the prevention and timely detection of possible deficiencies in providing medical care to patients with stroke.

Key words: defects in care, traumatic brain injury, cerebrovascular diseases, arterial aneurysm, public administration, healthcare organization

INTRODUCTION

Official statistics on «medical errors» are not maintained in Ukraine, which is associated with the absence of a clear definition of this concept in Ukrainian legislation and regulatory acts. However, information is provided through official mass media that up to 10 thousand patients die annually from «medical errors» in the country [1]. A semantic analysis of medical literature defines the term «medical error» as a defect or mistake in professional medical activity if it is made without conscious negligence or carelessness on the part of the doctor. In the section of
the Criminal Code of Ukraine titled «Crimes against life and health of an individual», there are 11 articles under which medical or pharmaceutical workers may be held accountable (Articles 131, 132, 136, 137, 139-145 of the Criminal Code of Ukraine).

Patient rights advocates and representatives of patient rights organizations are advocating for increased accountability for medical practitioners. However, according to many authors, increasing the pressure of criminal legislation on the medical field may not solve this problem [2-4]. Nevertheless, if a defect in providing assistance is proven to have caused significant harm to a patient’s health or led to the patient’s death, medical practitioners can face criminal, civil, administrative, and disciplinary responsibility.

Civil liability primarily refers to the financial responsibility of medical practitioners and/or healthcare institutions. In most advanced countries, including those with a developed insurance market for doctors and healthcare institutions, civil liability covers cases of defects in providing assistance and medical errors. In Germany, for instance, according to Deutsche Welle (DW), statistics on «medical errors» are maintained by several associations of insurance companies and expert communities [5].

Medical errors are categorized into deontological, diagnostic, and therapeutic. According to the Criminal Code of Ukraine, three conditions are necessary for criminal responsibility for a committed crime: intent, guilt, and a cause-and-effect relationship between the actions or inaction of a medical practitioner and the consequences for the health or life of an individual [2-4].

Legal practice in defining defects in the provision of medical care or services relies on existing standards and protocols for providing assistance in a specific medical field and is based on the results of expertise. Quality medical care should be provided in full compliance with the standards of diagnosis and treatment for a particular disease. In the event of establishing a defect in providing assistance, shortcomings or discrepancies in the provision of medical care, non-compliance of the actions of a medical practitioner with the current regulations of the Ministry of Health of Ukraine, and relevant documents regulating the specified activity in a particular medical field should be identified.

The most significant evidence of the presence or absence of defects in providing medical care is, in fact, the forensic medical examination, which is appointed within the framework of criminal proceedings and civil cases [6, 7]. The conditions for conducting such examinations are regulated by the current legislation of Ukraine [8, 9, 10].

In the structure of pathologies requiring urgent neurosurgical care, traumatic brain injury and cerebrovascular diseases, particularly acute stroke, constitute the majority. According to statistical data as of February 24, 2022, in Ukraine, among the civilian population, more than 11,000 individuals per 100,000 population died from traumatic brain injury. Of these, 55% died at the pre-hospital stage, and 41% in the hospital, exceeding the hospital mortality rate compared to developed countries by more than 1.5 times. Given that traumatic brain injury (TBI) holds a prominent place in the overall trauma structure, it is one of the most important aspects of forensic medical research [11-13].

Every year in Ukraine (statistical data up to 2022), there were registered between 100,000 to 110,000 new cases of strokes, equating to 278.2 per 100,000 population. The ratio of hemorrhagic stroke (HS) to ischemic stroke (IS) across the country averages 1:4. The mortality rate from strokes in Ukraine ranged from 91.3 to 95 per 100,000 population. Of these, 45.2 per 100,000 were from IS, and 28.9 per 100,000 were from intracranial hemorrhages (ICH). Additionally, due to subarachnoid hemorrhages (SAH), there were over 2.8 cases per 100,000 population, which could amount to 12,600 cases annually [11-13].

The second most common factor contributing to intracranial hemorrhages (ICH) is the rupture of saccular aneurysms of the brain (cerebral aneurysms). Between 10% and 15% of patients with a rupture of intracranial aneurysms (IA) die at the pre-hospital stage, and over 50% die within 30 days after the rupture of cerebral aneurysms. Each year in Ukraine, approximately 1,500 individuals die from subarachnoid hemorrhages (SAH). Among those who survive, over half experience persistent symptoms and disorders related to brain injury.

According to industry reporting, mortality rates in the population, especially by causes of death, serve not only as demographic indicators but also as indicators of the health system’s performance [7-9]. The relevance of conducting this study is driven by the need to create organizational conditions and optimize the clinical-diagnostic aspect of medical care for patients with traumatic brain injury (TBI) and acute stroke. This aims to improve patients’ quality of life by enhancing the effectiveness of medical care provision in Ukraine. The study intends to identify the causes and analyze deficiencies in providing medical care for these conditions.

**The aim of the research** was to investigate the specifics of deficiencies in providing medical care to patients with isolated traumatic brain injury (TBI) and acute hemorrhagic stroke resulting from the rupture of cerebral arterial aneurysms. This was based on a retrospective analysis of medical documentation and the treatment outcomes of patients in cases where there were discrepancies between clinical and forensic diagnoses concerning the primary, concomitant diseases, and their complications.

**MATERIALS AND METHODS**

The expert assessment of deficiencies in providing medical care to patients with traumatic brain injury...
(TBI) and stroke was conducted based on a retrospective analysis of the results of commission forensic medical examinations related to the provision of medical care to patients who died from traumatic brain injury. The examinations were carried out by the Main Bureau of Forensic Medical Examination of the Ministry of Health of Ukraine, Kyiv City Clinical Bureau of Forensic Medical Examination, Zhytomyr Regional Bureau of Forensic Medical Examination, and Kharkiv Regional Bureau of Forensic Medical Examination.

Additionally, the medical documentation of patients was analyzed in cases where there were discrepancies between clinical and forensic diagnoses regarding the primary clinical diagnosis and its complications. The cases were drawn from the multiprofile Kharkiv City Clinical Hospital for Urgent and Emergency Medical Care named after Prof. O. I. Meshchaninov from 2021 onwards, totaling 207 cases. Moreover, forensic medical commission examinations for «medical cases» were analyzed for the past 10 years, carried out in 4 forensic medical examination bureaus (covering central, eastern, and western Ukraine), amounting to 1052 observations. Forensic medical examinations of the bodies of individuals who died as a result of TBI were selected, totaling 30 examinations from the overall number of examinations for «medical cases», which amounted to 6129 cases.

The clinical assessment of the results of providing care to patients with traumatic brain injury (TBI) and stroke was conducted through a retrospective analysis of medical documentation for patients who were hospitalized with these pathologies. The analysis covered the provision of emergency medical care to the neurosurgical and neurological departments of the Chernihiv Regional Hospital from 2019 to 2021, totaling 1243 observations. Additionally, the study involved the results of comprehensive examination and surgical treatment of 547 patients with saccular cerebral aneurysms (CA) in the Department of Vascular Neurosurgery at the State Institution «Romodanov Neurosurgery Institute of the National Academy of Medical Sciences of Ukraine» (SI «INH NAMS») during the period from 2011 to 2019.

Methods of investigation included:


2. Laboratory studies of homeostasis and metabolism parameters.

3. Instrumental: MSCT, CT angiography, and perfusion CT of the brain; MRI of the brain, MR angiography; ultrasound — duplex scanning of the major arteries of the head and neck, transcranial dopplerography in dynamic monitoring mode, intraoperative contact dopplerography; EEG; SPECT; cerebral angiography.

The statistical significance of the difference between continuous variables in two groups was assessed by the t-Student criterion if the distribution of indicators followed the Gaussian law; otherwise, the Mann-Whitney criterion (U) was used. For discrete variables, percentage ratios were calculated by groups, and contingency tables of features were compiled. Differences between groups were determined using the Pearson’s chi-square criterion (χ2), and the strength of the relationship between indicators was assessed using the phi coefficient (φ) in the case of fourfold tables. If the number of degrees of freedom was greater than 1, the Cramer’s V coefficient was calculated. The relative risk (RR), indicating the ratio of the risk of an event in the presence of a factor to the risk when this factor is absent, was used to assess the relationship between variables. Hypotheses were accepted with a confidence level of at least 95 % (significance level \( p \leq 0.05 \)). To identify the most informative features (I) for predicting the outcome of surgical intervention and diagnostic coefficients (DC) for determining the event class, a sequential diagnostic procedure algorithm based on Bayes’ formula was applied.

Diagnostic examinations included a detailed study of the medical history, dynamics of neurological status, assessment of somatic status, and instrumental methods of examination according to the current standards and recommendations of the Ministry of Health of Ukraine for the treatment of traumatic brain injury and stroke. For patients being treated in the neurosurgical department, in addition to the parameters recommended in the relevant documents of the Ministry of Health of Ukraine, the following criteria were separately analyzed and systematized: patient’s gender and age, date of hospitalization, date of death, duration of treatment, time of hospitalization, time of death, the mode of referral and hospitalization of the patient (emergency medical care, outpatient, self-referral), the diagnosis in the accompanying letter of the emergency medical
care doctor, the presence of additional consultations with specialists, the results and scope of applied clinical and diagnostic methods of examination, the established clinical diagnosis (main, complications, concomitant, forensic—medical diagnosis), discrepancies in diagnoses by main and complications (complete and incomplete), and the reasons for identified discrepancies.

Neurovisualization methods of examination included multislice computed tomography in standard and angiographic mode (MSCT, MSCT-A), magnetic resonance tomography in standard and angiographic mode (MRI, MR-A), and cerebral angiography (CA), which was performed in all patients with aneurysmal subarachnoid hemorrhage (ASH). Functional examinations included ultrasonic Dopplerography (USDG) of the vessels of the head and neck, intraoperative contact microvascular Dopplerography (IOCMD), and electroencephalography (EEG).

To standardize the examination results, the following scales and classifications were used: the Glasgow Coma Scale (GCS) by G. Teasdale and B. J. Jennett (1974), the severity of the condition according to the World Federation of Neurosurgeons (WFNS) scale (1988), the CT classification of hemorrhage in the rupture of an aneurysm of the brain’s main arteries (BGA) according to M. Fisher (1980), and the modified Raymond—Roy scale for the quality of BGA occlusion (J. R. Mascitelli et al., 2015). In the presence of intracerebral hematoma, the volume of the high-density hematoma portion, the volume of the surrounding low-density zone, and the overall dimensions of the pathological focus were determined. Based on this data, indications for surgical intervention were determined. The severity of intraventricular hemorrhage was assessed using the D. A. Graeb scale. The quality of life of operated patients was evaluated according to the Extended Glasgow Outcome Scale.

The analysis of expertise data was conducted based on organizational and clinical components of the medical care provision process. In examining the organizational aspects, the following factors were taken into account: the year the case was identified, the territorial affiliation of the bureau, the date of death, the time of death, the date of injury, the time of injury, the date and time of the arrival of the ambulance, the level of the healthcare institution (HCI) where the patient was hospitalized (city clinical hospitals, central district hospitals, regional clinical hospitals, specialized institutes, dispensaries, etc.), the time of hospitalization, and the time of the start of medical care.

As for the clinical aspects subject to assessment, in addition to those specified in the current normative documents of the Ministry of Health of Ukraine according to the identified nosology, the following parameters were separately analyzed: the general condition of the patient upon admission; the level of consciousness according to the scales mentioned above; the gender and age of the deceased; the presence in the medical documentation of a description of existing bodily injuries; examination by related specialists; the volume of mandatory (according to the protocols and standards of medical care provision of the Ministry of Health of Ukraine in effect at the time of the case) and additional examinations, according to the diagnosed comorbid or concomitant pathology; formulation of the clinical diagnosis: primary, concomitant diagnosis (presence or absence of concomitant pathology); specific indicators of hemodynamics and respiratory function at admission: systolic blood pressure (SBP), diastolic blood pressure (DBP), heart rate (HR), respiratory cycle and its disturbances (normal, pathological breathing); type of surgical intervention, time of the operation, and its results.

All stages of the research were conducted in accordance with the Council of Europe's Convention on Human Rights and Biomedicine (ETS No. 164) dated April 4, 1997, and the Helsinki Declaration of the World Medical Association (2008).

**RESEARCH RESULTS AND DISCUSSION**

According to the analysis of medical documentation from multiprofile medical institutions in Kyiv (207 medical records of hospitalized patients), a comparison of clinical diagnoses made by physicians with forensic medical diagnoses revealed that among other diagnoses established by physicians, traumatic brain injury (TBI) was more often identified as the primary condition in the clinical diagnosis (27.8 %). In cases of discrepancies between TBI and cerebrovascular pathology (hemorrhagic stroke) diagnoses, where the cerebrovascular disease led to the patient’s death, in most cases, TBI was listed as the primary condition in the clinical diagnosis (68.8 %), 63.6 % of which were subdural hematomas (without confirmation of TBI by CT or MRI results of the brain). These discrepancies were most likely associated with defects in the analysis of anamnestic data and incorrect interpretation of neuroimaging results (CT, MRI of the brain). The determination of the primary diagnosis as TBI in these cases was likely based on common clinical manifestations of these conditions: for moderate and severe TBI and hemorrhagic strokes with the formation of intracranial hematomas of various localization, such as a depressed level of consciousness at admission with a Glasgow Coma Scale (GCS) score below 11, the presence of psychomotor agitation, pronounced meningeal symptoms, seizure attacks, and gross focal neurological symptoms. However, patient trauma at the onset of hemorrhagic stroke due to sudden loss of consciousness, seizure attacks, or progressive deepening of focal neurological symptoms against the background of altered or suppressed consciousness level is quite common and has been described in specialized literature [14-16].

Therefore, formulating the primary diagnosis based on information from anamnestic data collected by
emergency medical service teams and existing soft tissue injuries to the head, torso, or limbs without clarification or confirmation of the direct fact of trauma, including the results of neuroimaging examinations of the patient, may be considered a defect in providing assistance. The absence of an analysis of the cause-and-effect relationship between clinical manifestations of the disease (sudden deterioration of the patient’s condition, loss of consciousness, and, as a consequence, injury) and their etiological factor (the absence of the fact of trauma preceding the appearance of the corresponding symptom complex) leads to the application of an inadequate range of diagnostic and therapeutic measures, which directly affects the further tactics and outcomes of treatment.

When pneumonias led to a lethal outcome, more often than not, the primary disease in the clinical diagnosis was also traumatic brain injury (TBI) — 29.4%. In all these cases, neither TBI nor pneumonia underwent basic diagnostic procedures aimed at confirming or refuting the specified diagnoses. Specifically, for TBI, no neuroimaging studies (CT or MRI of the brain) were performed, and neurologists diagnosed based on complaints of headaches and sometimes, in the presence of soft tissue injuries to the head, combined with changes in mental status or a decrease in the level of consciousness, which essentially constitutes a component of the clinical phenomenology of numerous neurological and somatic diseases of various etiologies.

In cases where there was a discrepancy in the diagnoses and death occurred due to traumatic brain injury (TBI), TBI was indicated as the main diagnosis in 20% of observations. In these cases, instead of TBI, physicians diagnosed general hypothermia (ICD-10 code T68 Hypothermia) as the main diagnosis.

When assessing medical care in the same healthcare institutions, it was found that in the neurosurgery department, a diagnosis of traumatic brain injury (TBI) was made in 77.8% of cases, while the cause of death was another disease in 77.8% of cases. Among the specified clinical diagnoses, TBI in various forms was the most common — 72.2%, with cerebrovascular disease being the direct cause of death in 23.1% of them, and general hypothermia in 17.9%. In the remaining cases, the results of the discrepancy between clinical and forensic diagnoses were quite diverse.

In a retrospective assessment of the volume of provided medical care in cases where death occurred due to cerebrovascular accident (CVA) with a clinical diagnosis of traumatic brain injury (TBI), the diagnostic and therapeutic tactics were generally chosen according to the current protocols of the Ministry of Health of Ukraine and implemented in full. However, in the remaining cases with a discrepancy between clinical and forensic diagnoses, the algorithm of diagnostic and therapeutic measures was not fully implemented in accordance with the actual pathology present in the patients, as it was based on incorrectly established diagnoses. It is worth noting that in all cases in this department, doctors established two or more diagnoses, and none of the diagnoses completely coincided with the forensic-medical diagnosis.

Thus, analyzing the identified discrepancies between clinical and forensic diagnoses, a predominance of physicians incorrectly diagnosing traumatic brain injury (TBI) when the cause of death was another condition was found. Another trend regarding the specificity of incorrectly established diagnoses was the assignment of a wrong primary diagnosis according to the specialization of the healthcare facility where the patient was initially hospitalized. This demonstrates a pattern in clinical thinking, where specialists are oriented towards pathologies within their own profile, prescribing corresponding treatments without considering the possible presence of comorbidities, competing, or concomitant pathologies. This underscores the shortcomings in the «standardization» model and the narrow specialization of doctors in the modern healthcare system, leading to a decrease in physicians’ knowledge in various medical fields and an increase in «diagnostic» gaps.

During the statistical analysis of forensic medical examinations related to the provision of medical care conducted by the State Expert Bureau «Main Bureau of Forensic Medical Examination of the Ministry of Health of Ukraine», Kyiv City Clinical, Zhytomyr, and Kharkiv Regional Bureaus of Forensic Medical Examination, the routes of patients, formulation of diagnoses (main disease, complications of the main disease, concomitant diseases), the timing of their establishment, diagnostic and therapeutic measures, and the results of medical care provision for traumatic brain injury (TBI) and acute stroke were analyzed.

In cases of deaths due to TBI, it was found that concomitant pathology was diagnosed during the patient’s lifetime in only 13.3% ± 6.2%. It is noteworthy that the date and time of the arrival of the ambulance were indicated in only 16.67% of cases (5 cases), while in the remaining cases, the accompanying records of the ambulance departure were absent in the medical documentation (although all examined cases were transported to the hospital by ambulances). This is a crucial factor in assessing the timeliness of medical care. Therefore, in the absence of such data shortly after TBI, the forensic medical evaluation of the quality of medical care becomes more challenging.

In the assessment of the level of healthcare institutions to which the patients were admitted, the following distribution was observed: 33.34% (10 cases) — emergency and urgent care hospitals, 30% (9 cases) — central district hospitals, 6.66% each (2 cases) — city district hospitals and regional clinical hospitals, and 3.33% (1 case) — specialized medical institutions.

The distribution over time, as one of the indicators of the quality of medical care in cases of acute stroke and traumatic brain injury (TBI), from the moment the
patient entered the admission department of the medical institution to the start of medical care, was as follows: within 10 minutes — 53.33 % (16 cases), from 11 to 20 minutes — 6.67 % (2 cases), from 21 to 40 minutes — 33.33 % (9 cases), from 41 to 60 minutes — 6.67 % (2 cases). In the remaining observations — 36.66 % (11 patients), the start of medical care was not specified, which is a crucial parameter in forensic-medical assessment of medical care, especially in the early stages.

As for the documentation and description of visible bodily injuries in the medical history: the description was absent in 16.67 % (5 cases) of the medical records, and in only one case, there were no bodily injuries; in the rest of the observations, 80 % were incompletely described (24 cases).

In patients with suspected traumatic brain injury (TBI) or acute stroke, during the assessment of the general condition and hemodynamic parameters at the time of admission to the hospital, the systolic arterial blood pressure was not recorded in 30 % (9 cases), diastolic arterial blood pressure in 33.33 % (10 cases), and heart rate was not described in a third of the cases (36.67 % / 11 observations). In the same sample, the overall condition upon admission to the medical institution was assessed by physicians as of moderate severity in 15.67 % (5 cases), severe in 46.67 % (14 cases), and extremely severe in 6.66 % (2 cases), while in 30 % (9 cases) the patient’s condition was not classified by physicians according to the severity level. The objectivity of assessing the depth of consciousness disturbance according to the Glasgow Coma Scale (GCS) also raises doubts, as, despite more than half (53.33 % / 16 observations) of the assessed patients being in a condition of severe or extremely severe severity, the level of consciousness at the time of hospitalization corresponded to clear in 43.33 % (13 individuals) and only 40 % (12 individuals) had varying degrees of consciousness depression, while in 16.67 % (5 cases) the level of consciousness was not assessed at all.

At the same time, medical documentation lacked consultations and examinations by a neurologist in 80 % (24 cases), a neurosurgeon in 20 % (6 cases), a surgeon/tramautologist in 30 % (9 cases), an anesthesiologist in 20 % (6 cases), and an ophthalmologist in 83.33 % (25 cases). Physicians of other specialties examined patients only in a third of cases — 33.33 % (10 cases). Considering the current protocols and treatment standards for TBI and its severity in the cases under study, it should be considered that one of the defects in care was the failure to perform necessary diagnostic and therapeutic measures.

During the analysis of the completeness of applying instrumental and neurovisualization studies, it was found that the following were not conducted: skull X-ray — in 50 % (15 cases), ultrasound — in 96.67 % (29 cases), CT/MRI of the head — in 46.67 % (14 cases), lumbar puncture (if indicated and in the absence of contraindications) — in 86.67 % (26 cases). Other additional instrumental studies were conducted only in 16.67 % (5 cases). It should be noted that in all analyzed cases, not only were these instrumental studies indicated, but they should have been mandatory according to existing branch standards and regulatory documents governing the process of providing medical care to patients with traumatic brain injury (TBI) and acute stroke. The performance of these instrumental studies, except for ultrasound (which was indicated only in the presence of concomitant pathology), was required by the existing normative-legal documents.

Thus, based on well-founded clinical-diagnostic indications, surgery was performed in 43.33 % (13 cases), of which only 69 % (9 patients) were performed promptly. In these cases, surgery was indicated for all patients; exceptions were cases where surgery was already deemed inappropriate due to the inevitability of death when patients were brought in a terminal state, and there were 7 such cases (23.33 %). Therefore, in 33.3 % (10 patients) with indications for surgical treatment, a defect occurred in the form of not performing the operation.

The correspondence of the clinical diagnosis to the forensic-medical diagnosis established after the autopsy was observed in only 26.67 % (8 cases), incomplete correspondence in 53.33 % (16 patients), and in 20 % (6 patients) of cases, the diagnosis did not correspond or was entirely absent.

When assessing the timing of medical care, it should be noted that untimely medical assistance was provided to patients in almost half of the cases from all examined examinations. The average time from the patient’s arrival at the hospital to the start of the operation was 5±0.7 hours. According to the research, the most common causes leading to diagnostic defects in traumatic brain injury (TBI) and acute stroke were: incomplete clinical-neurological examination of the patient (examination defects); underestimation or lack of necessary and additional investigation data; delayed seeking of medical help by the patient; lack of technical capabilities in the medical facility; the combination of the mentioned reasons.

Additionally, these defects were made by quite experienced medical professionals (no lower than the first category). Moreover, medical care defects (almost all cases of failure to provide assistance, essentially the inactivity of medical professionals when urgent measures were required for the patient) were mostly encountered in urban hospitals (especially in large cities in Ukraine), where the accreditation documents provided all the necessary conditions for the provision of highly specialized medical care. There were more highly qualified medical personnel of various profiles, and in addition to national protocols, there were local protocols for providing medical care in the specialty of «Neurosurgery».

With the aim of identifying possible defects in providing medical care to patients with acute hemorrhagic...
stroke and uncovering potential causes of «diagnostic» gaps in the ante-mortem detection of intracranial aneurysms (IA), a study was conducted to investigate the specifics of the clinical-neurological status of patients upon hospitalization, the timeframes for transferring patients to a specialized neurosurgical facility for this condition after establishing a diagnosis at the primary care facility, surgical treatment, and its consequences. Based on the results of a cohort observational analytical retrospective study of the comprehensive examination and surgical treatment of 547 (100 %) patients diagnosed with IA of the brain, who were under observation and treatment in the Department of Neurosurgical Pathology of the Head and Neck Vessels with X-ray surgery at the State Institution «Romodanov Neurosurgery Institute of the National Academy of Medical Sciences of Ukraine» from 2011 to 2019. Follow-up research in the formed groups was conducted until 2019. Characteristics of the age distribution of patients were performed according to the WHO classification from 1972. The comparative sample was gender-matched, with 268 (49.0±4.2 %) men and 279 (51.0±4.2 %) women. The age of patients ranged from 18 to 84 years. The composition of the sample by gender significantly depended on age, p < 0.01 (when divided into ten-year intervals). A statistically significant predominance of women was observed in age groups starting from 61 years, p < 0.001. The frequency of detecting intracranial aneurysms (IA) among women — 82 out of 117 (70.1±8.3 %) after 60 years — is 2.3 times higher than among men — 35 out of 117 (29.9±8.3 %).

In all 547 cases (100 %), patients underwent surgical treatment, including procedures aimed at aneurysm devascularization. Urgent surgical interventions were performed within several hours after admission based on life indications, determined by the volume of intracranial hematoma (ICH), displacement of the brain, or the progression of hydrocephalus (HC). Emergency surgeries for ruptured aneurysms were performed within the first 72 hours for patients with I-III-grade subarachnoid hemorrhage (SAH) according to the World Federation of Neurological Surgeons grades (WFNS) scale, taking into account the degree of cerebral vasospasm (CVS). Planned or «delayed» surgeries were conducted later than 14 days from the moment of aneurysm rupture or its initial clinical manifestations. The distribution of patients by the timing and method of surgery depended on the localization of the «symptomatic» IA. Thus, in terms of the timing of surgical intervention, 120 (21.9±3.5 %) were urgent, 264 (48.3±4.2 %) were non-urgent, and 163 (29.8±3.8 %) were planned operations. Two technologies of aneurysm devascularization were applied, including microsurgical clipping of the aneurysm neck (MC) in 293 (53.6±4.2 %) cases and endovascular embolization of the aneurysm body (EE) in 254 (46.4±4.2 %) patients (Diagram 1).

![Diagram 1](image)

- **Diagram 1**: Distribution of operations according to the timing of the procedure, the method of aneurysm devascularization, and its localization

In most cases — 203 (37.1±4.0 %), the Anterior Cerebral Artery – Anterior Communicating Artery (ACA – AComA) complex was detected. A statistically significant weak correlation was found in this case between gender and age (p=0.007). The proportion of ACA-AComA BAA cases among women aged over 61 was 1.7 times higher than the incidence among men of the same age, with 25 out of 40 (62.5±15.0 %) in women and 15 out of 40 (37.5±15.0 %) in men. In individuals under 61 years old, there was a 1.6-fold excess in the number of men, with 100 out of 163 (61.3±7.5 %).

In 65 cases (11.9±2.7 %), urgent surgical interventions were combined one-stage procedures,
involving both the exclusion of the cerebral aneurysm (CA) from blood flow and the operative correction of the consequences of the aneurysm rupture that necessitated urgent surgical intervention: removal of intracerebral hematomas, external ventriculostomy, decompressive craniotomy.

In cases where endovascular embolization (EV) was chosen as the optimal method of aneurysm cavity closure, urgent surgical interventions were performed as multi-stage procedures: embolization of the cerebral aneurysm (CA) (first stage) and external ventriculostomy (second stage) in 19 cases (3.5±1.5 %); embolization of the aneurysm and removal of intracerebral hematomas in 6 cases (1.1±0.9 %). Implementation of the EV stage as the first in multi-stage surgical treatment of ruptured CA complicated by intracerebral hematomas or occlusive hydrocephalus was possible in the absence of critical angiographic and sonographic indicators of cerebral vasospasm (CVS). Single-stage EV combined urgent operations were performed by converting diagnostic cerebral angiography into operative intervention – embolization of the aneurysm with subsequent completion of the second stage of surgical treatment (drainage of the ventricular system of the brain) under a single anesthesia care.

In cases of initial severity corresponding to grade IV-V on the World Federation of Neurological Surgeons (WFNS) scale, with the presence of critical cerebral vasospasm (CVS) against the background of aneurysm rupture complicated by bleeding into the brain’s ventricular system (VS), there were 9 cases (1.6±1.1 %). The first stage of urgent surgical treatment involved external ventriculostomy, and the second stage (after stabilizing the patient’s condition) involved aneurysm embolization.

In the analysis of clinical manifestations, a hemorrhagic onset of the disease was observed, with the rupture of cerebral aneurysms in the vast majority of patients – 474 (86.7±2.8 %). Among the patients with aneurysm ruptures – 474 (86.7±2.8 %), 423 (77.3±3.5 %) were hospitalized during the acute period of hemorrhagic stroke, and 51 (9.3±2.4 %) were hospitalized in the «cold» period (more than 28 days) of 547 (100 %) observations. 79 patients (14.4±1.1 %) were hospitalized after a recurrent rupture of the aneurysm, of which 67 (12.2±2.7 %) had two ruptures, and in 12 (2.2±1.2 %) cases, a third rupture was recorded.

The total number of patients without signs of cerebral aneurysm rupture was 73 (13.3±2.0 %) observations. Pseudotumor-like clinical manifestations were observed in 34 (6.2±2.0 %) patients, transient ischemic attacks (TIA) in 19 (3.5±1.5 %), acute cerebral circulation disorders with an ischemic type in the arterial basin distal to the aneurysm location in 6 (1.1±0.9 %), and migraine attacks in 14 (2.6±1.3 %) patients (Figure 1). All patients with other clinical manifestations were treated, examined, and observed by neurologists in their place of residence and other healthcare institutions in Ukraine for at least 6 months to 16.5 years before establishing the preliminary diagnosis of cerebral aneurysm after prescribing one of the neurovisualization studies (MRI or CT scan of the brain).

![Fig. 1. Clinical manifestations of cerebral aneurysm](image_url)
At the time of hospitalization, the level of consciousness was assessed in all observations. In 143 out of 547 examined patients (26.1±3.7 %), consciousness was clear before the operation. Patients hospitalized in the «cold» period of cerebrovascular accident (CVA) due to the rupture of cerebral aneurysms accounted for 51 out of 547 (9.3±2.4 %) observations, and patients with atypical manifestations of the disease – 73 out of 547 (13.3±2.8 %) cases did not have consciousness disorders.

The severity of the condition at hospitalization was assessed using the World Federation of Neurological Surgeons grades (WFNS) scale. Among patients hospitalized in the «acute» period of cerebral aneurysm rupture – 423 out of 547 (77.3±3.5 %), consciousness was clear in 19 (3.5±1.5 %). The majority of patients in the «acute» period of hemorrhagic stroke had varying degrees of consciousness disorders: 302 out of 547 (55.2±4.2 %) were in stupor, 74 (13.5±2.9 %) in a coma. In total, among all 547 (100 %) patients, consciousness disorders were observed in 404 (73.9±3.7 %).

Subarachnoid hemorrhage (SAH) due to the rupture of cerebral aneurysm was present in 137 out of 474 (28.9±4.1 %) cases with hemorrhagic clinical manifestations. Complicated SAH was defined in cases where it was accompanied by the formation of intraventricular hemorrhage (IVH) or blood breakthrough into the ventricular system, namely: – Complicated anatomical forms of aneurysm rupture were observed in the majority of patients – 337 (71.1±4.1 %): subarachnoid-parenchymal hemorrhage in 190 (40.1±4.4 %) cases, subarachnoid-parenchymal-ventricular hemorrhage in 119 (25.1±3.9 %) cases, subarachnoid-ventricular hemorrhage with obstructive hydrocephalus in 28 (5.9±2.1 %) cases.

Ruptures of the anterior communicating artery (ACA) – posterior communicating artery (PCoA) complex occurred in 180 cases (100 %), and in 1/3 of the cases, 61 (33.9±6.9 %), they presented as subarachnoid-parenchymal-ventricular hemorrhages, with acute obstructive hydrocephalus complicating 26 (14.4±5.1 %) of them. Intraventricular hemorrhage (IVH) was identified in the majority of cases – 337 out of 474 (71.1±4.1 %), with its volume ranging from 0.5 to 80 cm3. In 272 out of 474 (57.4±4.5 %) cases, the volume of IVH exceeded 30 cm3. IVH was accompanied by brain dislocation in all 143 (100 %) patients. Lateral displacement was observed in the majority of patients – 89 (62.2±7.9 %), axial+lateral displacement in 45 (31.5±7.6 %), and axial displacement alone in 9 (6.3±4.0 %) cases.

During the comprehensive examination of patients, it was found that the majority of individuals with intracranial aneurysms (IA) – 321 (58.7±4.1 %) had hypertension, 162 (29.6±3.8 %) had systemic atherosclerosis, and 112 (20.5±3.4 %) had type 2 diabetes. The combination of more than two of these conditions was present in 134 (24.5±3.6 %) cases. The need for differential diagnosis of IA with other pathological processes in thesellar region occurred in 1.5±1.0 % (8 patients).

The database for building a predictive system for the outcome of surgical treatment of intracranial aneurysms (IA) included 413 out of 547 (75.5 %) patients with a verified result of the operation 6 months after the surgery.

Clinical and neurological results of comprehensive treatment of intracranial aneurysms (IA), including surgical and rehabilitation aspects, were assessed at the time of discharge from the hospital or transfer to another medical institution and six months later. In the postoperative period, favorable clinical and neurological results were observed in 38 out of 547 patients (6.9±2.1 %). Moderate disability (patients with aphasic disorders, hemiparesis or ataxia, impairments in intellect, memory, or personality who did not require assistance in daily activities) was recorded in the majority of operated patients at the time of discharge – 287 out of 547 (52.5±4.2 %).

Lethal cases were registered in 45 out of 547 patients (8.2±2.3 %) within the first 30 days after the rupture of intracranial aneurysms following surgical treatment. The outcomes categorized as «good» and «moderate disability» were considered as «satisfactory», achieved in 284 observations (68.8±4.5 %). The vegetative state was observed in 53 cases (12.8±3.2 %), and lethal consequences in 58 cases (14.0±3.4 %) were classified as an «unsatisfactory» outcome, totaling 111 cases (26.9±4.3 %).

It was found that the lethal outcome of surgical treatment for intracranial aneurysms is statistically significantly dependent on age (U=6709.5; p=0.026) and the timing of the operation (U=6592.5; p=0.033). The age of patients with lethal outcomes was M=51.8±11.7 (Me=53.5; IQR: 46.5-58.0). In cases of satisfactory results of surgical treatment for intracranial aneurysms, the age of patients was M=48.3±12.3 (Me=49.0; IQR: 41.0-57.8).

The timing of the operation was found to influence the outcomes of surgical treatment. Surgical treatment for intracranial aneurysms in the group with lethal outcomes was performed urgently in the first few days from the onset of the disease – M=2.3±2.6 (Me=1.0; IQR: 1.0-3.5, Range: 0-13). In cases of satisfactory results of surgical treatment for intracranial aneurysms, surgical interventions were performed at a later stage from the onset of the disease – M=3.2±4.2 (Me=2.0; IQR: 1.0-4.0, Range: 0-49) days.

For patients whose condition after 90 days from the onset of intracranial aneurysms corresponded to a vegetative state, the significance of differences by patient age and days until the operation in comparison with the
group with a satisfactory result did not reach a statistically significant level.

Differences between groups of patients with a vegetative status and fatal outcomes were statistically significant (for patient age: $U=1189.5; p=0.040$, for the timing of the operation from the moment of aneurysm rupture: $U=1155.5; p=0.029$). There was no statistically significant impact of the patient’s biological sex on the frequency of lethal outcomes of surgical treatment of intracranial aneurysms ($\chi^2=0.007; p=0.93$).

The results of treatment for 21 (5.1%) patients with multi-stage surgical treatment of multiple intracranial aneurysms were sequentially applied microsurgical (MS) and endovascular (EV) methods, which led to the exclusion of this cohort from this analysis fragment but did not affect the reliability of the obtained results. The features of MS operations and the timing of their performance in intracranial aneurysms included a significant number of interventions for life-threatening and urgent indications in patients who were in IV-V severity stages according to the WFNS SAH scale and had complicated forms of SAH with signs of brain displacement and/or hydrocephalus. The initial severity of the patient’s condition subjected to MS intervention justifies the obtained result — the risk of a lethal outcome in MS operations on intracranial aneurysms is higher by 30% ($RR=1.3; 95\% CI: 1.06-1.55; \phi=0.12; p=0.03$) compared to EV. Moreover, the risk of vegetative status occurrence in EV operations on intracranial aneurysms increases by 50% ($RR=1.5; 95\% CI: 1.12-1.91; \phi=0.14; p=0.01$) compared to MS.

An analysis of risks regarding the possible impact on the results of surgical treatment of the clinical-anatomical form of intracranial hemorrhage (ICH) and the presence of complications of hemorrhagic stroke (CNS, recurrent rupture of aneurysms) due to the rupture of intracranial aneurysms (IA) has been conducted. Factors that increase the risk of lethal outcomes of surgical treatment of IA were identified. Thus, the risk of death, compared to satisfactory results, increases by 2.3 times in cases of a complicated form of ICH, namely, with intracerebral hematoma (ICH) with blood rupture into the ventricular system (VS) of the brain ($RR=2.3; 95\% CI: 1.4-3.8; \chi^2=10.87; \phi=0.18; p=0.001$). In the case of blood rupture into the VS with signs of hydrocephalus (HC), the risk of lethal outcomes increases by 2.6 times ($RR=2.6; 95\% CI: 1.6-4.3; \chi^2=15.02; \phi=0.21; p=0.0001$) compared to possible satisfactory results of surgical treatment of IA.

In cases of operations on intracranial aneurysms (IA) after their repeated rupture, the risk of lethal outcomes increases by 1.8 times ($RR=1.8; 95\% CI: 1.1-3.3; \chi^2=4.38; \phi=0.11; p=0.04$).

Surgical interventions for intracranial aneurysms (IA) performed against the background of cerebral vasospasm (CVS) have a 1.2 times higher risk of lethal outcomes ($RR=1.2; 95\% CI: 1.1-1.4; \chi^2=5.71; \phi=0.13; p=0.02$) compared to satisfactory results. In the case of hydrocephalus (HC), the risk is increased by 2.6 times ($RR=2.6; 95\% CI: 1.6-4.3; \chi^2=15.02; \phi=0.21; p=0.0001$).

In the first day after the rupture of the intracranial aneurysm (IA), surgical interventions were performed only in 6.4% (26/408) of patients, and on the second day, it was done in 35.0% (143/408). This suggests a delayed establishment of a clinical diagnosis in healthcare institutions where patients with hemorrhagic stroke were initially hospitalized.

When studying the potential impact of comorbidities on the outcomes of surgical treatment for intracranial aneurysms (IA), particularly conditions such as hypertension (HTN) and ischemic heart disease (IHD), it was found that their presence did not have a statistically significant influence on the outcome of the surgery itself. However, in cases of unsatisfactory results of surgical treatment for IA when assessing outcomes on the 90th day after a hemorrhagic stroke, patients with IA and concomitant IHD had a higher frequency of lethal outcomes, amounting to 88.9% (8/9) ($\chi^2=5.27; \phi=0.22; p=0.02$).

Considering the need for improvements in care and taking into account the identified risk factors for an adverse outcome of surgical treatment for IA, a personalized formula for recording a clinical case was created in the form of a symbolic representation of risk criteria and subsequent prediction of the likely outcome of the surgery.

The description of the personalized model for surgical treatment of intracranial aneurysms (IA) (individual formula) includes alphanumeric values that determine the position and gradation of clinical parameters, including predictors of an unfavorable outcome of surgical treatment, according to Table 1. To identify the most informative features and diagnostic coefficients (DC) for event classification in predicting the outcome of surgical treatment for IA, a sequential diagnostic procedure algorithm based on Bayesian formula was applied.

The calculations revealed signs with the highest informativeness in assessing the outcomes (results) of ST CA GA (Table 2), allowing the prediction of the likelihood of one or another case completion of ST CA GA, based on the individual characteristics of the disease course in a patient with identified GA at the stage of planning surgical treatment. When predicting the probability of a lethal outcome or a vegetative state as a result of surgical treatment, we find the cumulative score of the diagnostic coefficients (integral indicator), which is calculated individually in each clinical case, both in the presence and absence of the predictor indicated in the «individual formula» of recording a patient with ST CA GA (Table 2).
### Table 1

Position and Gradation of Predictor in the Individual Formula for Surgical Treatment of Intracranial Aneurysms (Abbreviated Recording)

<table>
<thead>
<tr>
<th>Predictor</th>
<th>Position</th>
<th>Gradation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>X</td>
<td>male – 1; female – 2</td>
</tr>
<tr>
<td>Age</td>
<td>XXX</td>
<td>Up to 50 years or (number of years)</td>
</tr>
<tr>
<td>Type of clinical course</td>
<td>XXXX</td>
<td>Hemorrhagic: «acute» – 1; «cold» – 2; ischemic – 3; pseudotumorous – 4; migrainous – 5.</td>
</tr>
<tr>
<td>Variant of clinical manifestations of subarachnoid hemorrhage (SAH) and the spread of intracranial hematomas (ICH).</td>
<td>XXXXXX</td>
<td>Without rupture – 0; Subarachnoid hemorrhage (SAH) – 1; SAH + intraparenchymal hematoma (IPH) – 2; SAH + IPH + ventricular hemorrhage (VH) – 3; SAH + IPH + VH + hydrocephalus (HC) – 4</td>
</tr>
<tr>
<td>Cerebrovascular Spasm</td>
<td>XXXXXX</td>
<td>No – 0; I degree – 1; II degree – 2; III degree – 3; IV – 4 degree</td>
</tr>
<tr>
<td>The number of BA</td>
<td>XXXXXXX</td>
<td>1; 2; 3; 4; 5-5 and more</td>
</tr>
<tr>
<td>Localization of the BA</td>
<td>XXXXXXXX</td>
<td>ACA – AComA – a; ACA – b; SCA – c; OA and PComA – d; VA-PMA – e</td>
</tr>
<tr>
<td>Type of surgery</td>
<td>XXX/X</td>
<td>MS – 1; EV – 2; simultaneous: drainage + MS – 3; Drainage + EV – 4, etc.</td>
</tr>
<tr>
<td>Intraoperative complications</td>
<td>XXX/X</td>
<td>No complications – 1; aneurysm rupture – 2; brain swelling – 3; coil migration – 4.</td>
</tr>
<tr>
<td>Results</td>
<td>XXX/X</td>
<td>Complete recovery – 1, death – 5; unknown – 6</td>
</tr>
<tr>
<td>Example</td>
<td>145211la232/1</td>
<td>male, 45 years old, cold phase of GPMK, SAH, CVD – 1 degree, one aneurysm ACA – AComA, planned EV, without complications / Complete recovery</td>
</tr>
</tbody>
</table>

### Table 2

Diagnostic coefficients and informativeness of features for predicting the outcomes of surgical treatment of cerebral aneurysms

<table>
<thead>
<tr>
<th>Characteristic ()</th>
<th>I</th>
<th>Frequency of observations of ST</th>
<th>Class F</th>
<th>Class V</th>
<th>Class DS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>S F V DS (X_i^1) (X_i) (X_j^1)</td>
<td>DC I DC I DC I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age up to 50</td>
<td>1</td>
<td>145 21 27 48 1 0,15 0 0 1 0,08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>139 31 26 63 -1 0 0 -1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Days from the moment of BA rupture</td>
<td>0-1</td>
<td>116 31 18 49 -1 0,14 1 0,10 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>&gt;3</td>
<td>115 17 24 41 1 -1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Localization of BA on VSA</td>
<td>1</td>
<td>192 17 24 41 1 0,03 1 0,07 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>182 41 30 71 0 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Localization of BA on ACA – AComA</td>
<td>1</td>
<td>94 29 11 40 -2 0,25 2 0,19 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>190 29 42 71 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Localization of BA on ACA</td>
<td>1</td>
<td>9 6 2 8 -5 0,18 -1 0 -4 0,08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>275 52 51 103 0 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Localization of BA on SMA</td>
<td>1</td>
<td>56 10 12 22 1 0,01 -1 0,01 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>228 48 41 89 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other localization of BA on (OA, DV PMA, and others)</td>
<td>1</td>
<td>39 4 10 14 3 0,10 -1 0,03 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>245 54 43 97 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Multiplicity of aneurysmal involvement</td>
<td>1</td>
<td>49 11 16 27 0 0,00 -2 0,19 -1 0,04</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>234 47 37 84 0 1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Acute period of ruptured cerebral aneurysm</td>
<td>1</td>
<td>198 50 19 69 -1 0,32 4 1,19 1 0,08</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>85 8 34 42 3 -3 -1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Secondary ischemic brain injury</td>
<td>1</td>
<td>45 20 9 29 -3 0,37 0 0 -2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>238 38 44 82 1 0 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of asymptomatic IA</td>
<td>1</td>
<td>47 8 9 17 1 0,01 0 0 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>236 50 44 94 0 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SAH</td>
<td>1</td>
<td>254 54 40 94 0 0,03 1 0,36 0 0,05</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>29 4 13 17 -2 -4 -2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IH</td>
<td>1</td>
<td>134 34 16 50 -1 0,11 2 0,26 0 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>149 24 37 61 1 -1 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>IH+SH</td>
<td>1</td>
<td>38 18 3 21 -4 0,44 4 0,16 -1 0,03</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>245 40 50 90 1 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recurrent rupture</td>
<td>1</td>
<td>34 13 5 18 -3 0,21 0,01 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>249 45 48 93 1 0 0</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cerebral Vasospasm</td>
<td>1</td>
<td>201 50 17 67 -1 0,30 3 1,36 -1 0,11</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>82 8 36 44 3 -4 -1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Continuation of Table 2

<table>
<thead>
<tr>
<th>Characteristic 0</th>
<th>I</th>
<th>Frequency of observations of ST</th>
<th>Class F</th>
<th>Class V</th>
<th>Class DS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>S  F  V  DS</td>
<td>DC I</td>
<td>DC I</td>
<td>DC I</td>
</tr>
<tr>
<td>Hydrocephalus</td>
<td>1</td>
<td>35 19 4 23</td>
<td>-4</td>
<td>0,51</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>248 39 49 88</td>
<td>1</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>High blood pressure</td>
<td>1</td>
<td>61 16 8 24</td>
<td>-1</td>
<td>0,03</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>223 42 45 87</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Ischemic Heart Disease</td>
<td>1</td>
<td>22 8 1 9</td>
<td>-5</td>
<td>0,09</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>262 50 51 102</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Type of surgery</td>
<td>CB</td>
<td>118 14 28 42</td>
<td>2</td>
<td>0,24</td>
<td>-1</td>
</tr>
<tr>
<td></td>
<td>MX</td>
<td>159 39 17 56</td>
<td>-1</td>
<td>0,43</td>
<td>0</td>
</tr>
</tbody>
</table>

Note: 1. i – gradation number; 2. DC($x^i_j$) – Diagnostic coefficient of the gradation number; 3. I($x^i_j$) – Informativeness coefficient of the gradation number; 4. I($x^i_j$) – Informativeness coefficient. 5. Designation of classes of consequences of surgical treatment: S – (satisfactory) F- (fatal outcome); V – (vegetative state); DS – (dissatisfactory)

Figure 2 demonstrates that the lower the number of points calculated according to the individual patient formula, the higher the probability of a fatal outcome, reaching 50±20 % at «-8» points.

Fig. 2. Frequency of lethal cases depending on the individual total score of diagnostic coefficients of features in the individual formula of the patient with cerebral aneurysm.

Notes: 1. Lower Limit - lower confidence limit; 2. Upper limit - upper confidence limit (95% confidence interval)

The identified impact of the timing of the surgery (first few days) and blood breakthrough into the ventricular system (including hydrocephalus) due to recurrent aneurysm rupture on the risk of lethal outcomes of surgical treatment justified the search for ways to optimize the treatment tactics in this category of patients, including identifying defects and shortcomings in the organizational aspect of medical care. In the comprehensive analysis of data regarding the timing of patients’ admission to specialized medical facilities correlating with the establishment of a clinical diagnosis — specifically, subarachnoid hemorrhage by hemorrhagic type, the form of intracranial hemorrhage, and the likely cause (source of bleeding) — it was found that the majority of patients in this study were hospitalized within the first 3 weeks from the manifestation of the disease — 84.1±3.1 % (n=460). The majority of patients who were in the acute period of hemorrhagic stroke — 423 (100 %) were hospitalized within
3 days from the moment of rupture of the aneurysm – 68.8±4.4 % (n=291), on the first day – 21±3.9 % (n=89), and between the first and third days – 47.8±4.8 % (n=202) (Table 3).

Table 3

<table>
<thead>
<tr>
<th>Clinical manifestations</th>
<th>The term of hospitalization from the onset of the disease (days)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>1-3</td>
</tr>
<tr>
<td>Migraine</td>
<td>N</td>
<td>P,%</td>
</tr>
<tr>
<td>Pseudotumorous</td>
<td>N</td>
<td>P,%</td>
</tr>
<tr>
<td>TIA</td>
<td>N</td>
<td>P,%</td>
</tr>
<tr>
<td>Ischemic stroke</td>
<td>N</td>
<td>P,%</td>
</tr>
<tr>
<td>Acute period of aneurysm rupture</td>
<td>N</td>
<td>P,%</td>
</tr>
<tr>
<td>«Cold» period of aneurysm rupture</td>
<td>N</td>
<td>P,%</td>
</tr>
<tr>
<td>Total</td>
<td>N</td>
<td>P,%</td>
</tr>
</tbody>
</table>

The untimeliness of diagnosis establishment (diagnostic gap) and transferring the patient to a specialized facility for providing appropriate surgical care leads to an increased risk of adverse outcomes of surgical treatment. This includes the recurrence of aneurysm rupture and, consequently, the presence of complicated forms of intracranial hemorrhages with brain displacement, intraventricular hemorrhages, hematoma compression of the ventricular system, and occlusive hydrocephalus. Additionally, performing surgical interventions against the background of cerebral vasospasm and secondary ischemic brain damage poses further risks.

CONCLUSIONS

1. According to forensic medical examinations, the following deficiencies in the provision of medical care were identified: a discrepancy between clinical and forensic medical diagnoses in 26.67 % and incomplete correspondence of diagnoses in 53.33 %; untimeliness of providing medical care for acute stroke and traumatic brain injury (TBI) – 36.66 %; inadequate implementation of the diagnostic component in the form of not using the scales recommended in the sectoral standards and protocols of the Ministry of Health of Ukraine for assessing the general condition, parameters of external respiration and hemodynamics, assessing neurological status, and using instrumental diagnostic methods (neurovisualization, functional), leading to untimely surgeries – 33.3 % or performing them for incorrect indications – 23.3 %.

2. In cases of discrepancies between clinical and forensic medical diagnoses, there is a tendency towards «overdiagnosis» of traumatic brain injuries (TBI) and the establishment of an incorrect primary diagnosis according to the narrow specialization of the doctor who initially admitted the patient with a preliminary diagnosis of concomitant pathology in 13.3±6.2 %, and the absence of recording visible bodily injuries in 16.67 %, with a partial description in 80 % of observations.

3. A typical diagnostic defect in providing medical care to patients with hemorrhagic stroke due to the rupture of saccular aneurysms was the untimely establishment of the diagnosis: 264 (48.3±4.2 %) – for more than 3 days, more than 14 days – 163 (29.8±3.8 %), of which over 28 days – 51 (9.3±2.4 %) out of 547 (100 %) observations, leading to a recurrent rupture of aneurysms in 79 (14.4±2.9 %) patients, of which in 67 (12.2±2.7 %) cases, the aneurysm rupture occurred twice, and in 12 (2.2±1.2 %) cases, a third rupture was recorded.

4. The «diagnostic» gap in patients with hemorrhagic stroke due to the rupture of saccular aneurysms led to the necessity of performing surgeries against the background of severe clinical and neurological conditions of patients, cerebral vasospasm, and urgent surgical interventions due to the existing dislocation syndrome and obstructive hydrocephalus (p=0.001). The volume and spread of intracranial hemorrhage significantly affect the results of surgical treatment, increasing the level of mortality and disability among operated patients.

5. Based on the analysis and identification of the most informative factors influencing the outcome of surgical treatment for cerebral aneurysms, a forecasting system has been developed. The application of this forecast is advisable in the prevention and timely detection of possible defects in providing medical care to patients with a stroke.

Prospects for further research:

1. Strategic planning of the management mechanism for the development of the medical care system for hemorrhagic stroke, organizational principles of its implementation, and realization in Ukraine.
2. Improvement of public administration in the specialized neurosurgical care system for stroke patients and the development of methodological recommendations for improving this system in Ukraine.

3. Development of practical recommendations for improving and enhancing the effectiveness of mechanisms for state regulation of emergency medical care for patients with cerebrovascular pathology within the framework of Ukraine’s recovery plan.

4. Enhancement of the effectiveness of treatment outcomes for patients with stroke based on a comprehensive assessment of risk factors, improvement of diagnostics, and implementation of principles of comprehensive treatment for patients with cerebrovascular pathology.

**The relevance of the work:** The work was carried out within the framework of the author’s own initiative research work «Expert and diagnostic system for objectification of forensic medical examination of traumatic brain injury» (2023-2026), state registration number 0123U101528.

**UDC 340.6: [617.51+616.831]-001-07**

**2. UDC: 616.831-005.4-089:616-06 state registration number: 0122U000332** «To study the features of manifestations of ischemic brain damage during surgical treatment of cerebrovascular pathology and ways to correct them» (2022-2024) Execution of scientific work on departmental topics – National Academy of Medical Sciences of Ukraine, State Institution «Romadanov Institute of Neurosurgery of the National Academy of Medical Sciences of Ukraine» of the Academy of Medical Sciences of Ukraine

**FUNDING AND CONFLICT OF INTEREST**

The authors declare that there is no conflict of interest. The article is self-funded.

**COMPLIANCE WITH ETHICAL REQUIREMENTS**

All stages of the research were conducted in accordance with the Council of Europe’s Convention on Human Rights and Biomedicine (ETS No. 164) dated April 4, 1997, and the Helsinki Declaration of the World Medical Association (2008).

**LITERATURE**


REFERENCES


9. Instruktsiya pro provedennya sudovo-medychnoi ekspertyzy: zatverzhena nakazom Ministerstva okhorony zhorov’ya Ukraїn’yi vid 17.01.95 r. N 6. [Instructions on conducting a forensic medical examination: approved by the order of the Ministry of Health of Ukraine dated 17.01.95 No. 6.]. Available from: http://zakon1.rada.gov.ua.


Резюме

ЕКСПЕРТНА ТА КЛІНІЧНА ОЦІНКА ДЕФЕКТІВ НАДАННЯ ДОПОМОГИ ХВОРИМ З ЧЕРЕПНО-МОЗКОВОЮ ТРАВМОЮ ТА ГЕМОРАГІЧНИМ ІНСУЛЬТОМ ВНАСЛІДОК РОЗРІВУ ЦЕРЕБРАЛЬНОЇ АНЕВРИЗМИ
Аліна О. Плетенецька, Світлана О. Литвак, Максим В. Ямковий, Олександр О. Садовський, Тетяна М. Лукаш, Лілія В. Чобітько

Вступ. Актуальність проведення даного дослідження обумовлена необхідністю створення організаційних умов та оптимізації клініко-діагностичної ланки медичної допомоги хворим з ЧМТ та гострим інсультом для підвищення якості життя хворих шляхом підвищення ефективності надання медичної допомоги в Україні на основі виявлення причин виникнення та аналізу дефектів надання медичної допомоги при даніх захворюваннях.

Мета. Дослідити специфіку дефектів надання медичної допомоги хворим з ізольованою черепно-мозковою травмою та гострим геморагічним інсультом внаслідок розриву артеріальної аневризми головного мозку на основі проведеного ретроспективного аналізу медичної документації, а також результатів лікування хворих у випадках розриву аневризми головного мозку.

Матеріали та методи. Клінічна оцінка результатів надання допомоги хворим з черепно-мозковою травмою та інсультом проведена при ретроспективному аналізі медичної документації, яка була госпіталізовані з цією патологією. Методи застосовані клінічні, лабораторні дослідження параметрів гемостазу та метаболізму; інструментальні.

Результати. Виявлений вплив терміну проведення операції (перші декілька діб) та прориву крові у ШС ГМ, у тому числі з ГЦ внаслідок повторного розриву аневризми, на ризик летальних наслідків хірургічного лікування, обґрунтував пошук шляхів оптимізації лікувальної тактики у даній категорії хворих, у тому числі виявлення дефектів та недоліків організаційної ланки медичної допомоги.

Висновки. На основі аналізу і виділення найбільш інформативних факторів, що впливають на результат хірургічного лікування аневризму головного мозку, розроблена система прогнозування, яка дозволяє розрахувати ймовірність його результату. Застосування прогнозу доцільно враховувати при профілактиці та своєчасному виявленні можливих дефектів надання медичної допомоги хворим з інсультом.

Ключові слова: дефекти надання допомоги, черепно-мозкова травма, цереброваскулярні захворювання, артеріальна аневризма, публічне управління, організація охорони здоров’я