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ENDOSCOPE – ASSISTED EVACUATION OF CHRONIC SUBDURAL HEMATOMAS

ABSTRACT

of dissertation work

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Supervisor:
Prof. Dr. Yavor P. Enchev, MD, PhD, DrMedSci, MHA, FRCS (Eng)

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The dissertation is written on 115 standard typewritten pages and is illustrated with 15 photographs, 37 figures and 3 tables. The bibliography covers 201 literary sources, of which 3 are in Cyrillic and 198 are in Latin. There is 1 publication related to the dissertation work .

The doctoral student works as a resident in the Neurosurgery Clinic of the UMHAT "St. Marina", Varna and as an assistant in the Department of "Neurosurgery and ENT Diseases" at the Faculty of Medicine, Medical University - Varna.

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CONTENTS

ABBREVIATIONS USED

CT	computed tomography
cSDH	chronic subdural hematoma
MRI	magnetic resonance imaging
BHC	Burr **-**hole craniostomy
GCS	Glasgow Coma Scale
GOT	Glasgow Outcome Scale
TDC	Twist – drill craniostomy

I. INTRODUCTION

Chronic subdural hematoma (cSDH) was originally defined as "hemorrhagic internal pachymeningitis" (pachymeningitis hemorrhagica interna) in 1857 by Virchow [Mark S., 2019; Scott M., 1949] It can be described as a predominantly hypodense or isodense growing collection along the cerebral convection - on computed tomography (CT) [Youmans and Winn, 2022].

It is a disease that predominantly affects the ageing population [Youmans and Winn, 2022; Santarius T., 2009]. According to worldwide studies, the average age of those affected is around 76.8 years. The male to female ratio is 3:1 - among all age groups studied [Youmans and Winn, 2022; Santarius T., 2009] The increase in the prevalence of is the result of a combination of an aging population and the widespread use of anticoagulants and antiplatelet medications [Youmans and Winn, 2022; Santarius T. et al. 2009; Asghar M, Adhiyaman V, Greenway MW, et al. 2002; Kudo H, Kuwamura K, Izawa I, et al. 1992]

Globally, cSDH represents an economic and social burden due to the high morbidity and mortality it causes [Iliev B., 2021].

The clinical picture may vary depending on the size of the cSDH and the compensatory capacity of the patient. The manifestation may be discrete - over a prolonged period of time with isolated cognitive impairment, similar to dementia; acute - with focal neurological deficit, similar to stroke; severe clinical manifestation - with coma and death due to increased intracranial pressure or mass effect on vital structures [Mark S., 2019].

The most common symptoms of cSDH include: signs of increased intracranial pressure - headache, nausea, vomiting, drowsiness, dizziness; focal symptoms - seizure symptomatology; quantitative and/or qualitative disturbances of consciousness; motor deficits - paresis/plegia of limbs [Mark S., 2019; Youmans and Winn, 2022; Iliev B., 2021].

The main method of treatment is surgical evacuation as it leads to the prevention of the development of a permanent neurological deficit. Timely treatment leads to a favourable outcome in a higher percentage of patients [Iliev B., 2021].

The main methods of diagnosis are CT and MRI, in a smaller percentage of cases [Youmans and Winn, 2022].

On CT, cSDH is seen as a hypodense (<30 Hounsfield units) growing collection along the cerebral convection, but may have an isodense (in subacute hematoma - 30-60 Hounsfield units) portion or a hyperdense (in acute hematomas , >60 Hounsfield units) [Markwalder TM., 1981; Santarius T, Kolias AG, Hutchinson PJ., 2012]. Subdural hygroma and subdural empyema are included in the differential diagnosis. MRI can be used to differentiate between them [Youmans and Winn, 2022].

Treatment of cSDH can be conservative and surgical [Iliev B., 2021]. Non-operative treatment is considered appropriate for patients in whom the risks associated with surgical intervention outweigh its benefits [Youmans and Winn, 2022; Iliev B., 2021].

Patients who are asymptomatic, with a small subdural collection size identified by imaging studies and multiple comorbidities are indicated for conservative management - follow-up of imaging findings; correction of coagulopathies or thrombopathies; therapy and control of comorbidities according to imaging findings [Youmans and Winn, 2022].

Patients with clinical manifestation and imaging-proven finding of cSDH undergo surgical treatment [Iliev B., 2021] Three main surgical techniques are described in the literature: twist drill craniostomy (TDC); burr-hole craniostomy (BHC); traditional/mini-craniotomy.

Combining surgical techniques with an endoscope makes most of the surgical interventions microsurgical [Iliev B., 2021] Among the advantages of minimally invasive neurosurgery are: small surgical incision; minimal trauma to the brain parenchyma [Iliev B., 2021] It is considered to have an impact on shorter hospital stay of patients and their faster return to normal lifestyle. [Iliev B., 2021] The endoscopic systems that are used are flexible endoscopic systems and rigid endoscopic systems. [Iliev B., 2021]

II. AIM, OBJECTIVES, HYPOTHESIS

2.1. Aim

The aim of this study was to evaluate endoscope-assisted evacuation of chronic subdural henatomas.

2.2. Objectives

1) To characterize patients and assess risk factors for subdural hematoma.
2) To examine the clinical picture of patients with subdural hematoma.
3) To make a comparative analysis of the operational techniques used
4) To predict the outcome of treatment according to risk factors, clinical presentation and surgical technique used
5) To define precise indications and contraindications for the intraoperative use of neuroendoscope in the evacuation of chronic subdural hematomas, based on a comprehensive literature review
6) To develop a protocol for intraoperative use of an endoscope in neurosurgical surgical treatment of chronic subdural hematomas.
7) On the basis of statistical processing and data analysis to formulate recommendations for the intraoperative use of the endoscope in the neurosurgical treatment of patients with chronic subdural hematomas

2.3. Hypothesis

Endoscope-assisted evacuation of chronic subdural hematomas is a safe and effective method for patients, including the elderly, and can be a minimally invasive surgical treatment with a favorable disease outcome.

III. MATERIAL AND METHODS OF THE DISSERTATION

3.1. Nature of the study

The study is retrospective in nature, analyzing the medical records of patients with chronic subdural hematomas who underwent surgical treatment at the Clinic of Neurosurgery at the University Hospital "St. Marina" - Varna for the period 2011-2021. The study was initiated after approval by the Ethics Committee of the Medical University - Varna with Protocol No. 127.

3.2. Clinical material

A total of 151 patients who underwent surgical treatment for chronic subdural hematoma were included in the study. The gender distribution was as follows: 108 males and 43 females. The mean age was 70.56 years and the standard deviation was 13.98 years.

Patient inclusion in the study is based on inclusion and exclusion criteria.

The criteria for inclusion in the study are:

- Patients hospitalized in the Department of Neurosurgery who underwent surgery for chronic subdural hematoma;
- Surgical intervention must have been performed within 48 hours of the incident;
- Patients with control CT before and after hematoma evacuation.

The exclusion criteria are:

- Patients with cSDH who have not undergone surgical treatment;
- Patients who have undergone surgical treatment for another type of pathology;
- Patients did not have control CT before and after hematoma evacuation.

3.3. Apparatus and own surgical instrument set

The surgical interventions performed at the Clinic of Neurosurgery of the University Hospital "St. Marina” Varna, endoscopic equipment of Aesculap company was used (Fig. 1), which includes, HD monitor, recorder (Fig. 2), light source "Xenon" (Fig. 3), HD camera high resolution (Fig. 4) rigid endoscopes with 0, 30 and 75 degree angle of optics (Fig. 5), a mechanical arm for fixing the endoscope in the operative field, and a high speed drill (Aesculap), (Fig. 6) for bone access (craniotomy/craniectomy).

The majority of endoscopic procedures were recorded on a specialized system (Aesculap) for video digitization and archiving.

The available records of the endoscopic interventions were analyzed. Accuracy in positioning of the entry point and access trajectory, the presence of anatomical abnormalities, and the extent to which the planned intervention was performed and the complications and technical problems encountered during surgery were taken into account.

Endoscopic equipment (Aescular)

Fig. 1. Neuroendoscopic equipment: monitor, recording device, light source

Fig. 2. Video digitizing and archiving recorder

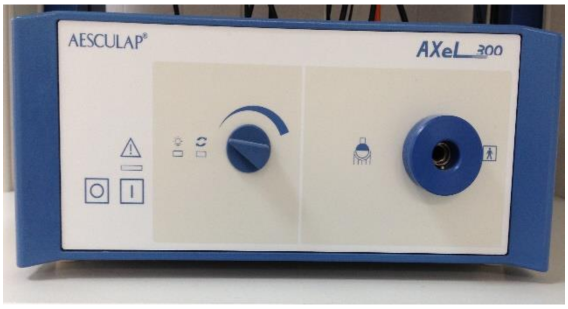

Fig. 3. Light source (Xenon)

Fig. 4. High-definition camera (Full HD)

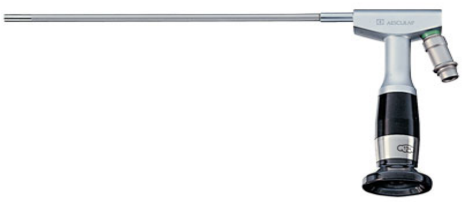

Fig. 5. High definition (HD) optics (Aesculap) at different angles of 30 and 70 degrees

Fig. 6. High-speed drill: 1.Motor; 2.Flexible cable; 3.Handle; 4.Craniotome; 5.Angled handle

3.4. Operational equipment

The surgical intervention is performed under general anesthesia. A 3-4 cm long linear skin incision is made followed by a 1.5-2 cm diameter milling trepanation. Cross incision of the dura. Small corticotomy. A transparent plastic working tube (trocar) with a metal mandrel (12 mm outer diameter, 10 mm inner diameter and 8 cm long) is inserted. This step can be done in real time under ultrasound control or under neuronavigation control, at the surgeon's preference. After removal of the mandible, a 2 mm 0°-30° endoscope lens is introduced into the clear working tube for visualization during hematoma removal. Depending on preference, the neurosurgeon may hold the working tube and endoscope together, or the working tube may be held by an assistant, or the working tube may be fixed by a fixator-adapter with a mechanical arm. (Fig. 7).

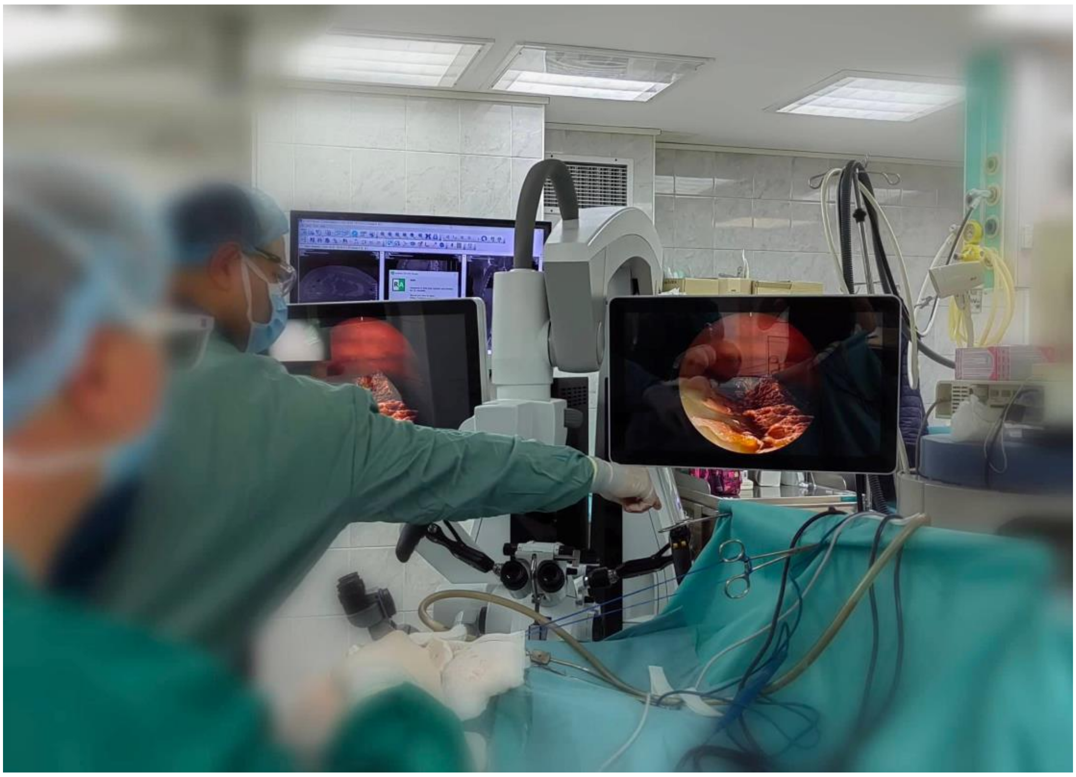

Fig. 7. Stage of the endoscope-assisted evacuation of cSDH

The diagnostic methods used are native CT of the brain; MRI of the brain - pre and postoperative.

3.5. Statistical methods

The statistical software package - IBM SPSS for Windows, v.20.0 was used for data processing.

A significance level of $p<0.05$ at 95% confidence interval was assumed for all analyses performed.

- Analysis of variance (ANOVA) to assess whether the influence of a factor is statistically significant or not.
- Variance analysis for the study of quantitative characteristics of indicators.
- Analysis to assess the risk of an event occurring (OR).
- Correlation analysis to assess the dependence between the studied indicators. The assessment of the strength of the dependence between the variables is based on the results of Pearson's coefficient (r) and Spearman's coefficient (p), where Spearman's coefficient

calculates the correlation based on monotonic relationships and Spearman's coefficient based on linear relationships.

The degree of association between variables is defined as:

- $0 < r(p) < 0.3$ – low correlation
- $0.3 < r(p) < 0.5$ – moderate correlation
- $0.5 < r(p) < 0.7$ – significant correlation
- $0.7 < r(p) < 0.9$ – high correlation
- $0.9 < r(p) < 1$ – very high correlation

- Regression analysis to assess possible functional relationships between the studied indicators. Investigation of causal relationships.
- Comparative analysis (hypothesis evaluation) - $\chi 2$, Student's t-test to compare quantitative and qualitative indicators and examine the difference between them.
- Graphical and tabular method of displaying the obtained results.

IV. RESULTS

4.1. Characterize patients and assess risk factors for subdural hematoma

151 patients with chronic subdural hematoma were studied, who were passed through the Clinic of Neurosurgery at University Hospital "St. Marina" in the city of Varna. The mean age of the studied subjects was 70.56 ± 13.98 years (6-94 years) (Fig. 1).

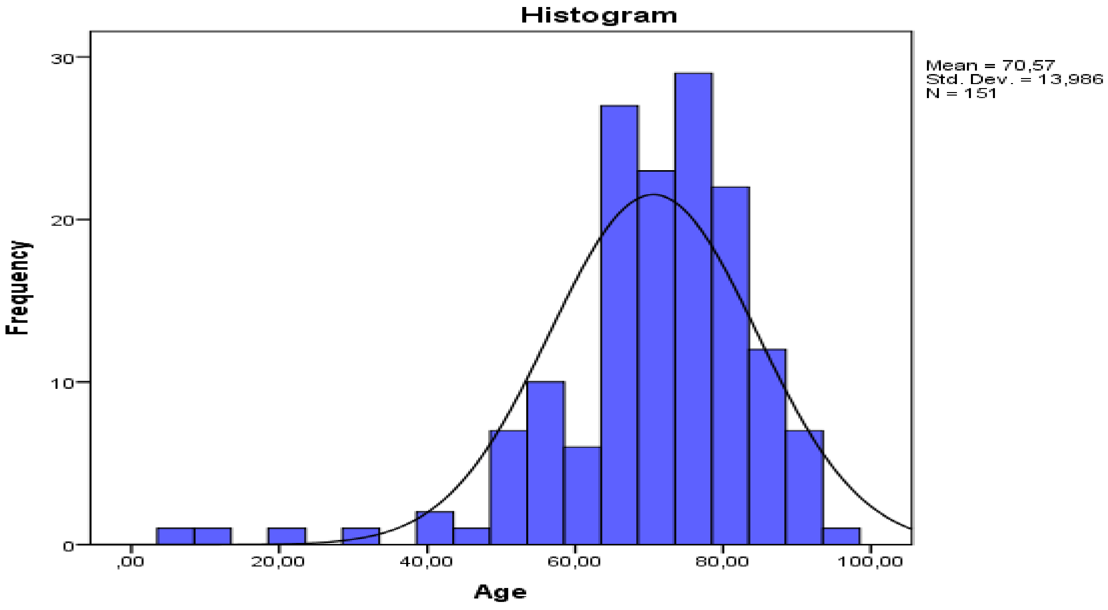

Fig. 1. Distribution according to age of patients

The gender distribution showed that males predominated (71.5%), accounting for about ¾ of the patients studied (Fig. 2).

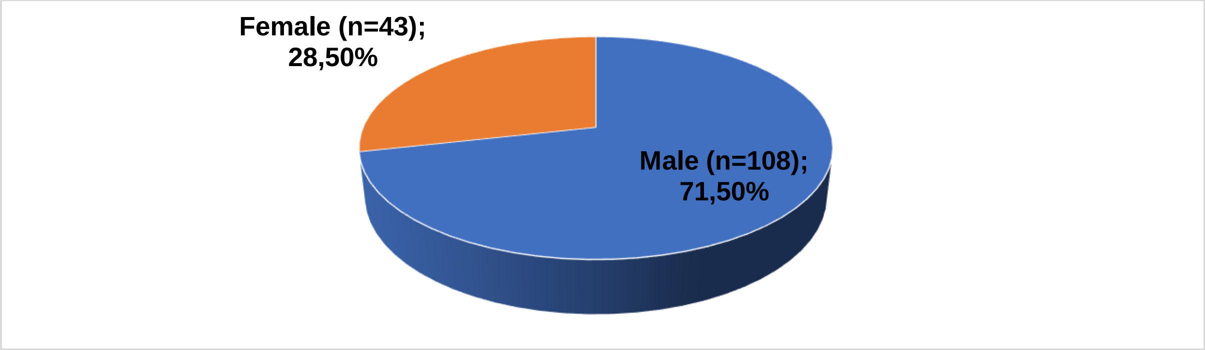

Fig. 2. Gender distribution

Although no significant difference was found, the results of the analysis showed that women with subdural hematomas were slightly younger than men (71.3 years for men and 68.7 years for women, respectively) (Fig. 3).

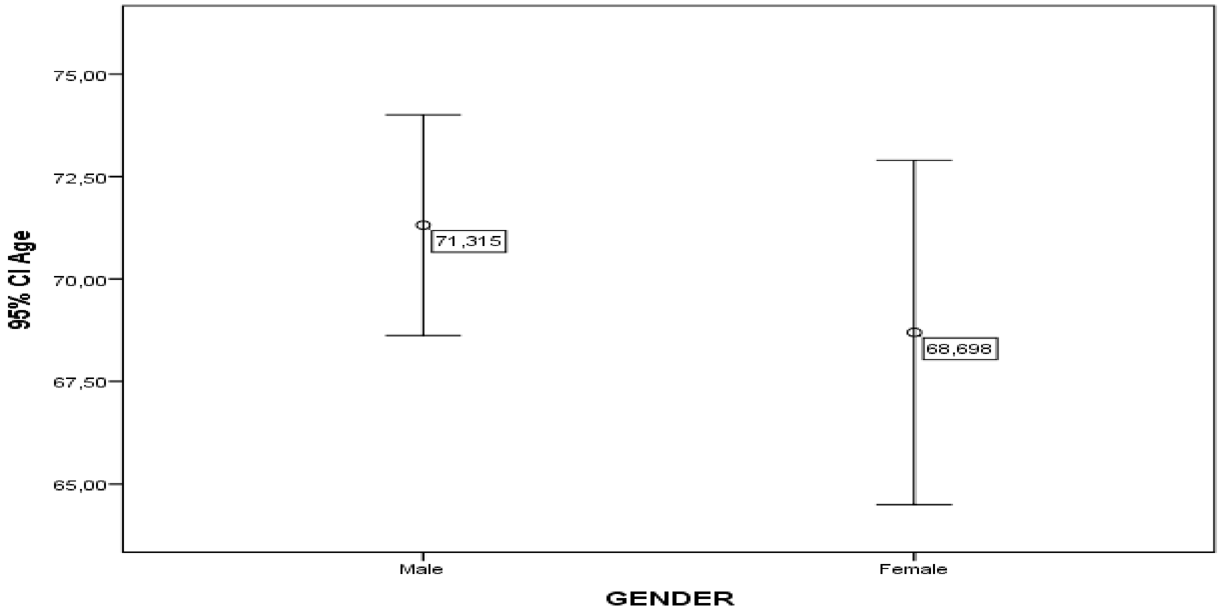

Fig. 3. Comparative analysis of patients according to gender and age

Analysis of the results according to place of residence showed that the majority of patients were from urban areas (Fig. 4).

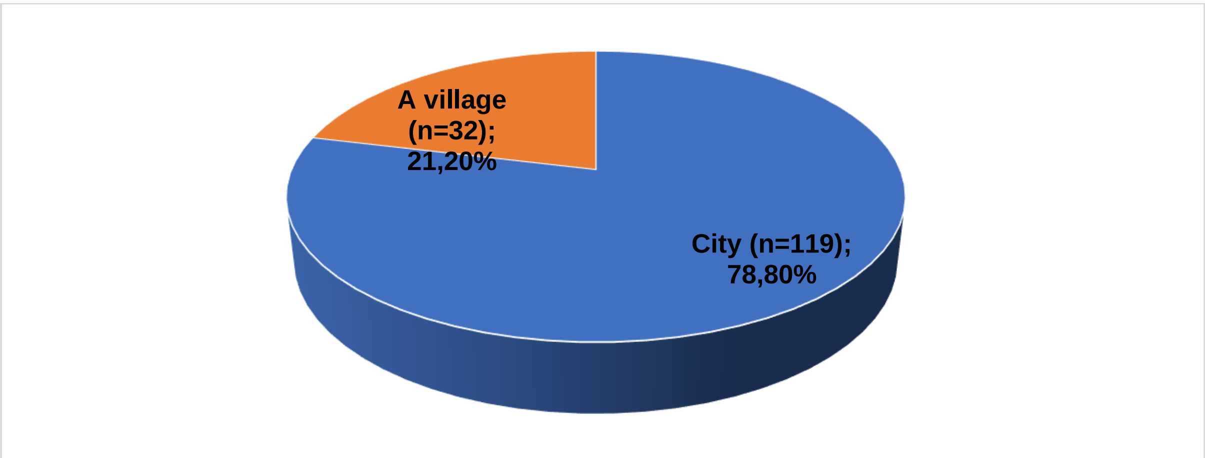

Fig. 4. Distribution by place of residence

There was no difference in the incidence of subdural hematomas according to gender and age of residence of the patients.

Investigation of risk factors showed that only 7.3% of patients reported being smokers and only 11.9% admitted to alcohol use. Smoking in combination with alcohol use was found in 3.3%.

There was a significant difference in age of patients with subdural hematoma according to smoking status ($p=0.008$). Smokers were significantly younger (Fig. 5).

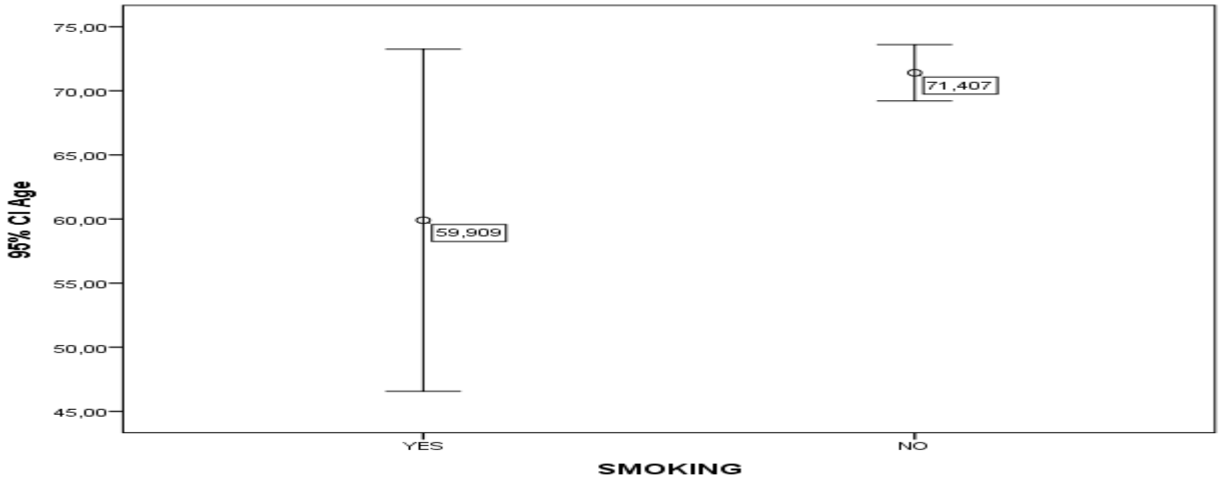

Fig. 5. Comparative analysis of patients according to smoking and age

Although no statistically significant difference was found, it can be said that smoking was more prevalent in men (Fig. 6) and patients living in rural areas (Fig. 7).

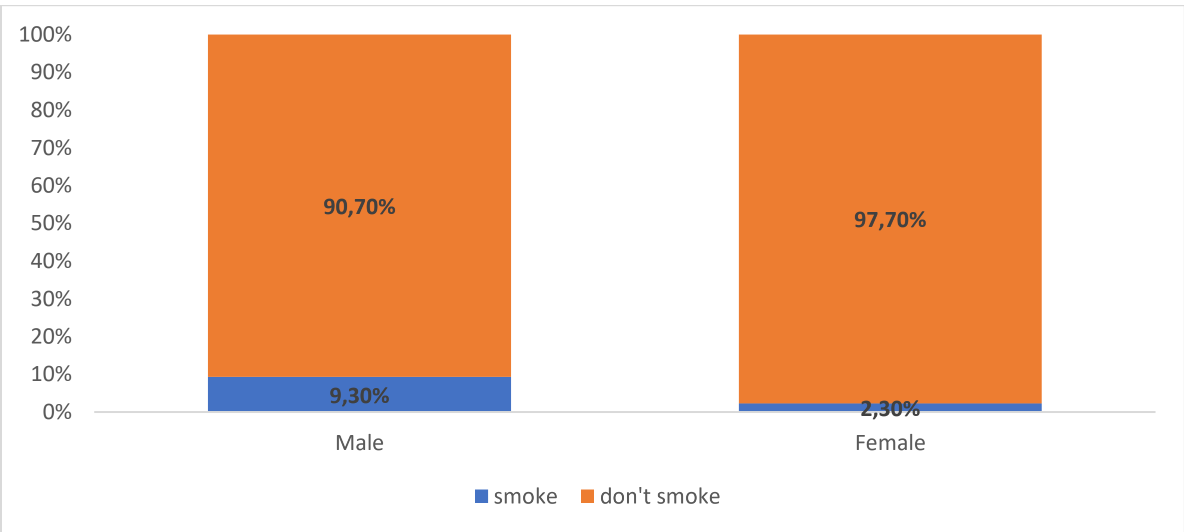

Fig. 6. Smoking by sex

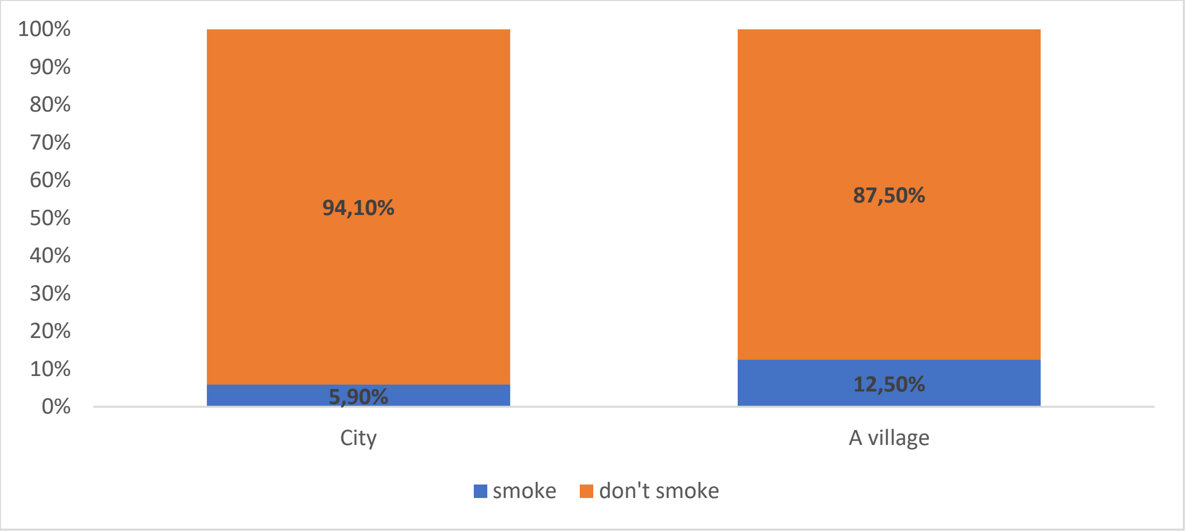

Fig. 7. Smoking by place of residence

Alcohol use was significantly higher in males (14.8%) compared to females (4.7%), with male gender resulting in over 3.6 times greater odds of alcohol use among patients with subdural hematoma (OR=3.56 (0.783-16.225) $p<0.05$) (Fig. 8).

On the other hand, unlike smoking, alcohol use was more prevalent among patients from urban areas (12.6%) compared to those from rural areas (9.4%) (Fig. 9).

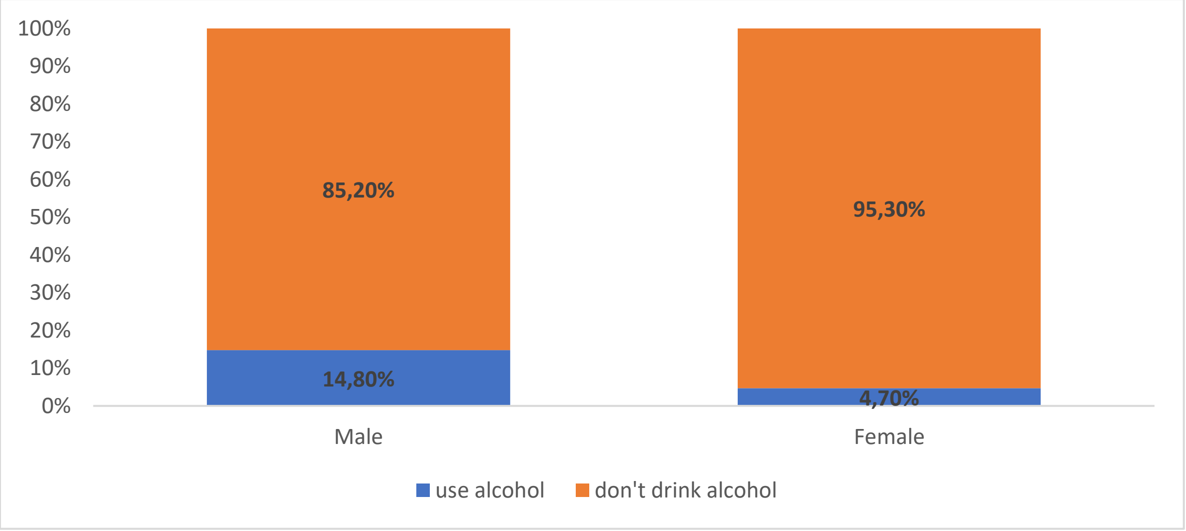

Fig. 8. Alcohol use by gender

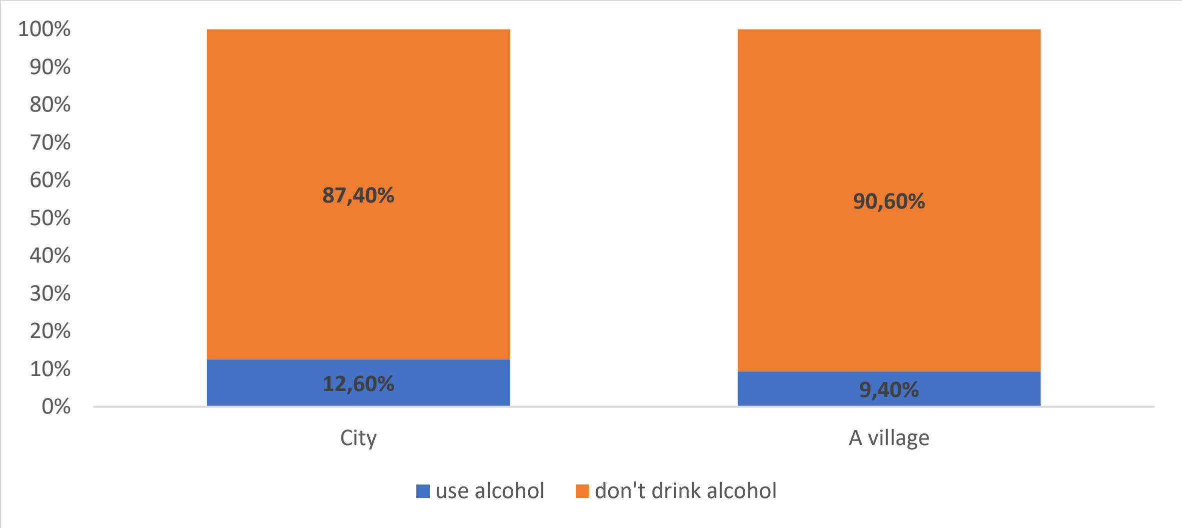

Fig. 9. Alcohol use by place of residence

No patient had a family history of subdural hematoma.

4.2. The clinical picture of patients with subdural hematoma

Analysis of the location of the subdural hematomas showed that unilateral chronic subdural hematomas predominated (74.2%) compared with bilateral hematomas (25.8%), with left-sided subdural hematomas predominating among the unilateral hematomas (45.7%) (Fig. 10).

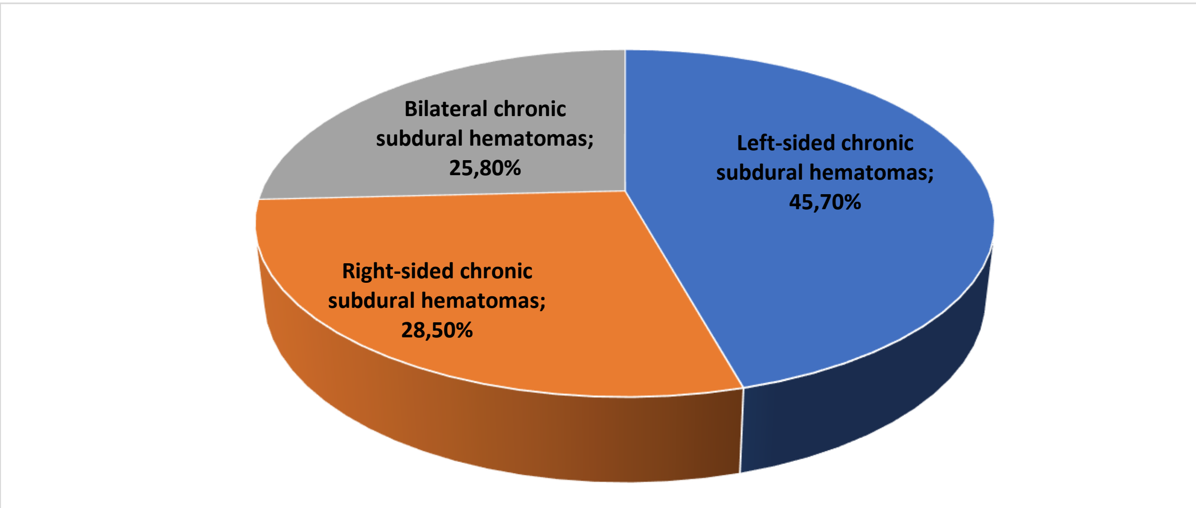

Fig. 10. Distribution according to the location of subdural haematomas

There was no significant difference in age between patients with unilateral and bilateral subdural hematomas (70.4 years for patients with unilateral hematomas and 71.1 years for patients with bilateral hematomas, respectively). There was also no difference in age for left-

sided and right-sided hematomas (70.9 years for patients with left-sided hematomas and 69.6 years for patients with right-sided hematomas, respectively).
The incidence of unilateral and bilateral subdural hematomas did not differ between the sexes (Fig. 11).

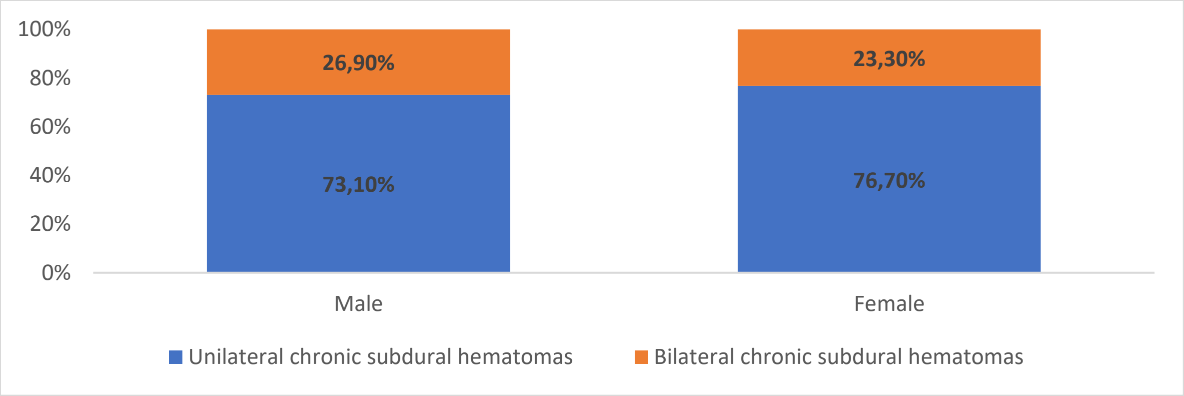

Fig. 11. Location of subdural hematoma according to sex

Although there was no statistical difference a higher relative proportion of left-sided chronic subdural haematomas was seen in males and right-sided haematomas had a higher relative proportion in females (Fig. 12).

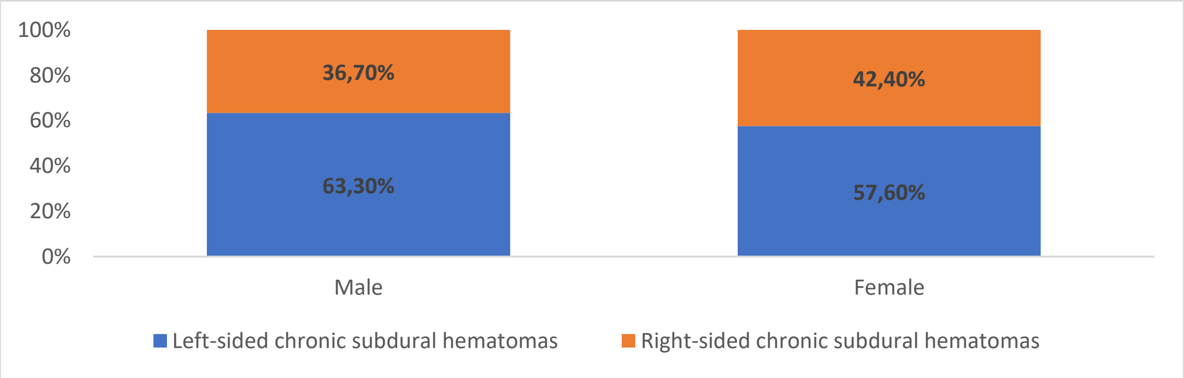

Fig. 12. Location of unilateral subdural hematoma according to sex

Analysis of the location of subdural hematomas according to smoking and alcohol use showed the same trend as the overall sample, left-sided chronic subdural hematomas predominated.

The mean length of stay of patients in the hospital was 6 days ± 3.7 days (3-34 days) (Fig. 13).

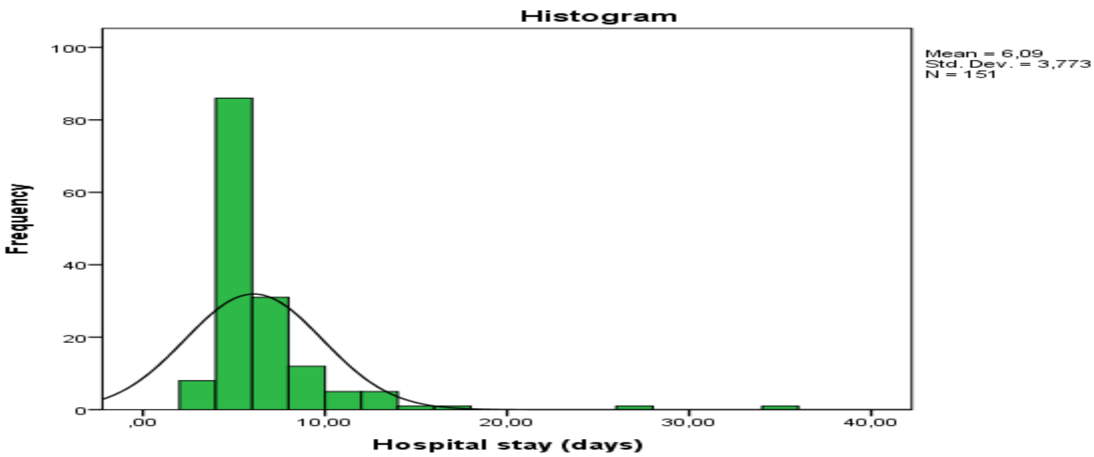

Fig. 13. Distribution according to hospital stay

There was no significant difference in mean hospital stay according to the area of subdural haematoma affected, with patients with unilateral haematomas staying an average of 5.9 days and those with bilateral haematomas 6.4 days. There was also no difference between left-sided and right-sided subdural hematomas (5.7 days for patients with left-sided hematomas and 6.3 days for patients with right-sided hematomas, respectively).

The mean subdural hematoma size was 15.5 mm ± 10.07 mm, ranging from 4 mm to 67 mm (Fig. 14).

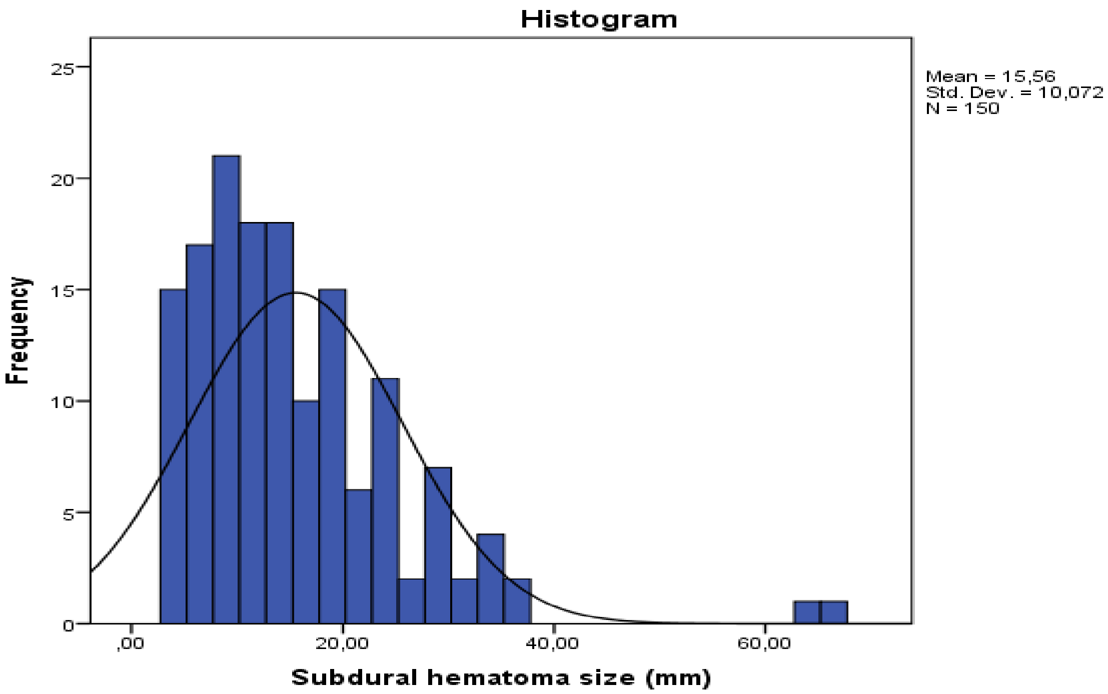

Fig. 14. Distribution according to subdural haematoma size

There was no significant difference in subdural hematoma size by location unilaterally or bilaterally (14.8 mm for patients with unilateral hematomas and 17.5 mm for patients with bilateral hematomas, respectively). No difference was also observed with respect to left-sided and right-sided subdural hematomas (15.9 mm for patients with left-sided hematomas and 13.1 mm for patients with right-sided hematomas, respectively).

Hospital length of stay did not correlate with subdural hematoma size.

A significant proportion (86.8%) of patients with chronic subdural hematomas had comorbidities, the most common of which are presented in Figure 15.

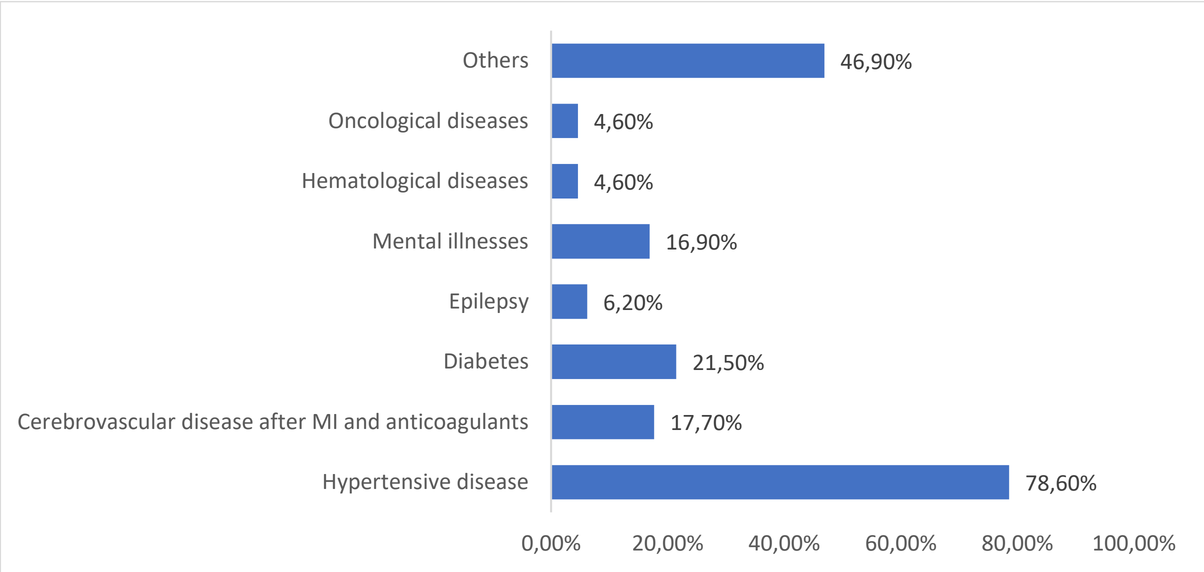

Fig. 15. Distribution according to comorbidities

Examination of hospital length of stay showed a significant difference only in patients with subdural hematoma and concomitant hematologic diseases, where the mean hospital stay was 10.8 days (p=0.004) (Fig. 16).

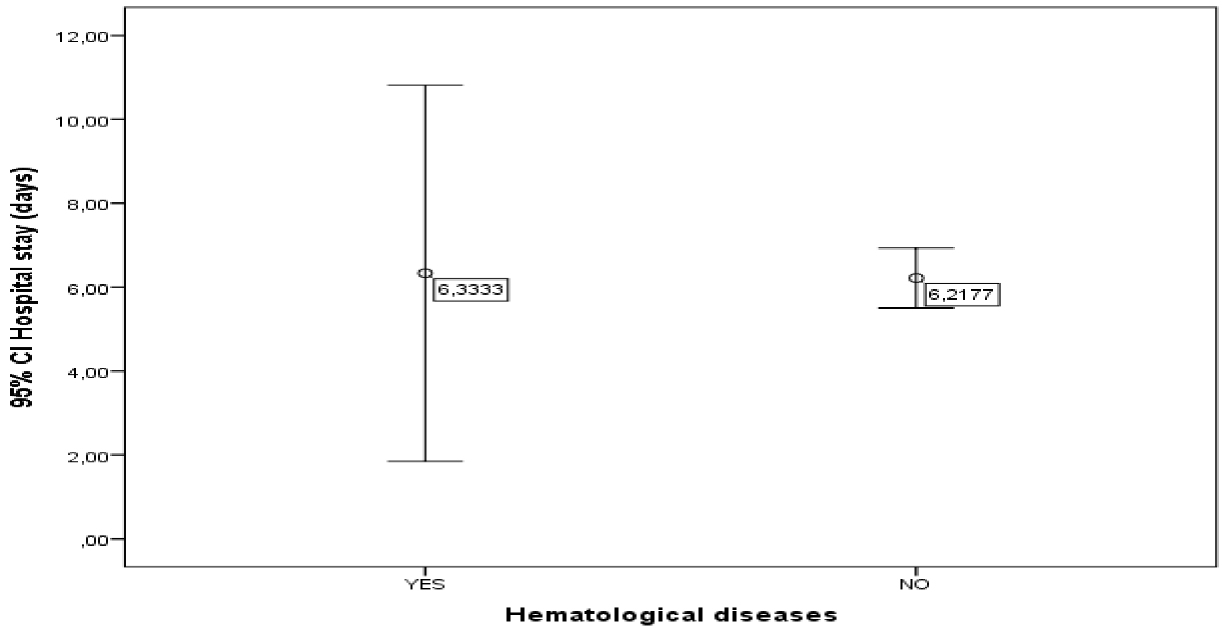

Fig. 16. Mean hospital stay of patients with subdural hematoma and hematological disease

Examination of the relationship between the presence of comorbidities and the size of the subdural hematoma showed that there was a significant difference between patients with and without comorbidities (p=0.025) (Fig. 17).

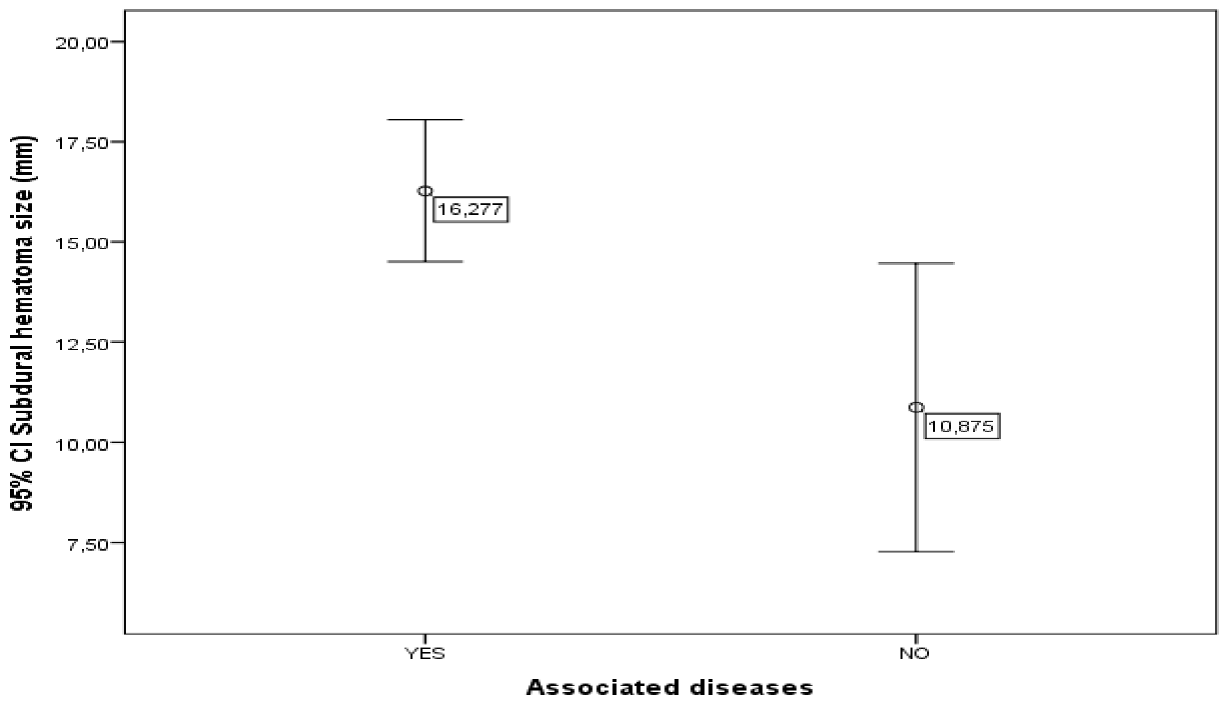

Fig. 17. Mean size of subdural hematoma according to the presence of concomitant disease

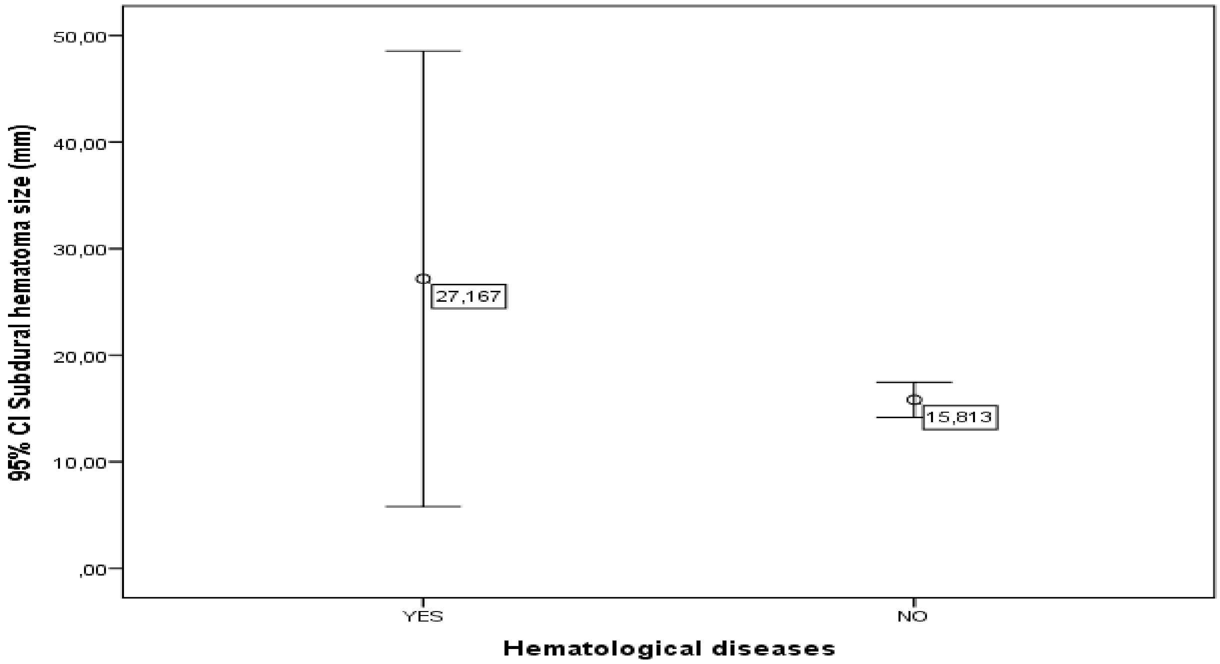

Fig. 18. Mean size of subdural haematoma according to the presence of haematological disease

This difference was mainly due to patients with hematological diseases, where the size of the subdural hematoma in these patients was 27.16 mm (p=0.007) (Fig. 18).

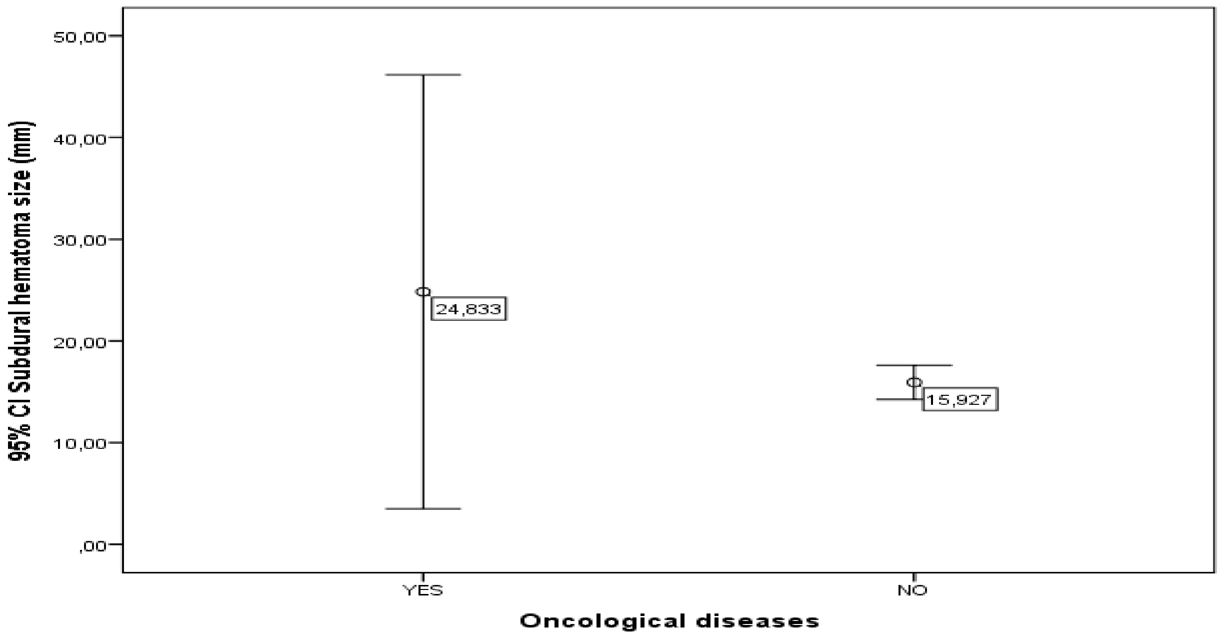

Fig. 19. Mean size of subdural hematoma according to the presence of oncological disease

Another group of accompanying diseases, in which patients are characterized by a large size of the subdural hematoma, are oncological diseases, where the average size of the hematoma is 24.83 mm (p=0.037) (Fig. 19).

In fig. 20 shows the average size of the subdural hematoma according to the presence of the various accompanying diseases.

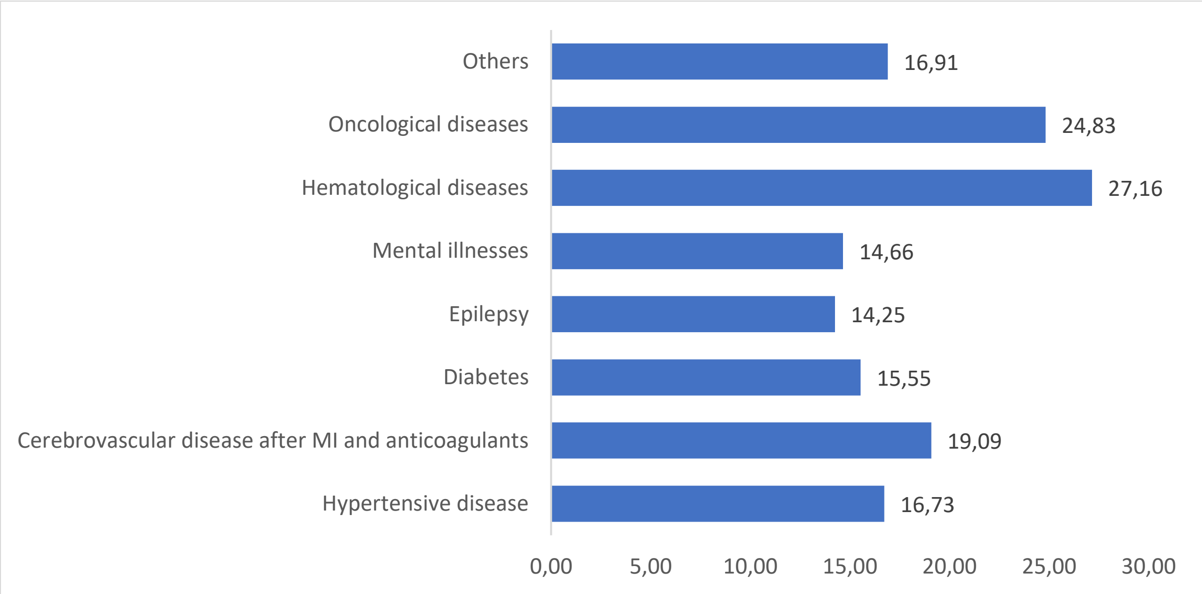

Fig. 20. Average size of subdural hematoma according to accompanying diseases

According to the clinical picture, the most common is paresis, which is observed in 72.7% of patients (Fig. 21).

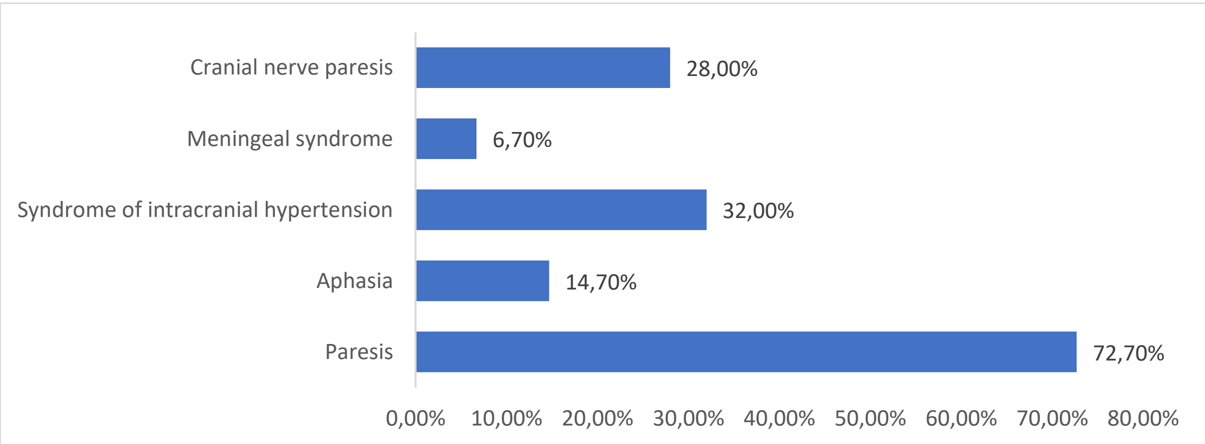

Fig. 21. Clinical picture

Paresis correlated strongly (r=0.577; p=0.008) with unilateral chronic subdural hematomas on the left, which carried a 21-fold higher risk of developing various paresis.

Aphasia correlated moderately (r=0.312; p=0.001) with unilateral chronic subdural hematomas on the left, which carried a 15-fold higher risk of developing various aphasias (OR=15.12 (1.937-118.043); p<0.001).

Meningealen syndrome correlated moderately (r=0.337; p=0.001) with unilateral chronic subdural hematomas on the right.

In fig. 22 presents the average hospital stay according to the clinical picture, with the longest stay observed in patients with Meningealen syndrome (8 days).

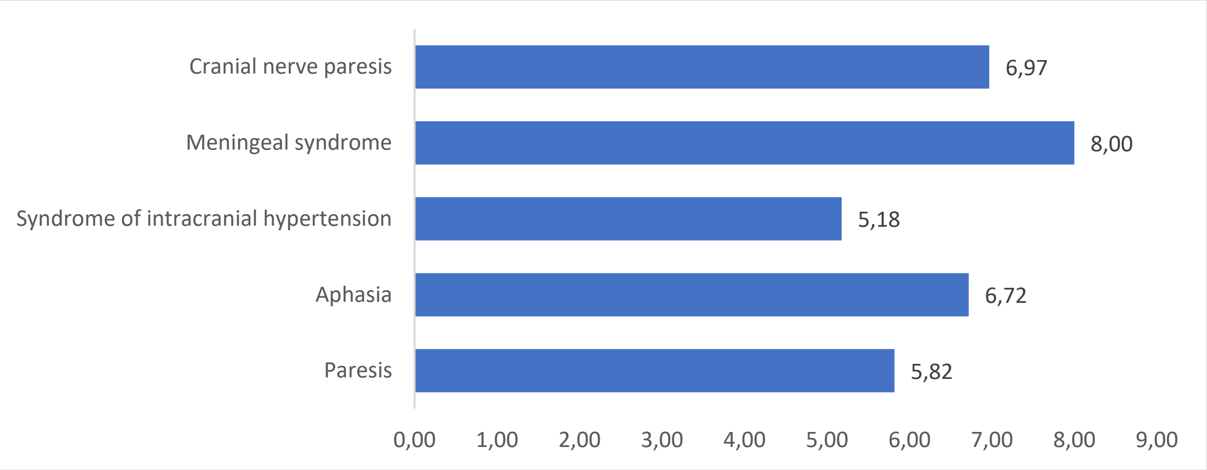

Fig. 22. Average hospital stay according to clinical picture

In fig. 23 presents the results according to the average size of the subdural hematoma, with the patients with cranial nerve paresis having the largest hematoma size (19.66 mm).

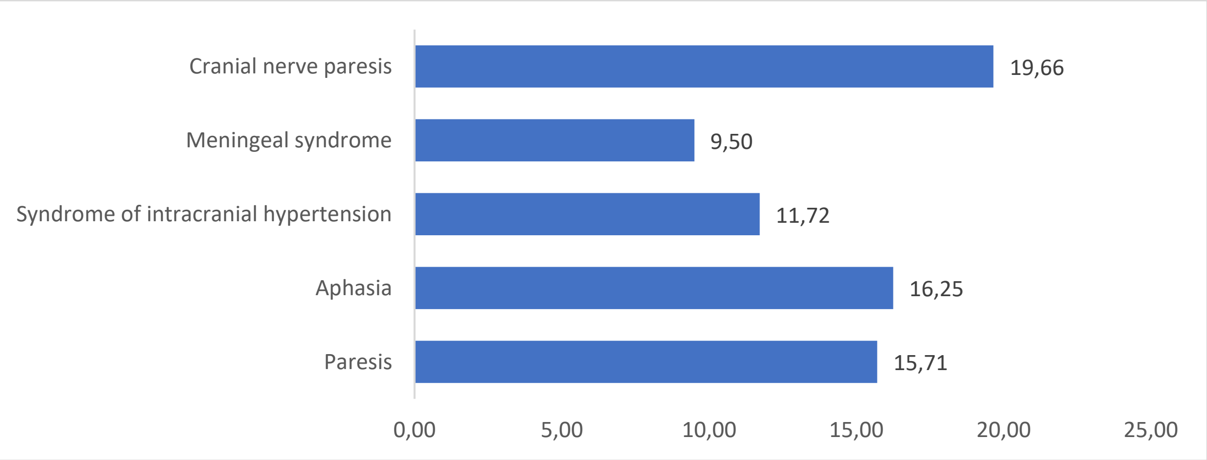

Fig. 23. Average size of subdural hematoma according to clinical picture

The patients' preoperative GCS scores ranged from 5 to 15 (mean 13.11±2.75) (Fig. 24).

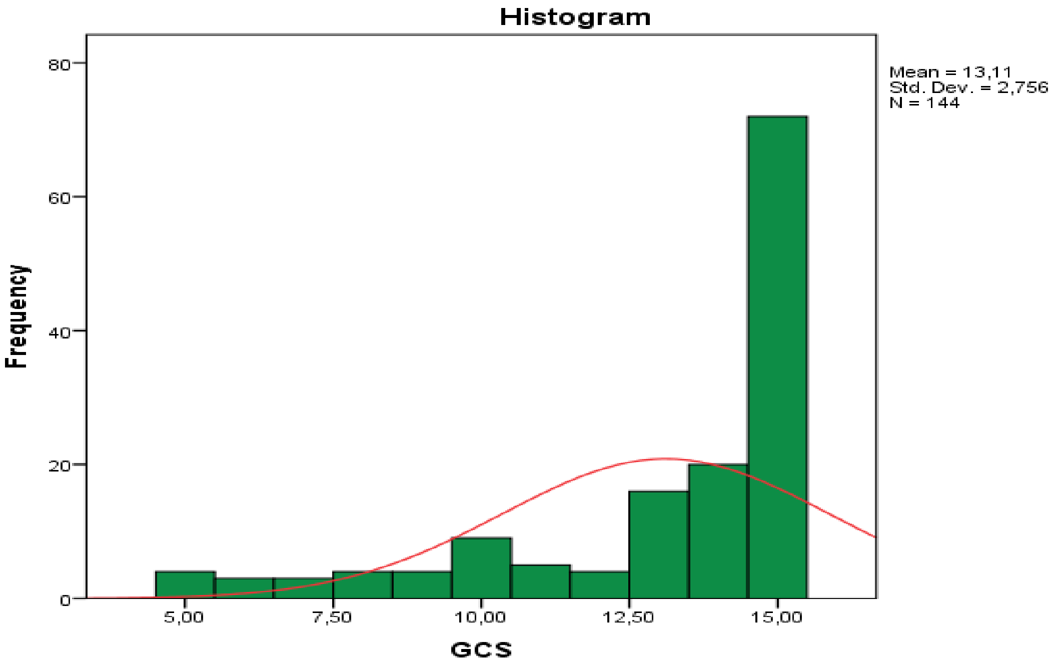

Fig. 24. Distribution of patients according to the preoperative Glasgow scale

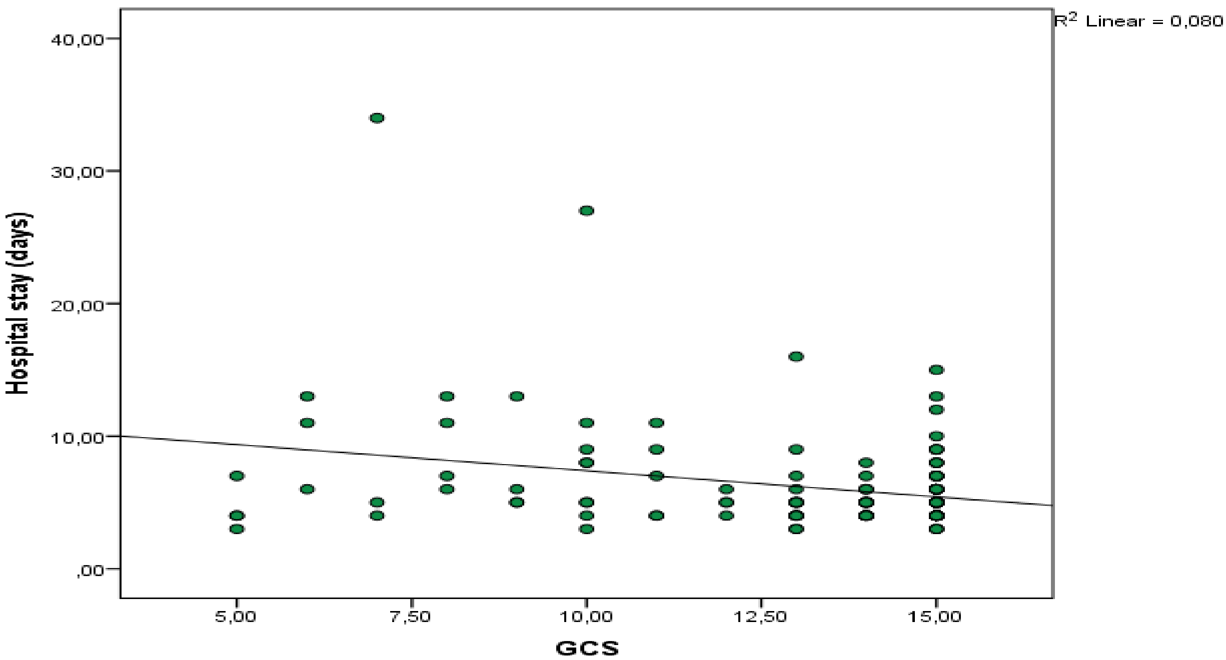

Fig. 25. Correlation analysis between length of hospital stay and Glasgow Scale score

A weak to moderate inverse correlation was found between length of hospital stay and Glasgow Scale score (r=-0.283; p=0.001), indicating that the higher the GCS score, the shorter the hospital stay (Fig . 25).

No correlation was found between the size of the subdural hematoma and the Glasgow scale score. There was also no difference in the Glasgow scale score according to the location of the hematoma.

4.3. Comparative analysis of the operative techniques used

In the treatment of chronic subdural hematomas, three main operative techniques were used (Fig. 26), with BHC prevailing (74.2%).

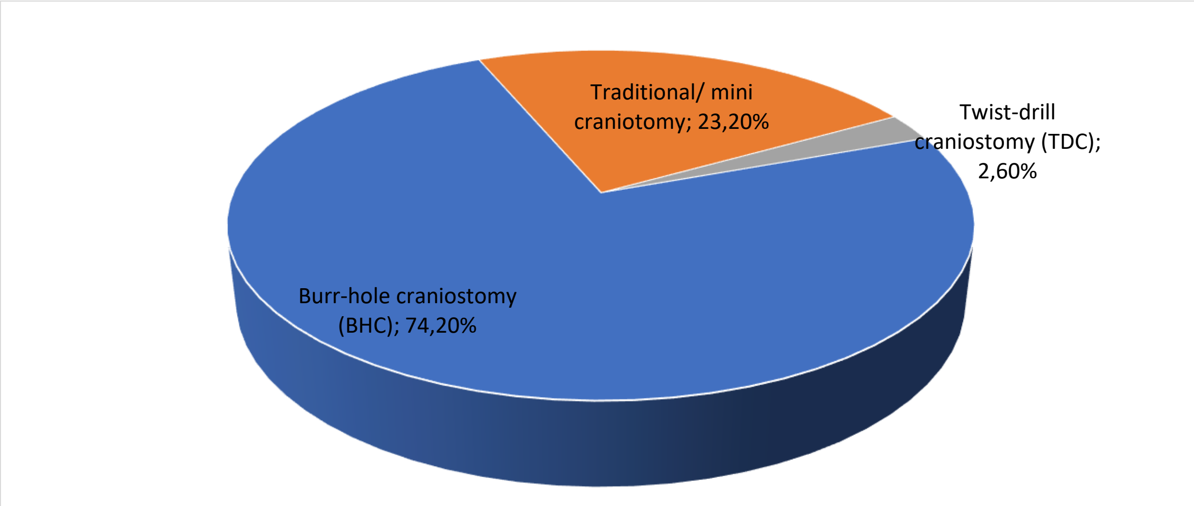

Fig. 26. Distribution of patients according to the operative technique

No significant difference was found in the choice of operative technique according to the age of the patients (Fig. 27).

From the point of view of the hospital stay, it was found that the patients in whom the traditional operative technique was used had the longest hospital stay (Fig. 28).

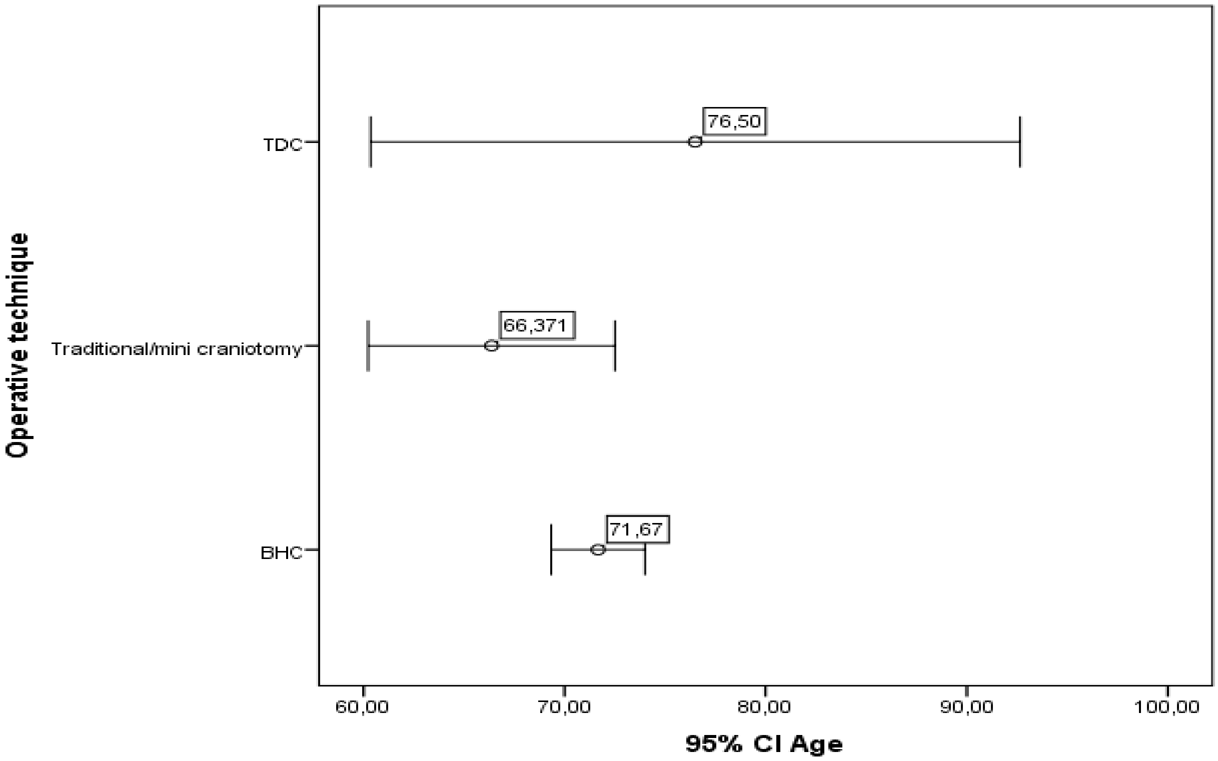

Fig. 27. Average age of patients according to operative technique

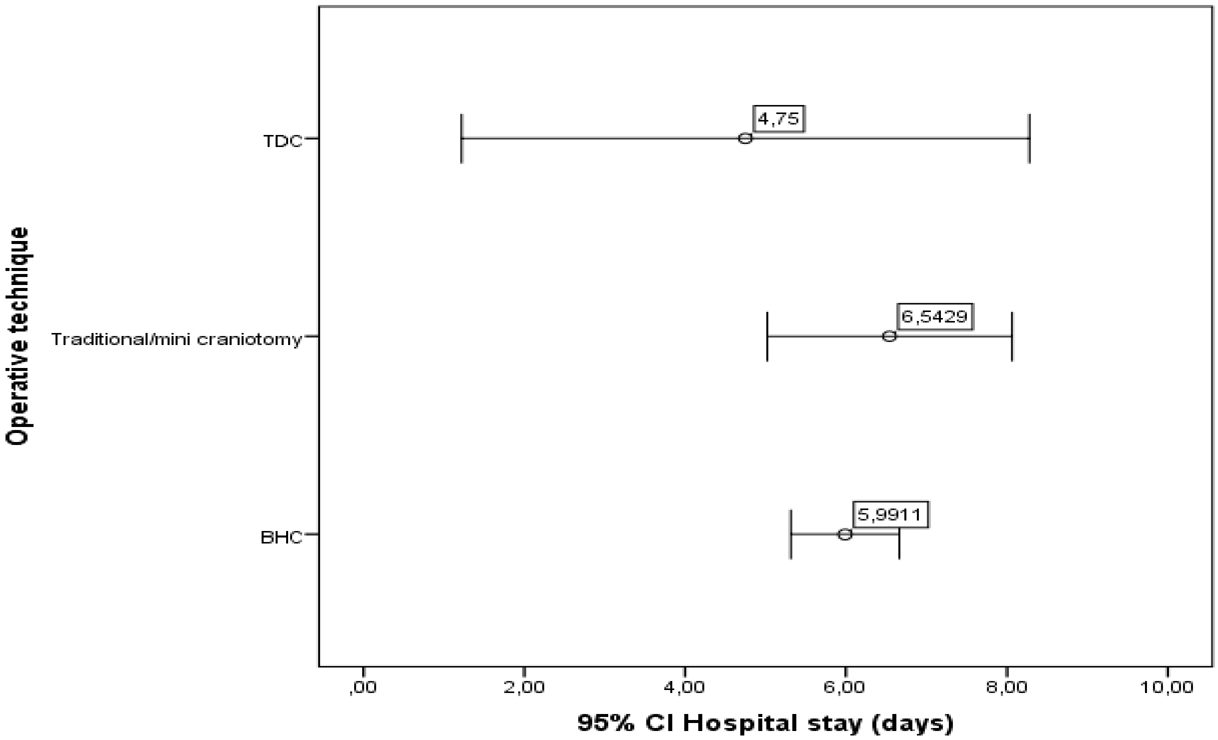

Fig. 28. Average hospital stay according to the operative technique used

The traditional operative technique was mainly used in patients with a smaller subdural carcinoma size (12.82 mm), while BHC was used in patients with a large hematoma size (16.45 mm).

The analysis of the selected operative technique according to the location of the subdural hematoma showed that in unilateral chronic subdural hematomas, BHC and the traditional operative technique were mostly applied, while TDC was used more often in bilateral hematomas (p=0.039) (Fig. 29). No difference was found in the technique used for left- and right-sided subdural hematomas.

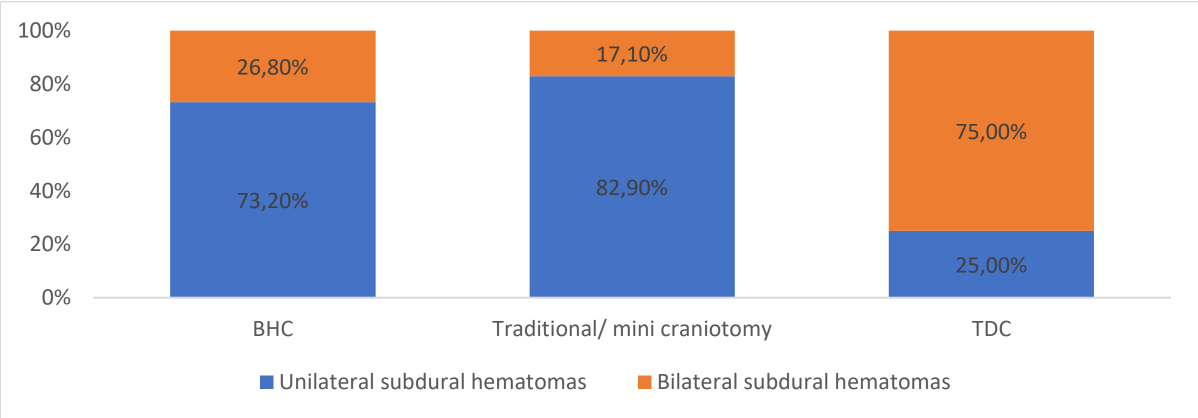

Fig. 29. Operative technique used according to the location of the subdural hematoma

BHC and TDC were mainly used in patients with accompanying diseases (p=0.001), and a weak dependence was established (r=0.246; p=0.002) (Fig. 30).

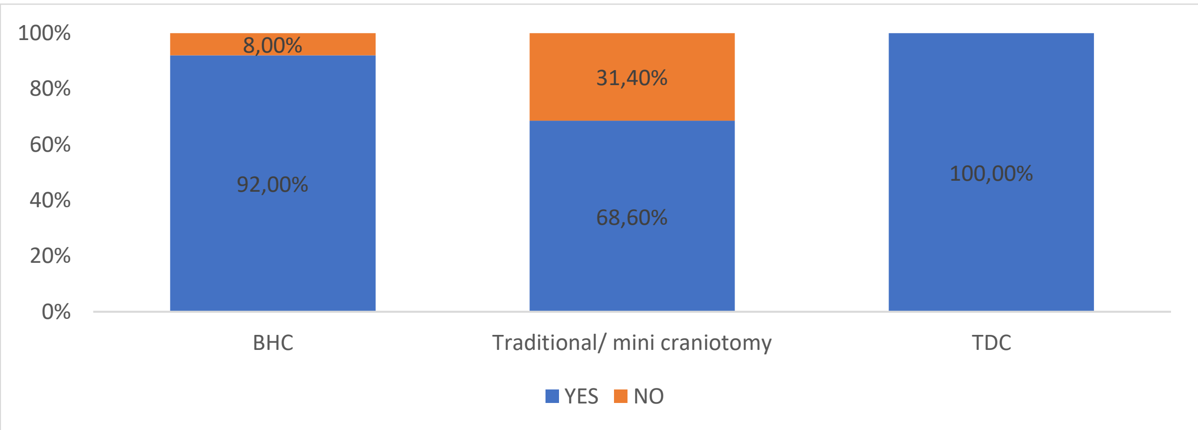

Fig. 30. Used operative technique according to the presence of accompanying diseases

According to the results presented in fig. 31, it is established that for all types of accompanying diseases, BHC is mainly used. The traditional operative technique is used in patients with epilepsy (25 %) and with mental illnesses (22.7 %).

In fig. 32 presents the results of the analysis of the used operative technique and the clinical picture. A significant difference was found in patients with aphasia (p=0.018) and Meningeal syndrome (p=0.001).

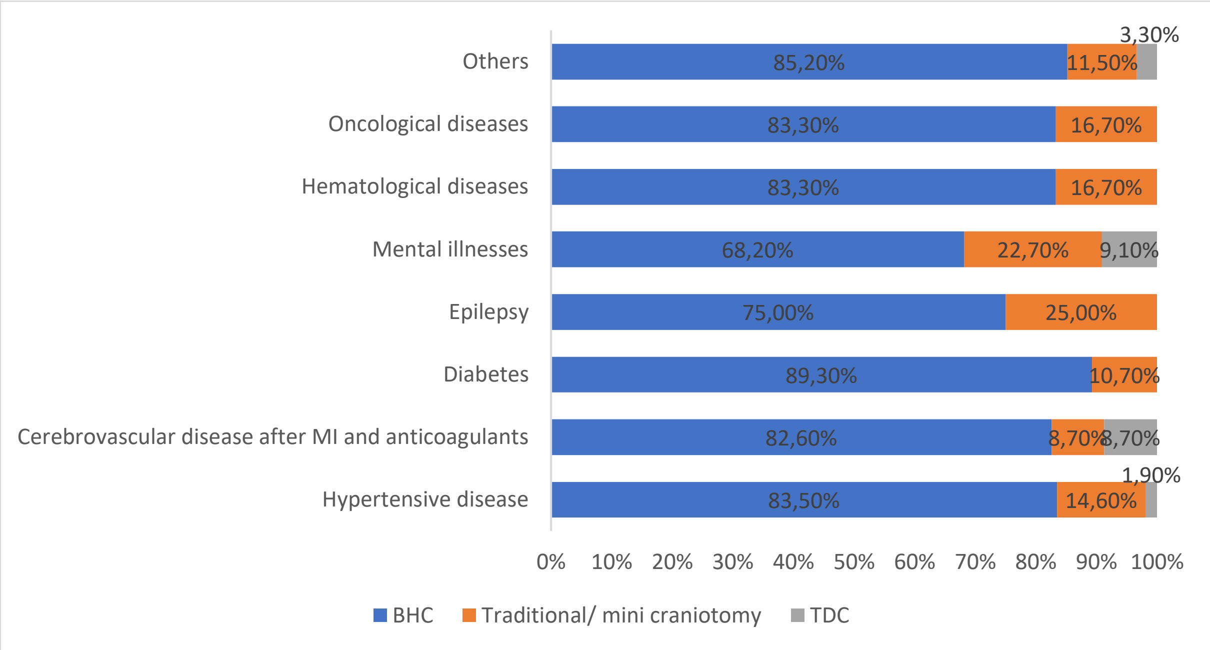

Fig. 31. Used operative technique according to the accompanying disease

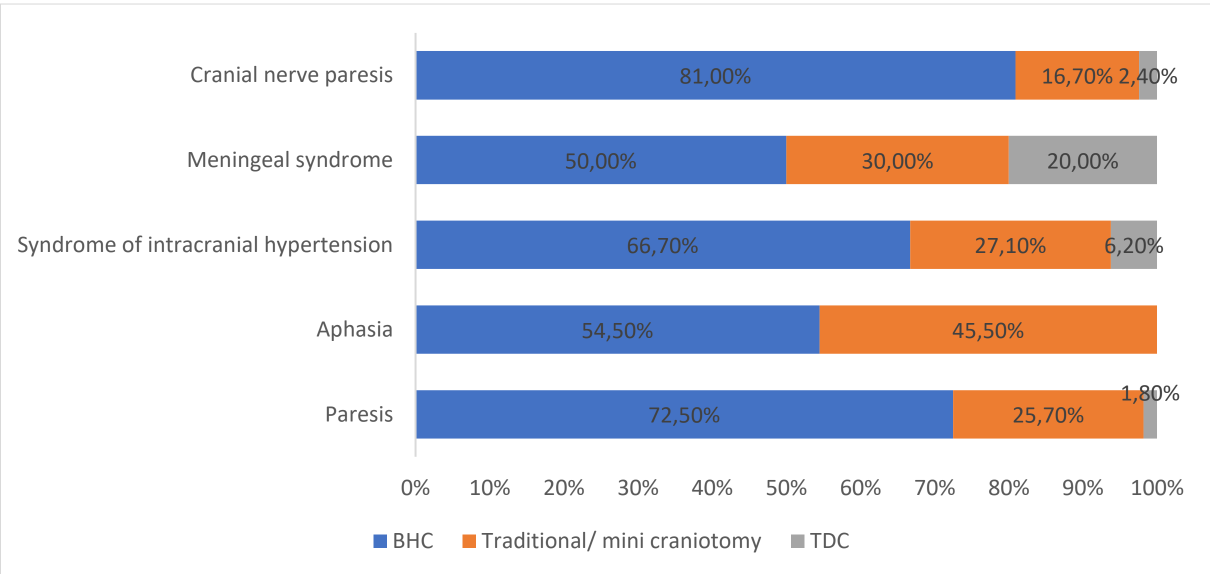

Fig. 32. Used operative technique according to the clinical picture

4.4. Prediction of the outcome of the treatment according to the risk factors, the clinical picture and the operative technique used

Postoperative complications were observed in 9 patients, infection was found in 4, epidural hematoma in 3, and intracerebral hematoma in 2. Recurrences were found in 5 patients.

With a fatal outcome, 8.6% of the cases with an average age of 74 years, and no difference according to gender and place of residence.

In terms of risk factors, no decedents were identified who indicated that they smoked. Of the patients who indicated that they consumed alcohol, 11.1% died despite the treatment.

A moderate correlation was found between the length of hospital stay and mortality ($r=0.420$; $p<0.001$), with the average length of stay being 11.2 days (Fig. 33).

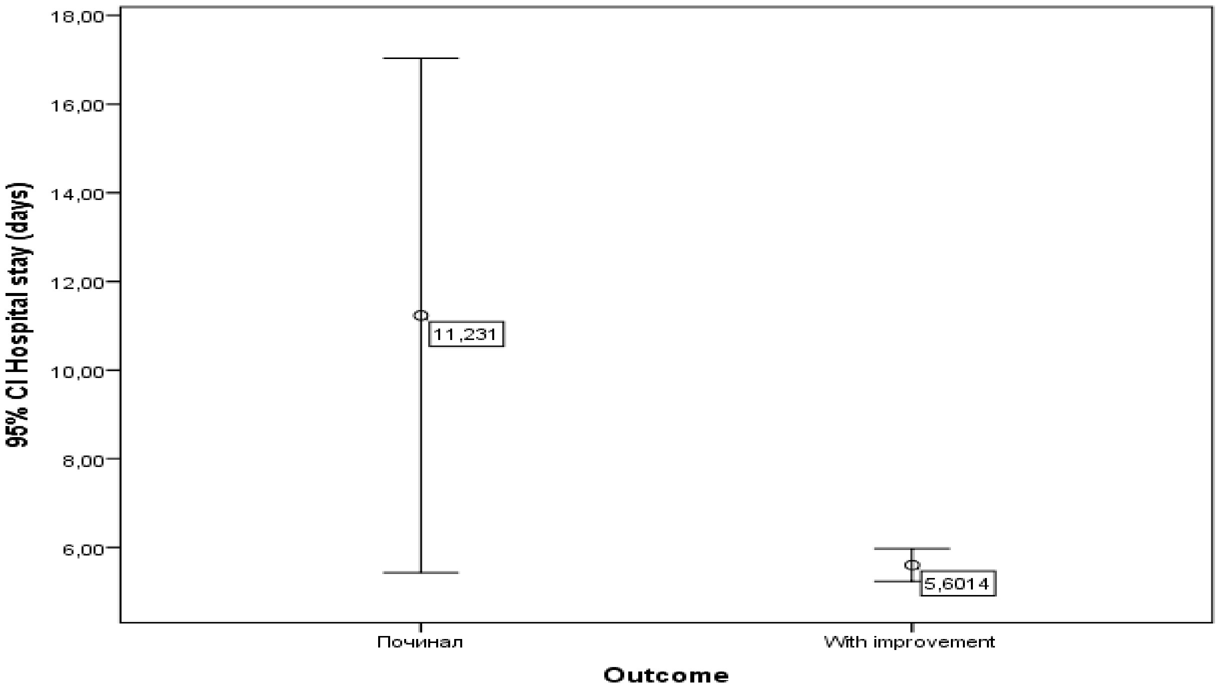

Fig. 33. Outcome of the disease and length of hospital stay

A moderate correlation was also found between the size of the subdural hematoma and the outcome of the disease ($r=0.328$; $p<0.001$), with the average size of the subdural hematoma being 26.23 mm. in deceased patients (Fig. 34).

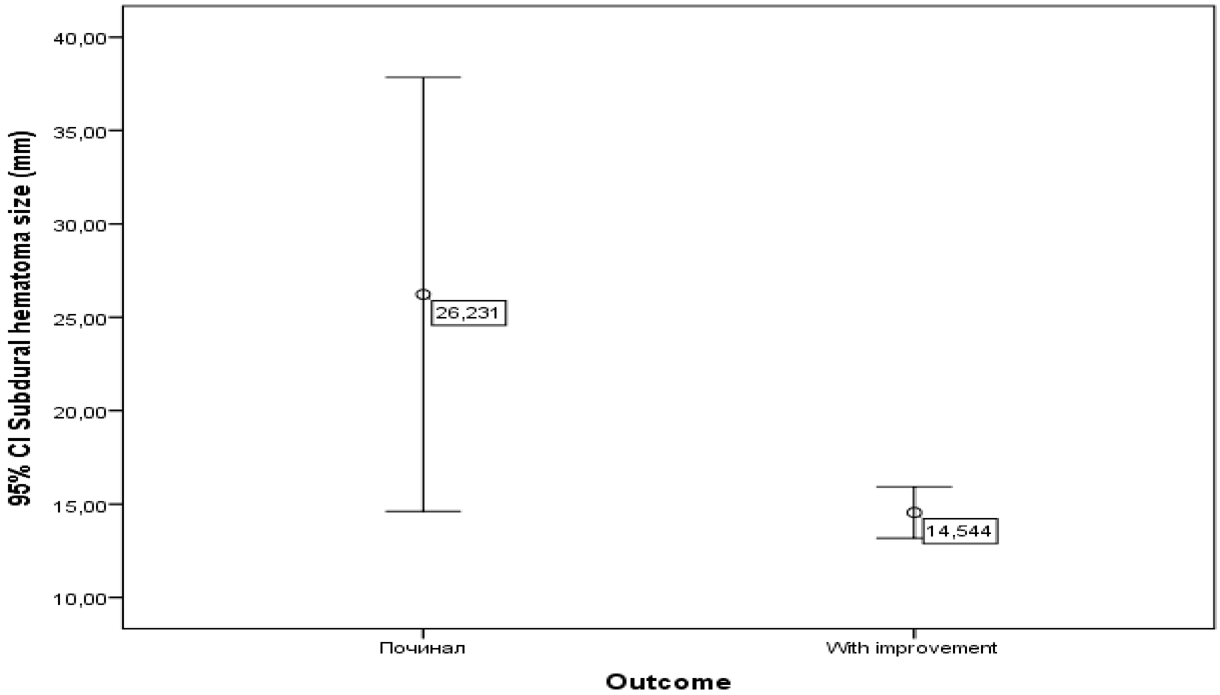

Fig. 34. Disease outcome and mean subdural hematoma size

No significant difference in the outcome of the disease was found, although in patients with bilateral subdural hematomas the mortality rate was higher (12.8 %) (Fig. 35), and in unilateral patients with left-sided hematomas the mortality rate was about 2 times higher than those with right sides (Fig. 36).

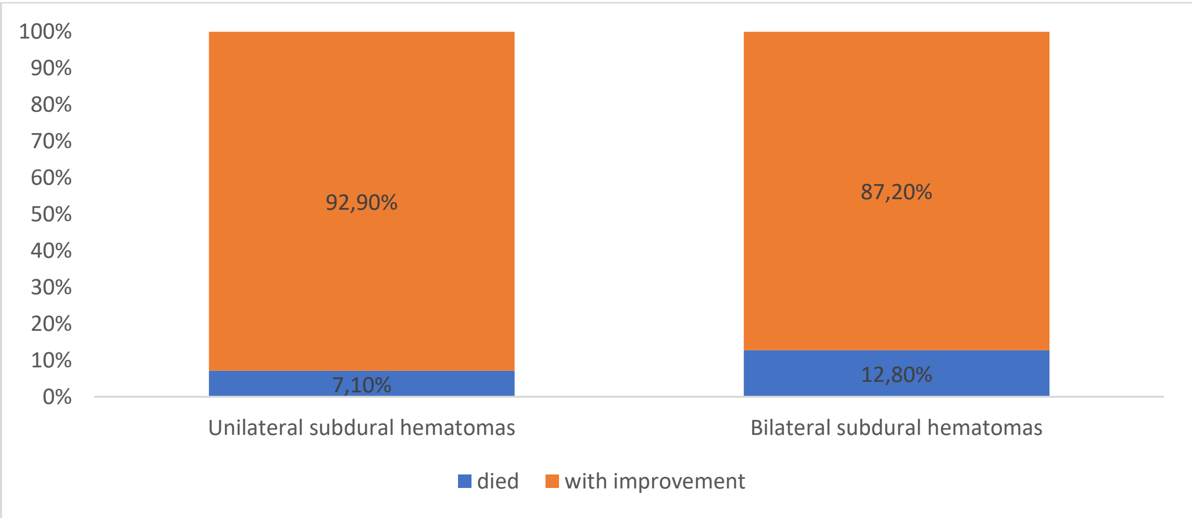

Fig. 35. Outcome of the disease according to the location of the subdural hematoma

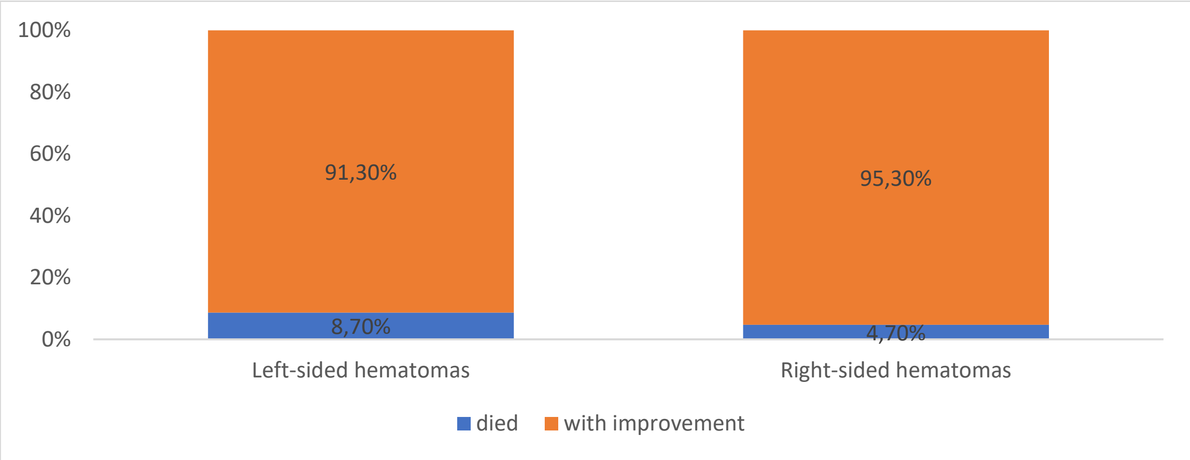

Fig. 36. Outcome of the disease according to the location of the unilateral subdural hematoma

Of the patients with comorbidities, 9.9% died as a result of the disease, while for the rest, all were discharged with improvement. In fig. 37 presents the outcome of the disease according to the accompanying disease.

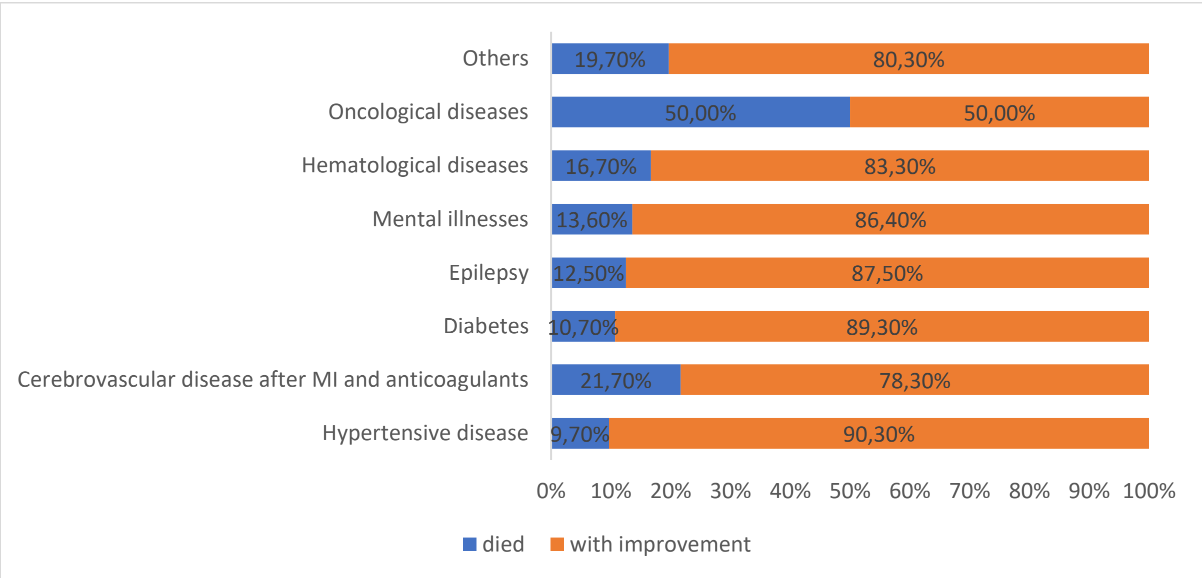

Fig. 37. Outcome of the disease according to accompanying diseases

Patients with cerebrovascular disease have more than 3 times higher risk of fatal outcome in the occurrence of subdural hematoma (OR=3.44 (1.010-11.702); p=0.039).

Patients with oncological diseases have more than 11 times higher risk of fatal outcome in the occurrence of subdural hematoma (OR=11.44 (2.029-64.042); p=0.001).

4.5. Defining precise indications and contraindications for intraoperative neuroendoscope use in the evacuation of chronic subdural hematomas

According to the literature review and statistical analysis of patients with chronic subdural hematomas, it can be concluded that it is necessary to define precise indications for the use of neuroendoscope in the evacuation of chronic subdural hematomas.

Karakhan and Khodnevich (1994) reported contraindications to endoscopic surgery, such as:

1) extensive area of traumatic injury;

2) large bleeding vessel;

3) prolapse of the brain;

4) calcification of hematoma.

They also excluded patients needing decompressive craniotomy or craniectomy. The most important point of these indications for endoscopic surgery is safety.

Our indications for intraoperative neuroendoscope use in the evacuation of chronic subdural hematomas are:

1) Presence of symptoms
2) Age over 65 years, not excluding use in younger patients
3) Absence of moderate or massive brain injury/hematoma
4) Absence of growing subdural hematoma
5) Low risk of bleeding.

4.6. Protocol for intraoperative application of endoscope in neurosurgical surgical treatment of chronic subdural hematomas

The protocol was developed for use by all neurosurgical patients at the Neurosurgery Clinic of the UMHAT "St. Marina" in the city of Varna, who are undergoing surgical treatment for a chronic subdural hematoma..

The protocol was created based on a thorough review and analysis of the available literature related to the problem at hand.

Through the protocol, a meticulous intraoperative inspection for actively bleeding vessels, clots or septa in the subdural space is performed. The protocol includes 15 points.

1. Positioning of the patient on the operating table after intubation - depending on the side on which the hematoma is found (in case of unilateral collection) - the position can be fully lateral or supine with the head rotated on the side opposite to the hematoma, with elevation of the essential shoulder; depending on whether it is bilateral - in supine position, with the head in neutral position, elevation of the chest at 30 degrees.

2. Drawing of the skin incision - according to the location of the hematoma; and according to the volume of the planned cranial opening.
3. Thorough cleaning of the operative field with iodine solution Brownol.
4. Making the skin incision, hemostasis, retraction of subcutaneous soft tissues.
5. Making cranial access : TDC (twist drill craniostomy)/ BHC (burr-hole craniostomy)/ traditional/ mini - craniotomy. In patients with unilateral chronic hematomas, the trapanial opening is made as high and anterior as possible to avoid pneumocephalus in the postoperative period. Usually this is the intersection of the temporalis superior line and the coronal suture, but in larger hematomas it is possible to make the punctate craniectomy in the parietal area. In bilateral chronic hematomas, in more cases, the patient's head is in neutral position, flexed in felexion, and two trapping detachments are made (usually in the parietal region). If necessary, the head can be tilted initially in one direction and then in the other. To avoid midline compression, the dura is opened simultaneously (in some cases, it may initially be on the side with the larger hematoma volume and more pronounced midline dislocation).
6. Duroperiosteal sutures (at least two).
7. Cruciate incision of the dura.
8. Subsequent evacuation of the hematoma - a catheter is introduced into the cavity of the hematoma, through which a lavage with physiological serum (body temperature) is performed until clarification of the fluid..
9. Placement of a neuroendoscope with 30 or 70 degree optics for viewing the cavity.
10. If necessary, flush or rupture the hematoma capsule again until complete evacuation of the hematoma.
11. A tubular subdural drain is placed for 12hours. A tubular subdural drain in the cavity of the haematoma is placed in the anterior part of the craniotomy in a previously made groove in the bone, with its tip pointing backwards occipitally
12. Sealing of the dura and placement of bone bran wrapped in suture to close the bone defect. Implants can be used to better seal the dura and the bone defect.
13. Layered stitching of soft fabrics. For better cosmetic effect, intradermal suture is performed.

14. Dry sterile dressing.

15. Placing the drain tank at head level.

4.7. Formulation of recommendations for the intraoperative use of an endoscope in the neurosurgical treatment of patients with chronic subdural hematomas

Recommendations for the intraoperative use of an endoscope in the neurosurgical treatment of patients with chronic subdural hematoma:

1. Administration of endoxope is highly recommended in patient(s) with chronic subdural hematoma over 1cm thick.
2. It is recommended that surgical intervention be performed within 24 hours after admission to the clinic - the exception being patients who are established on oral anticoagulants and/or anti-aggregants as they require replacement with low molecular weight heparin - the duration of replacement varies depending on the type of medication taken; patients with haematological disease where specific preparation is required.
3. It is highly recommended to perform a follow-up CT scan within 24 hours after surgery to report the extent of evacuation compared to the preoperative imaging.
4. Clinical follow-up of the patient using Glasgow Coma Scale (GCS) - pre- and post-operative and Glasgow Outcome Scale - post-operative.

Tabl. 1. Glasgow coma scale

Glasgow coma scale		*Points*
Eye Response	**Spontaneous opening** **Opening on voice command** **Opening consequence of pain** **No response**	**4** **3** **2** **1**
Verbal response	**Conversation/ oriented** **Confused speech/ disorientation** **Unrelated individual words** **Unintelligible sounds** **No response**	**5** **4** **3** **2** **1**
Motor response	**Executes commands** **Localizes pain** **Withdrawal in pain** **Abnormal flexion** **Extension** **No response**	**6** **5** **4** **3** **2** **1**

(Teasdale et al., 1974; Teasdale et al., 1979; Meredith W, 1998; Iver V.N, 2009; Fischer M, 2010; Green S.M, 2011).

The Glasgow Outcome Scale (GOS) provides information on the functional outcome of a patient's condition in one of five categories: death, vegetative state, severely disabled, moderately disabled or good recovery (Jennett B et al., 1975; Wilson JT et al., 1997; Teasdale GM et al., 1998; Wilson JT et al., 2007). Postoperative GOS score is reported at the first and third month by follow-up outpatient examinations and/or by telephone survey.

Tabl 2. Glasgow scale - postoperative

GOS1	good recovery
GOS2	moderate disability
GOS3	severe disability
GOS4	vegetative status
GOS5	death

V. DISCUSSION

Subdural hematomas are a common and highly painful condition affecting all age groups [Benko MJ, Abdulla SG, Cuoco JA, Dhiman N, Klein BJ, Guilliams EL, Marvin EA, Howes GA, Collier BR, Hamill ME., 2019; El-Fiki M., 2012; Whitehouse KJ, Jeyaretna DS, Enki DG, Whitfield PC., 2016; Wilberger JE Jr, Harris M, Diamond DL., 1991] . Mortality and morbidity from this condition increase with age with mortality rates reported to be as high as 90% in the elderly population [Benko MJ, Abdulla SG, Cuoco JA, Dhiman N, Klein BJ, Guilliams EL, Marvin EA, Howes GA, Collier BR, Hamill ME., 2019; El-Fiki M., 2012; Whitehouse KJ, Jeyaretna DS, Enki DG, Whitfield PC., 2016; Cagetti B, Cossu M, Pau A, Rivano C, Viale G., 1992; Lukasiewicz AM, Grant RA, Basques BA, Webb ML, Samuel AM, Grauer JN., 2016] . Falling is the most common mechanism of injury [Cagetti B, Cossu M, Pau A, Rivano C, Viale G.,1992]. These falls can lead to life-threatening hematoma, especially in patients on antithrombotic therapy or anticoagulants [Lavrador JP, Teixeira JC, Oliveira E, Simão D, Santos MM, Simas N., 2018; Gaist D, García Rodríguez LA, Hellfritzsch M, Poulsen FR, Halle B, Hallas J, Pottegård A., 2017].

The current understanding of risk factors for cSDH is that they primarily include alcohol use, the presence of certain diseases such as liver cirrhosis, chronic renal failure and haematological diseases. Another factor is the intake of anticoagulants and antiaggregants, which play an important role in the pathogenesis of cSDH. The results of the present study showed that patients with cSDH who reported alcohol use accounted for 11.9% and those taking anticoagulants accounted for 17.7%. Patients with hematological diseases were 4.6%, which were characterized by prolonged hospital stay, complicated clinical picture and in most cases fatal outcome.

Many risk factors for the development of cSDH have been described in the literature [Baechli H, Nordmann A, Bucher HC, Gratzl O., 2004; Choi WW, Kim KH., 2002; Jeong JE, Kim GK, Park JT, Lim YJ, Kim TS, Rhee BA, et al. 2000; Wintzen AR, Tijssen JG., 1982]. More than one contributing factor may be present and they have a cumulative effect [Baechli H, Nordmann A, Bucher HC, Gratzl O., 2004; Choi WW, Kim KH., 2002; Jeong JE, Kim GK, Park JT, Lim YJ, Kim TS, Rhee BA, et al., 2000; Wintzen AR, Tijssen JG., 1982]. Commonly recognized important risk factors are direct or indirect head trauma, chronic alcoholism, male gender, and advanced age [Chen JC, Levy ML., 2000; Choi WW, Kim KH., 2002; Jeong JE, Kim GK, Park JT, Lim YJ, Kim TS, Rhee BA, et al. 2000; Kang HL, Shin HS, Kim TH, Hwang

YS, Park SK., 2006; Ko BS, Lee JK, Seo BR, Moon SJ, Kim JH, Kim SH., 2008; Markwalder TM., 1981; Wintzen AR, Tijssen JG., 1982]. Among them, history of head trauma is generally understood as the most important risk factor [Chen JC, Levy ML., 2000; Choi WW, Kim KH., 2002; Kang HL, Shin HS, Kim TH, Hwang YS, Park SK., 2006; Ko BS, Lee JK, Seo BR, Moon SJ, Kim JH, Kim SH., 2008; Wintzen AR, Tijssen JG.,1982]. Other significant factors include bleeding tendency, renal disease, hemodialysis, hepatic dysfunction, epilepsy, chemotherapeutic agents, and arachnoid cysts [Chen JC, Levy ML., 2000; Choi WW, Kim KH., 2002; Jeong JE, Kim GK, Park JT, Lim YJ, Kim TS, Rhee BA, et al. 2000; Kang HL, Shin HS, Kim TH, Hwang YS, Park SK., 2006; Ko BS, Lee JK, Seo BR, Moon SJ, Kim JH, Kim SH., 2008; Markwalder TM., 1981; Wintzen AR, Tijssen JG.,1982]. Anticoagulants and antiaggregants are also considered risk factors for cSDH. The widespread use of anticoagulants and anti-aggregants, has increased significantly [Baechli H, Nordmann A, Bucher HC, Gratzl O., 2004; Forster MT, Mathé AK, Senft C, Scharrer I, Seifert V, Gerlach R., 2010; Gonugunta V, Buxton N., 2001; Jeong JE, Kim GK, Park JT, Lim YJ, Kim TS, Rhee BA, et al. 2000; Lindvall P, Koskinen LO., 2009]. But extended studies on the relationship with cSDH and the increasing use of anticoagulants and anti-aggregants are lacking.

As confirmed in previous studies, cSDH is a typical disease in elderly patients [Jeong JE, Kim GK, Park JT, Lim YJ, Kim TS, Rhee BA, et al. 2000; Kang HL, Shin HS, Kim TH, Hwang YS, Park SK. 2006; Kwon HJ, Youm JY, Kim SH, Koh HS, Song SH, Kim Y. 2004; Lee JK, Choi JH, Kim CH, Lee HK, Moon JG. 2009]. Older adults have a greater risk of cSDH due to brain atrophy [Jeong JE, Kim GK, Park JT, Lim YJ, Kim TS, Rhee BA, et al, 2000; Kang HL, Shin HS, Kim TH, Hwang YS, Park SK., 2006; Kwon HJ, Youm JY, Kim SH, Koh HS, Song SH, Kim Y., 2004; Lee JK, Choi JH, Kim CH, Lee HK, Moon JG., 2009; Roob G, Fazekas F., 2000]. Cerebral parenchymal atrophy induces dilation of the subarachnoid space and stretching of the bridging veins [Jeong JE, Kim GK, Park JT, Lim YJ, Kim TS, Rhee BA, et al, 2000; Kang HL, Shin HS, Kim TH, Hwang YS, Park SK., 2006; Kwon HJ, Youm JY, Kim SH, Koh HS, Song SH, Kim Y., 2004; Lee JK, Choi JH, Kim CH, Lee HK, Moon JG., 2009; Roob G, Fazekas F., 2000]. The reported peak age of cSDH is the 7th decade of life of patients [Chen JC, Levy ML, 2000; Jeong JE, Kim GK, Park JT, Lim YJ, Kim TS, Rhee BA, et al, 2000; Kang HL, Shin HS, Kim TH, Hwang YS, Park SK., 2006; Ko BS, Lee JK, Seo BR, Moon SJ, Kim JH, Kim SH., 2008; Kwon HJ, Youm JY, Kim SH, Koh HS, Song SH, Kim Y., 2004]. This result was also observed in our study, as the mean age of patients with cSDH was 70.56 years. The importance of advanced age as a risk factor for cSDH will increase as society ages.

In the literature, it is found that there is a male preponderance among patients with cSDH, with 2-3 times more males than females due to the higher incidence of head trauma following male gender [Jeong JE, Kim GK, Park JT, Lim YJ, Kim TS, Rhee BA, et al, 2000; Kang HL, Shin HS, Kim TH, Hwang YS, Park SK., 2006; Kwon HJ, Youm JY, Kim SH, Koh HS, Song SH, Kim Y., 2004; Lee JK, Choi JH, Kim CH, Lee HK, Moon JG., 2009]. Males with cSDH were more than twice as numerous as females (M:G=2.51:1) in our study.

In the literature, head trauma is considered to be the most important risk factor for cSDH and can be identified in 50% to 80% of patients [Chen JC, Levy ML, 2000; Forster MT, Mathé AK, Senft C, Scharrer I, Seifert V, Gerlach R, 2010; Jeong JE, Kim GK, Park JT, Lim YJ, Kim TS, Rhee BA, et al, 2000; Kang HL, Shin HS, Kim TH, Hwang YS, Park SK., 2006; Kang MS, Koh HS, Kwon HJ, Choi SW, Kim SH, Youm JY., 2007; Ko BS, Lee JK, Seo BR, Moon SJ, Kim JH, Kim SH, 2008; Kwon HJ, Youm JY, Kim SH, Koh HS, Song SH, Kim Y., 2004; Lee JK, Choi JH, Kim CH, Lee HK, Moon JG., 2009; Lindvall P, Koskinen LO., 2009; Wintzen AR, Tijssen JG., 1982]. Although previous minor head injuries may sometimes be unrecognized, traumatic events usually precede the onset of cSDH [Forster MT, Mathé AK, Senft C, Scharrer I, Seifert V, Gerlach R., 2010; Kang HL, Shin HS, Kim TH, Hwang YS, Park SK., 2006; Ko BS, Lee JK, Seo BR, Moon SJ, Kim JH, Kim SH., 2008; Lindvall P, Koskinen LO., 2009]. Head trauma (83% of 151 patients) was also the most important etiological factor in our study.

The increased incidence of cSDH in chronic alcoholism is explained by the fact that persistent alcohol intake induces cerebral atrophy and coagulation dysfunction [Chen JC, Levy ML., 2000; Forster MT, Mathé AK, Senft C, Scharrer I, Seifert V, Gerlach R., 2010; Jeong JE, Kim GK, Park JT, Lim YJ, Kim TS, Rhee BA, et al. 2000; Kang HL, Shin HS, Kim TH, Hwang YS, Park SK, 2006; Ko BS, Lee JK, Seo BR, Moon SJ, Kim JH, Kim SH, 2008; Kwon HJ, Youm JY, Kim SH, Koh HS, Song SH, Kim Y., 2004; Lee JK, Choi JH, Kim CH, Lee HK, Moon JG., 2009; Lindvall P, Koskinen LO., 2009; Wintzen AR, Tijssen JG., 1982].

In chronic alcoholism, there are also more chances of unrecognized head trauma. The reported incidence of cSDH in patients with chronic alcoholism range from 6 to 35% [Choi WW, Kim KH., 2002; Gonugunta V, Buxton N., 2001; Jeong JE, Kim GK, Park JT, Lim YJ, Kim TS, Rhee BA, et al, 2000; Kang HL, Shin HS, Kim TH, Hwang YS, Park SK., 2006; Ko BS, Lee JK, Seo BR, Moon SJ, Kim JH, Kim SH., 2008; Kwon HJ, Youm JY, Kim SH, Koh HS, Song SH, Kim Y., 2004; Lee JK, Choi JH, Kim CH, Lee HK, Moon JG., 2009; Lindvall P, Koskinen LO., 2009]. In our study, alcoholism still plays an important role as a risk factor.

Our results suggest that head trauma and chronic alcoholism are the most important risk factors for cSDH, consistent with earlier reports.

The reported proportion of cSDH associated with the use of anticoagulants and antiaggregants ranges from 0.6% to 22.5% in the literature [Baechli H, Nordmann A, Bucher HC, Gratzl O., 2004; Forster MT, Mathé AK, Senft C, Scharrer I, Seifert V, Gerlach R., 2010; Jeong JE, Kim GK, Park JT, Lim YJ, Kim TS, Rhee BA, et al. 2000; Lindvall P, Koskinen LO., 2009; Weir B, Gordon P., 1983]. The proportion of cSDH associated with the use of anticoagulants and antiaggregants was reported as 0.6% by Jeong et al. [Jeong JE, Kim GK, Park JT, Lim YJ, Kim TS, Rhee BA, et al. 2000] and 14.2% by Torihashi et al. [Torihashi K, Sadamasa N, Yoshida K, Narumi O, Chin M, Yamagata S. 2008]. The proportion of warfarin-associated cSDH is reported as 11.8-20.0% by Gonugunta and Buxton [Gonugunta V, Buxton N., 2001]. The prevalence of anticoagulant and anti-aggregant use-related cSDH in our study (17.7% of 151 patients) was similar to previous results. We speculate that the current widespread use of anticoagulants and antiaggregants may have altered the incidence of cSDH. These agents are commonly used as prophylaxis against ischemic stroke, myocardial infarction or deep vein thrombosis [Gorelick PB, Weisman SM., 2005]. Based on their cost-effectiveness and widespread availability, the use of anticoagulants and antiaggregants has recently expanded significantly for the prevention of cardio- cerebrovascular accidents [Bershad EM, Farhadi S, Suri MF, Feen ES, Hernandez OH, Selman WR, et al, 2008; Gonugunta V, Buxton N., 2001; Gorelick PB, Weisman SM., 2005; Hart RG, Boop BS, Anderson DC., 1995; Lindvall P, Koskinen LO., 2009; Majeed A, Moser K, Carroll K., 2001; Spektor S, Agus S, Merkin V, Constantini S., 2003;99:661-665, Zingale A, Chibbaro S, Florio A, Distefano G, Porcaro S., 1999]. Despite the proven benefits of these drugs, concerns have recently been raised about the major side effect associated with hemorrhagic complications [Bershad EM, Farhadi S, Suri MF, Feen ES, Hernandez OH, Selman WR, et al, 2008; Quinones-Hinojosa A, Gulati M, Singh V, Lawton MT., 2003; Wintzen AR, Tijssen JG.,1982; Zingale A, Chibbaro S, Florio A, Distefano G, Porcaro S., 1999]. Aspirin acts by irreversibly inactivating the enzyme cyclooxygenase, resulting in reduced production of the natural platelet aggregate thromboxane A_2 [Quinones-Hinojosa A, Gulati M, Singh V, Lawton MT., 2003]. Clopidogrel also inhibits platelet aggregation by acting as glucoprotein IIb/IIIa inhibitors [Quinones-Hinojosa A, Gulati M, Singh V, Lawton MT, 2003]. Warfarin interferes with vitamin K metabolism in the liver [Quinones-Hinojosa A, Gulati M, Singh V, Lawton MT., 2003]. This leads to the synthesis of non-functional coagulation factors II, VII, IV and X as well as protein C and S [Quinones-Hinojosa A, Gulati M, Singh V, Lawton MT., 2003; Wintzen AR, Tijssen

JG., 1982]. However, the reason why these mechanisms increase the incidence of intracranial hemorrhagic (ICHO) complications, including cSDH, is unclear [Quinones-Hinojosa A, Gulati M, Singh V, Lawton MT., 2003]. One idea is that ICHO may grow to clinical significance as these agents inhibit normal hemostatic mechanisms [Bershad EM, Farhadi S, Suri MF, Feen ES, Hernandez OH, Selman WR, et al. 2008; Quinones-Hinojosa A, Gulati M, Singh V, Lawton MT, 2003].

Wintzen and Tijssen [Wintzen AR, Tijssen JG., 1982] reported that 1% of patients over 40 years of age treated with antiaggregants had cSDH. Mattle et al [Mattle H, Kohler S, Huber P, Rohner M, Steinsiepe KF., 1989] reported that 23% of patients with cSDH had increased anticoagulant use. We believe that these findings are related to the recent widespread use of anticoagulants and antiaggregants. However, a community-based epidermological study is needed to confirm that the use of anticoagulants and antiaggregants has increased the actual incidence of cSDH.

The incidence of subdural hematomas increases secondary to the large number of individuals undergoing more aggressive antithrombotic and anticoagulant therapeutic regimens [Gaist D, García Rodríguez LA, Hellfritzsch M, Poulsen FR, Halle B, Hallas J, Pottegård A., 2017; Won SY, Dubinski D, Bruder M, Cattani A, Seifert V, Konczalla J., 2017]. This has led us to seek less invasive alternatives in the management of this pathology. Typically, subdural hematomas that are considered amenable to surgery are evacuated using open craniotomy [Wilberger JE Jr, Harris M, Diamond DL.,1991; Winter CD, Adamides A, Rosenfeld JV., 2005; Rush B, Rousseau J, Sekhon MS, Griesdale DE., 2016]. In the current literature, endoscope-assisted craniotomies have been described as a less invasive treatment for chronic subdural hematomas [Masopust V, Netuka D, Häckel M., 2003; Berhouma M, Jacquesson T, Jouanneau E., 2014; Zhang J, Liu X, Fan X, Fu K, Xu C, Hu Q, Jiang P, Chen J, Wang W., 2018; Wakuta N, Abe H, Fukuda K, Nonaka M, Morishita T, Arima H, Inoue T., 2020]. The technical advantages of the endoscope allow the surgeon to reduce blood loss, decrease operative time, minimize the size of the craniotomy, and potentially improve postoperative recovery. Recent publications suggest that endoscope-assisted evacuation of subdural hematomas via small craniotomy may be safe and feasible in ideal candidates [Codd PJ, Venteicher AS, Agarwalla PK, Kahle KT, Jho DH., 2013; Kon H, Saito A, Uchida H, Inoue M, Sasaki T, Nishijima M., 2014; Yokosuka K, Uno M, Matsumura K, Takai H, Hagino H, Matsushita N, Toi H, Matsubara S., 2015; Kawasaki T, Kurosaki Y, Fukuda H, Kinosada M, Ishibashi R, Handa A, Chin M, Yamagata S., 2018; Matsumoto H, Minami H, Hanayama H, Yoshida Y., 2018; Ichimura S, Takahara K, Nakaya M, Yoshida K, Mochizuki Y, Fukuchi M, Fujii K., 2019; Hwang SC, Shin

DS., 2020; Khattar NK, McCallum AP, Fortuny EM, White AC, Ball TJ, Adams SW, Meyer KS, Wei G, John KD, Bak E, Sieg EP, Ding D, James RF., 2021].

The results of the present study suggest that endoscopic assisted evacuation of chronic subdural hematomas can be a safe and effective operative technique. The use of the endoscope through a small craniotomy of the superior temporal line offers a unique opportunity for easy hematoma removal.

It is important to emphasize the inclusion criteria, such as the general clinical status of patients is not critical, the presence of imaging studies demonstrating the stability of the hematoma as well as the absence of additional intracranial injuries.

Given that the majority of patients are over the age of 65, advanced age may facilitate the use of this technique due to age-related brain atrophy, allowing more space to operate the endoscope and surgical instruments in the narrow operative field. All of these factors potentially reduce the likelihood of postoperative cerebral edema and allow planning for this less invasive procedure.

The mean hospital stay in the present study was about 6 days and was significantly better compared with other studies using endoscopic assisted evacuation with reported data (mean 23 days) [Ichimura S, Takahara K, Nakaya M, Yoshida K, Mochizuki Y, Fukuchi M, Fujii K., 2019]. The mean hospital stay in the present study using the traditional surgical technique was also significantly shorter (6.5 days) than that reported in other studies describing traditional evacuation of subdural hematomas. In a large retrospective study published in 2012, Ryan et al. reported their findings on mortality and functional outcomes in adults with traumatic subdural hematoma [Ryan CG, Thompson RE, Temkin NR, Crane PK, Ellenbogen RG, Elmore JG., 2012]. Within the group that underwent standard surgical evacuation, 49% of their population had a GCS of 13-15 and a mean hospital stay of 15.1 days. The average hospital stay reported by various databases of patients who underwent standard craniotomy or craniectomy for evacuation of subdural hematomas was 10-13 days [Lukasiewicz AM, Grant RA, Basques BA, Webb ML, Samuel AM, Grauer JN., 2016; Ball T, Oxford BG, Alhourani A, Ugiliweneza B, Williams BJ., 2019].

According to the location of the cSDH, it can be said that our data confirm those of other investigators regarding the predominance of left-sided chronic subdural hematomas, which remains a mystery to researchers [Hammer, A., et al. 2017; Rahimi, A.R. and M. Poorkay, 2000].

The overall rate of postoperative complications was low (5.9%), with only 4 patients (2.6%) having a surgical site infection. These results are better than reported data for standard craniotomy/craniectomy, which reach 19% of infections, including urinary tract infections, ventilation-associated pneumonia, cellulitis, and others [Whitehouse KJ, Jeyaretna DS, Enki DG, Whitfield PC., 2016; Lukasiewicz AM, Grant RA, Basques BA, Webb ML, Samuel AM, Grauer JN., 2016; Ryan CG, Thompson RE, Temkin NR, Crane PK, Ellenbogen RG, Elmore JG., 2012].

For neurosurgeons, the treatment of cSDH is considered unsuccessful when relapses occur [Chen, F.M., et al., 2020; Liu, L.X., et al., 2019]. In the present study, recurrence of subdural hematoma was observed in 5 patients. The well-known pathophysiology of cSDH suggests that the formation of an osmotic difference caused by the fibrinolysis of cSDH over time is a vicious cycle that must be broken to avoid hematoma growth [Holl, D.C., et al., 2018]. According to the pathophysiology of cSDH, the compartment or the fluid is one of the important recurrence factors of interest to specialists as modern surgical treatment of cSDH advances [Ducruet, A.F., et al., 2012]. It appears that from the point of view of the pathophysiology of the formation of cSDH, disruption of the outer membrane is not sufficient to avoid recurrence of the subdural hematoma. The alteration of the osmotic gradient is the most important issue that currently prevails in endoscopic technique since the endoscopic transsphenoidal approach (TSA) and optical technology improved with the perfect removal of part of the inner membrane to interrupt the osmotic difference at the onset of cSDH.

As life expectancy increases, so does the incidence of cSDH. Although cSDH is a treatable disease, the recurrence rate can be as high as 28% and up to 20% of cSDH patients end up with a poor neurological outcome.

In some cases, the treatment of cSDH can be conservative, but surgical evacuation of the hematoma remains the primary method of treatment. A large number of studies have investigated the optimal therapeutic management of cSDH in terms of neurological outcome, complications and recurrence rates. There is still much controversy surrounding the surgical management of chronic subdural hematoma, limiting the formation of specific guidelines or a general consensus among neurosurgeons. Addressing those issues on which there is consensus and updating our knowledge of them is important as this will help to improve outcomes for patients with cSDH, but will also highlight areas where research is needed.

On Tab. 3 presents the main controversies and corresponding recommendations that arise from the analysis of each aspect of the surgical treatment of cSDH [Weigel, R.; Schmiedek, P.; Krauss, J.K., 2003; Hallett, M.; Litvan, I., 1999].

Tabl. 3. Controversies and recommendations regarding the surgical treatment of chronic subdural haematoma

Guidance	**Recommendation**
Indications for surgery	Surgical treatment is indicated when: - Neurological deficits + radiological findings. -Neurological deterioration worsening radiological findings. Conservative treatment may be beneficial when: - Asymptomatic + no evidence of compressive signs.
	Surgical treatment is recommended when: - The thickness of the haematoma is >10 mm or more than the thickness of the bone. - Midline displacement >5-7 mm. - Symptomatic with evidence of minor radiological signs.
Time to perform the operation	No recommendation. The timing of surgery should be determined by the severity of the disease, taking into account risk factors (e.g., intake of anticoagulants).
Surgical method	BHC, TDC, and craniotomy are effective in the treatment of cSDH. BHC is considered a first-line treatment and appears to offer the best cure to complication ratio. TDC is recommended for high-risk surgical patients. TDC is associated with a higher recurrence rate than BHC. In recurrent cSDH, it is reasonable to perform either BHC or craniotomy. Craniotomy offers comparable results to BHC, possibly with a higher complication rate. Craniotomy is recommended in patients with thickened membranes or multiple recurrences. Endoscopically assisted evacuation is safe and effective. TDC is recommended in high-risk surgical patients.
Number of holes	Single and double orifices offer comparable outcomes and recurrence rates.
Irrigation	The result is the same with or without irrigation when drainage is used.
Placement of drainage	The placement of drainage is highly recommended
Location of drainage	Subperiosteal drain placement is as effective as subgaleal placement, with a potentially lower complication rate. In high-risk patients, subperiosteal drainage may be preferred.

Duration of drainage	There is no difference between the duration of drainage between 24 and 48 hours
Membraniectomy	When craniotomy is used, concomitant membranectomy may reduce recurrences
Embolization of the middle meningeal artery	The use of middle meningeal artery embolization as a primary stand-alone procedure either for recurrent cSDH or as prophylaxis is a safe and effective method with low recurrence rates.

The decision for surgical intervention in cSDH largely depends on the clinical presentation and radiological features such as hematoma size, midline shift, presence of membranes, and presence of bilateral hematomas [Sahyouni, R.; Goshtasbi, K.; Mahmoodi, A.; Tran, D.K.; Chen, J.W., 2017; Shlobin, N.A.; Kedda, J.;Wishart, D.; Garcia, R.M.; Rosseau, G., 2020]. It is generally accepted that patients with neurological symptoms and corresponding radiological findings should undergo surgical evacuation. On the other hand, asymptomatic patients without signs of compression on imaging usually undergo conservative treatment [Sahyouni, R.; Goshtasbi, K.; Mahmoodi, A.; Tran, D.K.; Chen, J.W., 2017; Soleman, J.; Noccera, F.; Mariani, L., 2017; Kolias, A.; Chari, A.; Santarius, T.; Hutchinson, P., 2014; Mehta, V.; Harward, S.C.; Sankey, E.W.; Nayar, G.; Codd, P.J., 2018; Feghali, J.; Yang, W.; Huang, J., 2020].

The surgical approach is also recommended when the neurological status worsens, even without worsening radiological findings. Apart from the above relatively straightforward scenarios, there is still much controversy about the decision to surgically treat cSDH. Optimal treatment of asymptomatic patients with radiologic evidence of brain compression and midline shift, and of symptomatic patients with minor radiologic findings, remains a matter of debate. No studies are available comparing surgical with conservative treatment in this setting. There is clinical consensus that hematomas greater than 1 cm or equal to the thickness of the skull should be evacuated. Similarly, midline displacement of more than 5 to 7 mm necessitates surgery [Soleman, J.; Noccera, F.; Mariani, L., 2017; Kolias, A.; Chari, A.; Santarius, T.; Hutchinson, P., 2014; Yadav, Y.; Parihar, V.; Namdev, H.; Bajaj, J., 2016; Holl, D.C.; Volovici, V.; Dirven, C.M.; Peul,W.C.; van Kooten, F.; Jellema, K.; van der Gaag, N.A.; Miah, I.P.; Kho, K.H.; Hertog, H.M.D.; et al, 2018; Nouri, A.; Gondar, R.; Schaller, K.; Meling, T., 2021; Ivamoto, H.S.; Lemos, H.P.; Atallah, A.N., 2015]. Sahyouni et al. reported a cutoff value of 7-10 mm for midline shift for acute subdural hematomas and therefore it is controversial whether it also applies to chronic subdural hematomas [Sahyouni, R.; Goshtasbi, K.; Mahmoodi, A.;

Tran, D.K.; Chen, J.W., 2017]. So far, there are no clear cut-off values for the midline and in this respect the decision for surgery remains largely empirical [Soleman, J.; Taussky, P.; Fandino, J.; Muroi, C., 2014]. Other radiological findings may also be considered when deciding on the best treatment for this group of patients, such as the presence of brain atrophy. However, the extent to which each of these findings carries weight in treatment decisions is unclear. Again, with regard to the second group of patients - namely those with symptoms but also minor radiological findings in the absence of evidence-based data, the consensus is that once other causes (e.g. stroke) have been excluded, surgery is recommended.

In general, conservative treatment is usually reserved for patients with minor symptoms, e.g. with a Markwalder score of 0-1, individuals with significant operative risk and for those who refuse any surgical intervention [Soleman, J.; Noccera, F.; Mariani, L., 2017; Yadav, Y.; Parihar, V.; Namdev, H.; Bajaj, J., 2016; Mehta, V.; Harward, S.C.; Sankey, E.W.; Nayar, G.; Codd, P.J., 2018; Roh, D.; Reznik, M.; Claassen, J., 2017; Baschera, D.; Tosic, L.; Westermann, L.; Oberle, J.; Alfieri, A., 2018].

Controversy exists in almost all aspects of the surgical treatment of cSDH, from the type of surgical technique to the number of holes, their location, and the use of irrigation, to name a few. Unfortunately, the evidence is mostly based on meta-analyses and retrospective studies in single centers.

TDC versus BHC versus craniotomy. Only a few studies have compared all three of the most commonly used surgical techniques, and none of them offer Class I evidence. A 2003 meta-analysis by Weigel et al. confirmed that TDC and BHC have a better safety profile compared to craniotomy, which has a significantly higher morbidity rate of about 12.3% [Weigel, R.; Schmiedek, P.; Krauss, J.K., 2003]. Differences in cure rates did not reach statistical significance. Both burr hole craniotomy and craniotomy recurrence rates are lower than those of twist drill craniotomy [Weigel, R.; Schmiedek, P.; Krauss, J.K., 2003]. Furthermore, in recurrent cSDH, BHC appears to be more effective than TDC or craniotomy, which should be considered the treatment of last choice [Weigel, R.; Schmiedek, P.; Krauss, J.K., 2003]. The authors conclude that twist drill and burr hole craniostomy can be considered first-line treatment, while craniotomy can be used as second-line treatment. RCT from 2022, comparing BHC, minicraniotomy, and TDC, concluded that all three techniques are effective in treating patients with HSDH, with similar 6-month outcomes [Duerinck, J.; van der Veken, J.; Schuind, S.; van Calenbergh, F.; van Loon, J.; Du Four, S.; Debacker, S.; Costa, E.; Raftopoulos, C.; deWitte, O.; et al., 2022]. BHC appears to have the lowest recurrence rate with a manageable complication rate, although this difference does not reach statistical significance

[Duerinck, J.; van der Veken, J.; Schuind, S.; van Calenbergh, F.; van Loon, J.; Du Four, S.; Debacker, S.; Costa, E.; Raftopoulos, C.; deWitte, O.; et al., 2022]. In their 2012 meta-analysis, Ducruet et al. recommended that TDC with drainage should be the primary treatment of choice for high-risk surgical candidates with unseptated cSDH, whereas craniotomy should be chosen for xDH with multiple membranes [Ducruet, A. F.; Grobelny, B.T.; Zacharia, B.; Hickman, Z.; DeRosa, P.L.; Anderson, K.; Sussman, E.; Carpenter, A.; Connolly, E.S., 2011]. TDC seems to have given the best outcome and least complications compared to BHC and craniotomy, while the mortality rate seems to be higher in cases where craniotomy was performed. Another meta-analysis of 34829 patients by Almenawer et al. found no significant difference between different surgical techniques in terms of morbidity, mortality, outcome and recurrence rates [Almenawer, S.A.; Farrokhyar, F.; Hong, C.; Alhazzani,W.; Manoranjan, B.; Yarascavitch, B.; Arjmand, P.; Baronia, B.; Reddy, K.; Murty, N.; et al, 2014]. The authors reported that craniotomy is more effective in cases of recurrent cSDH, but it is also associated with the highest number of complications [Almenawer, S.A.; Farrokhyar, F.; Hong, C.; Alhazzani,W.; Manoranjan, B.; Yarascavitch, B.; Arjmand, P.; Baronia, B.; Reddy, K.; Murty, N.; et al., 2014]. Lega et al. in their analysis, concluded that BHC balances the lowest recurrence and complication rates, and thus is generally the most effective choice [Lega, B.C.; Danish, S.F.; Malhotra, N.R.; Sonnad, S.S.; Stein, S.C., 2010]. However, the lowest recurrence rate, but also the highest complication rate, belongs to patients treated with craniotomy [Lega, B.C.; Danish, S.F.; Malhotra, N.R.; Sonnad, S.S.; Stein, S.C., 2010].

BHC versus craniotomy. A number of studies have focused on the comparison of BHC with craniotomy: Mondorf et al. conducted a retrospective study examining outcomes and recurrence in 193 patients with cSDH treated with craniotomy (151 patients) or BHC (42 patients) [Mondorf, Y.; Abu-Owaimer, M.; Gaab, M.R.; Oertel, J.M., 2009]. Their results showed. that recurrence occurred in 27.8% of patients in the craniotomy group and in 14.3% in the BHC group. In the same study, about 52.3% of patients treated with craniotomy had complete neurological recovery at discharge, whereas the corresponding rate in BHC patients was 64.3% [Mondorf, Y.; Abu-Owaimer, M.; Gaab, M.R.; Oertel, J.M., 2009]. The authors concluded that drainage with a hole was superior in terms of recurrence rate and symptom recovery to craniotomy [Mondorf, Y.; Abu-Owaimer, M.; Gaab, M.R.; Oertel, J.M., 2009]. In a retrospective study by Shim et al, the authors examined the recurrence and length of hospitalization of patients treated for cSDH by BHC or minor craniotomy [Shim, Y.W.; Lee, W.H.; Lee, K.S.; Kim, S.T.; Paeng, S.H.; Pyo, S.Y., 2019]. Their findings support the claim that BHC is superior to the small craniotomy, as it has a lower recurrence rate (13.3% for BHC vs. 26.7% for the small craniotomy) and a shorter mean hospitalization period (10.3 days for the BHC group vs. 15.7 days for the craniotomy group) [Shim, Y. W.; Lee, W.H.; Lee, K.S.; Kim, S.T.; Paeng, S.H.; Pyo, S.Y., 2019]. A small single-center study from 2020 presents different findings, as its results showed fewer recurrences in patients treated with craniotomy compared to those who underwent BHC [Raghavan, A.; Smith, G.; Onyewadume, L.; Peck, M.R.; Herring, E.; Pace, J.; Rogers, M.; Momotaz, H.; Hoffer, S.A.; Hu, Y.; et al., 2019]. Furthermore, a retrospective single-center analysis by Gazzeri et al, which compared four groups of patients with cSDH treated with BHC or craniotomy using subdural or subgaleal drainage, found that recurrence and neurological outcome were independent of these two surgical techniques and of and the site of drainage, thus the authors suggest that individual choice of technique for the treatment of cSDH [Gazzeri, R. ; Laszlo, A.; Faiola, A.; Colangeli, M.; Comberiati, A.; Bolognini, A.; Callovini, G., 2020].

TDC v. BHC. The only study comparing the two minimal treatments for HCC is the study by XU et al. which showed no significant differences between cure and mortality rates of patients treated for cSDH [Xu, C.; Chen, B.; Xue, L.; Xia, L.; Yang, X.; Wei, M.; Hui, X.; Chen, Q.; Zheng, J.; Li, Z.; et al., 2018]. In terms of neurological outcome, however, TDC appears to be superior to BHC, as the mRS score at 3-month follow-up was significantly improved in the TDC group compared with that in the BHC group, and the total duration of hospitalization was significantly shorter when TDC was performed [Xu, C. ; Chen, B.; Xue, L.; Xia, L.; Yang, X.; Wei, M.; Hui, X.; Chen, Q.; Zheng, J.; Li, Z.; et al, 2018]. The clinical equilibrium between twist drill craniostomy and burr hole craniostomy was addressed in a meta-analysis by Yagnik et al. in 2021 [Yagnik, K.J.; Goyal, A.; van Gompel, J.J., 2021]. They performed a systematic review and meta-analysis comparing outcomes after BHC and TDC for the initial surgical management of cSDH. Although complication, recurrence, cure, and mortality rates did not differ significantly between the two surgical techniques, TDC was associated with a higher reoperation rate compared with BHC [Yagnik, K.J.; Goyal, A.; van Gompel, J.J., 2021].

Endoscope-Assisted BHC (EBHC) vs BHC/Craniotomy. The newest technique for the treatment of cSDH, endoscope-assisted evacuation of HSDH, was compared with BHC in a meta-analysis conducted by Guo et al [Guo, S.; Gao, W.; Cheng, W.; Liang, C.; Wu, A., 2020]. Their results showed that the recurrence and complication rates were significantly reduced in the group of patients treated with endoscopically assisted surgery [Guo, S.; Gao, W.; Cheng, W.; Liang, C.; Wu, A., 2020]. Retrospective study from 2018, conducted by Zhang et al. compared endoscopically assisted burr hole craniostomy with conventional BHC and found that, the endoscopically assisted technique was superior in terms of reduction in recurrence rate, morbidity rate, drainage duration and hospital length of stay [Zhang, J. ; Liu, X.; Fan, X.; Fu, K.; Xu, C.; Hu, Q.; Jiang, P.; Chen, J.;Wang,W., 2018]. Similarly, a retrospective comparative study between 97 patients treated endoscopically and 380 patients treated with conventional BHC found lower rates of rebleeding and reoperation in favor of the endoscopic technique [Amano, T.; Miyamatsu, Y.; Otsuji, R.; Nakamizo, A., 2021]. The advantage of EBHC is maintained even when the analysis includes only the complicated cases, i.e., those with the presence of thrombus and/or septa [Amano, T.; Miyamatsu, Y.; Otsuji, R.; Nakamizo, A., 2021]. EBHC also has an advantage over craniotomy. In a retrospective study conducted by Zhang et al, the group using endoscopy had less blood loss and shorter hospital stay [Zhang, J.; Chen, J., 2020]. These findings, however, were not uniform across all studies; the retrospective analysis by Yan et al. found no difference between BHC and EBHC in terms of hematoma recurrence rates (8.7% and 13.7%, respectively). The authors concluded that in light of this finding, BHC seems like a better choice as it requires less surgical time [Yan, K.; Gao, H.; Zhou, X.;Whou,W.; Xu,W.; Xu, Y.; Gong, K.; Xue, X.;Wang, Q.; Na, H., 2017].

CONCLUSIONS

1. The main causes of chronic subdural haematomas are traumatic moments, possibly combined with the use of OAC/AG - patients are predominantly adult males.
2. Most often chronic subdural hematomas are unilateral to the left.
3. Endoscope-assisted evacuation is characterized as a reliable method with reduced hospital stay, minimal mortality, lower risk of complications and recurrences compared to traditional craniotomy.
4. The risk profile of patients with cSDH includes age over 65, male sex, alcohol use, presence of hypertensive disease, hematologic disease, and use of anticoagulants and antiaggregants.
5. Unilateral cSDH carries a higher risk of developing paresis and aphasia.
6. Patients with cSDH and comorbidity have an increased risk of postoperative complications, recurrence and mortality.

CONCLUSION

Chronic subdural hematomas occur most often as a result of mild head trauma and are one of the most frequently treated diseases in the field of neurosurgery. Due to natural cerebral atrophy, accompanying lengthening of the subdural bridging veins, and the need to take anticoagulants, the incidence of cSDH increases with age. Clinical presentation is often nonspecific with symptoms ranging from headache to impaired alertness, focal neurological deficits, or hemiparesis. Computed tomography of the head is a reliable diagnostic method, allowing a valid assessment of the configuration and age of the hematoma.

The results of the literature review and conducted research prove that endoscope-assisted evacuation of chronic subdural hematomas has its advantages over traditional craniotomy.

Evacuation of chronic subdural hematomas through a small craniotomy and with the aid of an endoscope represents a safe and effective alternative in patients who meet the specific criteria that allow this less invasive procedure to be planned. On the other hand, further studies in a more controlled setting and with a larger population are needed to compare the efficacy of this method with standard craniotomy, as well as to possibly expand its indications.

CONTRIBUTIONS

1. A comprehensive characterization of patients with chronic subdural hematoma was performed, risk factors were assessed and derived, and a patient risk profile was created.
2. Based on the conducted analyses, the effectiveness of neuroendoscope-assisted evacuation of subdural hematoma was demonstrated.
3. On the basis of a thorough analysis of the existing specialized literature and the results of the study, indications and contraindications for the application of neuroendoscope-assisted evacuation of subdural hematoma are formulated..
4. A protocol for intraoperative application of endoscope in neurosurgical surgical treatment of chronic subdural hematomas in the Clinic of Neurosurgery of University Hospital "St. Marina"Varna as a routine method of surgical treatment.
5. On the basis of statistical processing and data analysis recommendations for the intraoperative use of endoscope in neurosurgical treatment of patients with chronic subdural hematomas are formulated.

DISSERTATION RELATED PUBLICATIONS

1. Todorova S. Endoscopically – assisted evacuation of chronic subdural hematoma – new gold standart?, International Bulletin of Otorhinolaryngology. 3/2022, 10-13

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