DOI: 10.4149/BLL_2023_001

Bratisl Med J 2023; 124 (1)

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CLINICAL STUDY

Non-acute subdural hematoma: estimation of recurrence using CT-volumetric measurements

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ABSTRACT

OBJECTIVES: To identify risk factors for unilateral non-acute subdural hematomas NASH recurrence, as well as to perform volumetric quantitative analysis of hematoma, postoperative pneumocephalus and extent of hematoma evacuation.

BACKGROUND: Recurrence of NASH increases morbidity and mortality and has negative socio-economic consequences. Its accurate prediction could improve patient specific care.

METHODS: Records of 102 patients after unilateral NASH evacuation during the period from 2014 to 2020 with a 4-month follow-up were evaluated. Impacts of preoperative clinical signs and factors on the incidence of NASH recurrence were evaluated, namely those of age, gender, timing of surgery, hematoma side, surgical technique (number of burr holes, trepanation versus craniotomy), duration of drainage, antithrombotic agents, morphological type of hematoma, preoperative hematoma volume (PHV), post-evacuation hematoma cavity volume (PHCV), pneumocephalus volume (PCV) and extent of hematoma evacuation (EHE) on the incidence of NASH recurrence were evaluated.

RESULTS: An overall recurrence rate of 13.7 % was observed. Preoperative hematoma volume, postoperative hematoma cavity volume and postoperative pneumocephalus volume had a significant impact on incidence of recurrence.

CONCLUSIONS: Pre- and postoperative volumetric evaluations, of patients with NASH, particularly the measurements of preoperative hematoma volume and postoperative volume of hematoma cavity and pneumocephalus have a potential to improve the prediction of clinically significant recurrence *(Tab. 6, Fig. 3, Ref. 51)*. Text in PDF *www.elis.sk*

KEY WORDS: subdural hematoma, recurrence, pneumocephalus, risk factors.

Abbreviations: EHE – extent of hematoma evacuation, HV – hematoma volume, NASH - Non-acute subdural hematoma, PCV – pneumocephalus volume, PHCV – post-evacuation hematoma cavity volume

Introduction

Non-acute subdural hematoma (NASH) represents a special and diverse nosological entity. NASHs are manifested by a variety of subjective symptoms and objective neurological signs but may also remain unrecognised when asymptomatic. Due to the internal architecture of NASH, several subtypes are distinguished: homogeneous (hypodense, isodense and hyperdense), separated, laminar and trabecular (1). Regarding the time of their development, subacute, subchronic and chronic NASHs are recognised. This classification is limited by the fact that the exact moment causing the injury often remains unknown and repeated spontaneous bleeding into the hematoma cavity may occur over time. Because NASHs typically occur in elderly patients, surgical treatment is associated with a higher risk of morbidity and mortality (2). Also, there is a considerably high rate of recurrence of evacuated NASHs, reaching up to 21.9 % (3). Recurrence of NASH may lead to situations requiring repeated surgery, thus naturally increasing the potential overall risk of complications as well as increasing the overall personal and economic burdens affecting the health system. CT measurements and architecture do affect the rate of recurrence of NASH (4). There have, however, been contradictory reports regarding the prognostic value of volumetric studies (4, 5). Our aim was to identify risk factors of NASH recurrence based on patients' history, pre- and postoperative CT findings, including volumetric analysis.

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Acknowledgements: This work was supported by project The application of PACS (Picture Archiving and Communication System) in research and development, ITMS 26,210,120,004.

Material and methods

Adult patients diagnosed with unilateral NASH and subsequently surgically treated at our institution during the period of 2014–2020 were enrolled in this study. Since the primary objective of this work was to assess NASH recurrence, patients with the need of surgical revision due to a development of acute extracerebral hematoma or epidural abscess/subdural empyema (both scenarios interfering with the "natural" postoperative course) and patients who died during the follow-up period were excluded. We assessed the postoperative course of our patients during a follow-up period of 4 months. Patients' age, sex, subjective symptoms and objective clinical signs were assessed before surgery in all patients (phatic disorder, hemiparesis, quantitative disorder of consciousness, headache, vertigo, gait disturbance, epilepsy, disorientation). The history of anticoagulants and antiplatelet drugs intake was noted. The NASHs were either evacuated via one or two burr-holes followed by irrigation of the subdural space, or via craniotomy and external membranectomy. In both cases, subdural drainage was installed and left in place for 1 to 6 postoperative days. Prior to the extraction of drainage, CT scan with volumetric measurement was performed and compared with preoperative CT findings. Localization of the hematoma (left/right side), timing of the surgery (performed as an emergency i.e., during first 6 hours after admission or delayed), number of burr-holes used (one/two) and duration of drainage (1–2 days vs 3–6 days) were recorded. CT analysis was performed in TomoCon Viewer (version 24.0.45.10, TatraMed, Slovakia). The assessed CT findings included internal architecture of NASH according to Nakaguchi et al. (1) based on the preoperative CT exam (Fig. 1). Volumetric measurements were done based on 3D reconstructions of preoperative hematoma volume (HV), post-evacuation hematoma cavity volume (PHCV) and pneumocephalus volume (PCV). PHCV was defined as volume of residual post-evacuation space containing fluid, air, residual hematoma volume and possible acute admixture of blood (Fig. 2). Extent of hematoma evacuation (EHE) was determined as a relative volume (quantified as percentage) obtained by surgery and

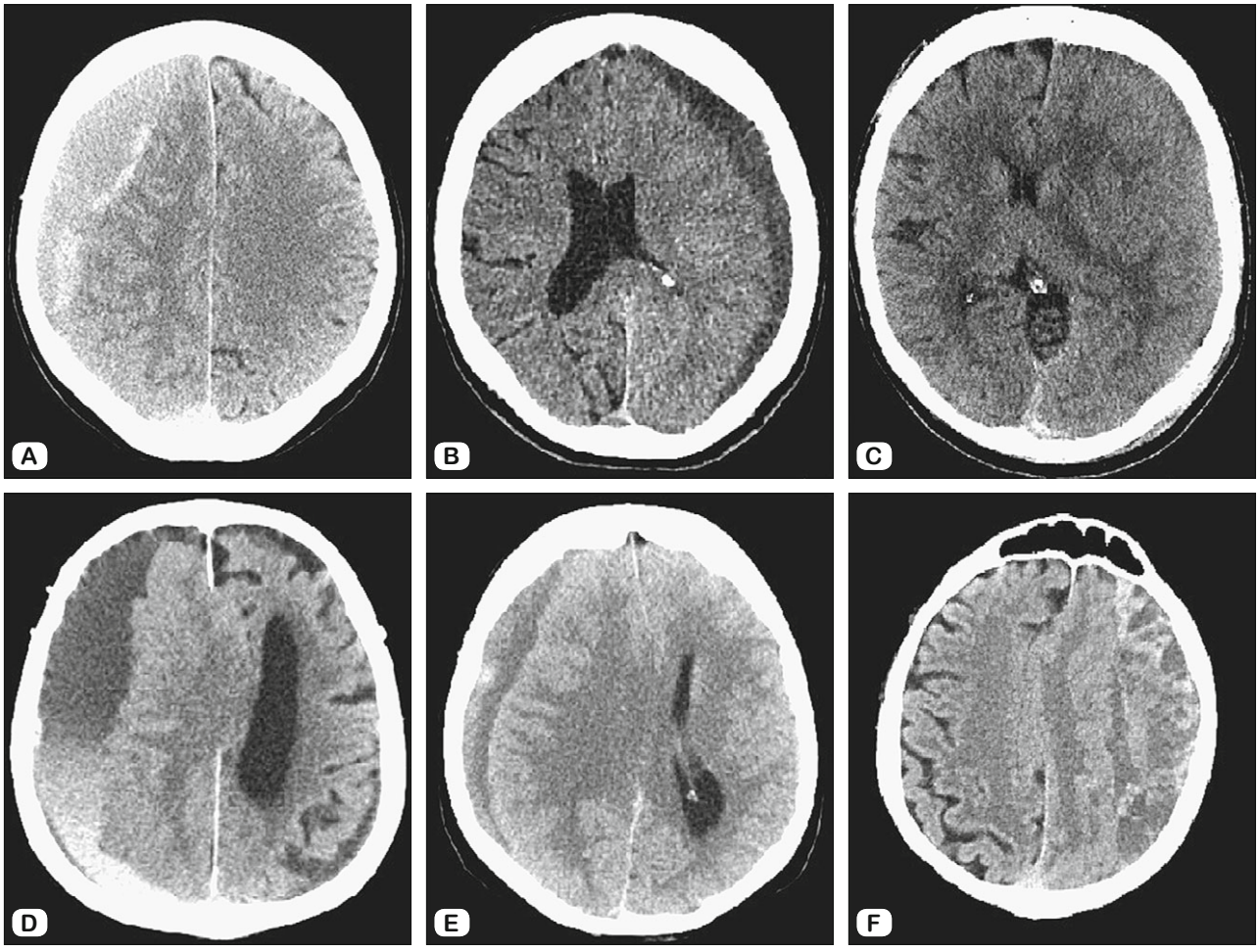

Fig. 1. Morphological types of NASH according to Nakaguchi (1) (A – homogeneous hyperdense, B – homogeneous hypodense, C – homogeneous isodense, D – separated, E – laminar, F – trabecular; author´s archive).

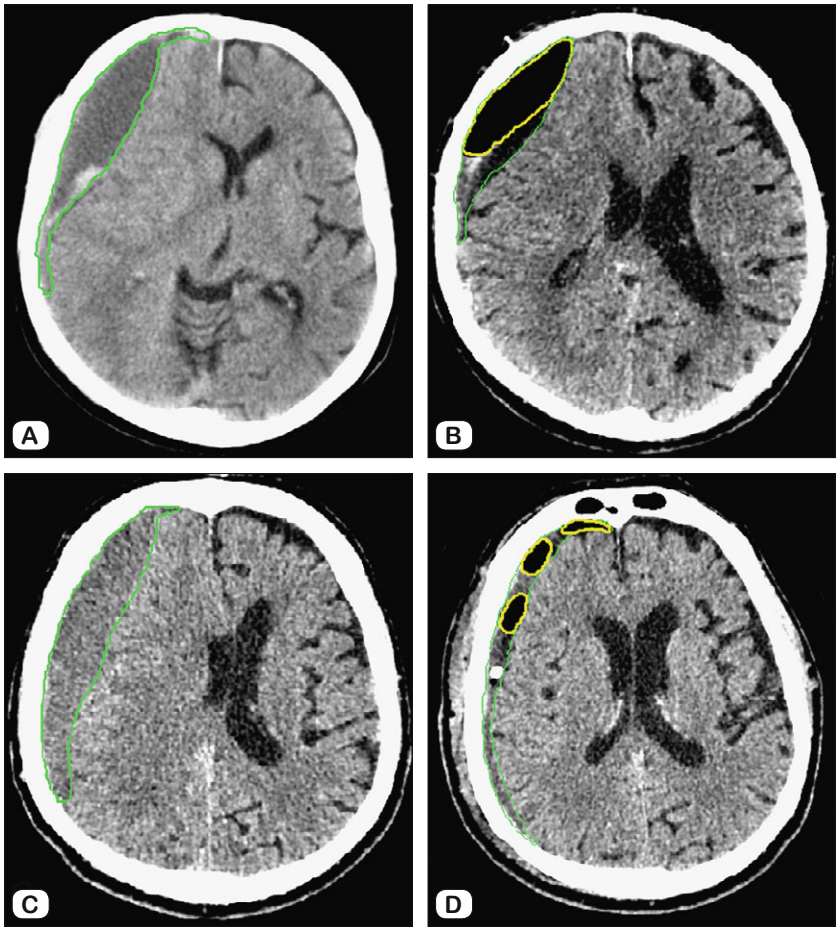

Fig. 2. The measurement of preoperative hematoma volume, post-evacuation hematoma cavity volume and pneumocephalus volume in TomoCon Viewer (A, C – before surgery, B, D – after surgery, green line – hematoma/cavity volume, yellow line – pneumocephalus volume; author´s archive).

drainage. It was calculated as difference between HV and PHCV subsequently divided by HV. During the 4-month follow-up period, we assessed the rate of NASH recurrence, which was considered significant only if requiring a repeated surgery. Statistical analysis was performed using IBM SPSS Statistics for Windows, version 25, (Armonk, New York, IBM Corporation) and PAST, version 4.03 (Oslo, Norway). Level of significance was defined as $p < 0.05$ Univariate statistical measures were used, specifically paired and unpaired Student´s t test and chi² (chi-squared) test. The relationship between NASH's recurrence and mentioned factors was calculated.

Results

During the assessed period, we have treated a total number of 129 patients. Inclusion criteria were met by a total number of 102 patients. The basic cohort characteristic is shown in Table 1. There was a majority of male patients (74.5 %) with mean age of 70.0 years (95 % CI = 67.20–72.72). Male patients were significantly younger than women (68.1 vs 75.4 years, $p = 0.022$). The percentage distribution of patients useing antiplatelet agents and anticoagulants is 26.5 % and 10.8 %, respectively. In most cases, delayed surgery (64.7 %) was performed after necessary preoperative preparation. NASHs were evacuated via 1 burr hole (59.8 %), via 2 burr holes (26.5 %), or via craniotomy with membranectomy (13.7 %). During the follow-up period of 4 months, NASH recurrence requiring repeated surgery was observed in 14 patients (13.7 %). In 7 cases re-evacuation via burr-holes with subdural drainage while in 7 others, craniotomy with external membranectomy was performed. The highest incidence of NASH recurrence was observed in patients with preoperative manifestation of a phatic disorder. However, neither the subjective

Tab. 1. Basic cohort parameters.

Number of patients: 102	Number of NASH: 102
Male: 76	Female: 26
Left-sided NASH: 51	Right sided NASH: 51
Emergency surgery: 36	Delayed surgery: 66
Antiplatelet drugs: 27	Anticoagulants: 11
Burr holes: 88	Craniotomy: 14

Tab. 2. Impact of clinical signs before surgery on incidence of NASH recurrence.

Clinical manifestation before surgery	Overall incidence	Recurrence of NASH	Impact on recurrence of NASH
Phatic disorder	26/25.5 %	5/19.2 %	p=0.418 χ^2=0.65714 *none*
Hemiparesis	51/50.0 %	8/15.7 %	p=0.616 χ^2=0.25131 *none*
Quantitative disorder of consciousness	7/6.9 %	0/0.0 %	p=0.312 χ^2=1.0225 *none*
Headache	33/32.4 %	4/12.1 %	p=0.776 χ^2=0.081038 *none*
Vertigo	20/19.6 %	2/10.0 %	p=0.634 χ^2=0.22689 *none*
Gait disturbance	25/24.5 %	4/16.0 %	p=0.742 χ^2=0.10831 *none*
Epilepsy	6/5.9 %	1/16.7 %	p=0.853 χ^2=0.034495 *none*
Disorientation	25/24.5 %	4/16.0 %	p=0.742 χ^2=0.10831 *none*
Asymptomatic	11/10.8 %	1/9.1 %	p=0.675 χ^2=0.176 *none*

Tab. 3. Incidence of NASH recurrence due to drainage duration.

Duration of drainage	Number of patients	Incidence of recurrence
1 day	8/7.8 %	2/25.0 %
2 days	36/35.3 %	7/19.4 %
3 days	36/35.3 %	4/11.1 %
4 days	13/12.8 %	0/0.0 %
5 days	6/5.9 %	0/0.0 %
6 days	3/2.9 %	1/33.3 %

symptoms, nor the objective clinical signs before surgery had any significant effect on the incidence of NASH recurrence (Tab. 2). The highest incidence of NASH recurrence was associated with drainage duration of 6 days after surgery (33.3 %) (Tab. 3). There was no significant difference in the duration of subdural drainage between the recurrence group and non-recurrence groups of patients (2.4 vs 2.9; p = 0.160; 95 % CI (–0.18374, 1.0993). There was also no significant difference in the incidence of NASH recur-

Tab. 4 Risk factors for incidence of NASH recurrence.

Risk factors	Input data	Impact on recurrence of NASH	Evaluation
Number of burr holes (1 vs 2)	61/11 vs 27/2	p=0.255 χ^2=1.2949	*none*
Trepanation vs craniotomy	88/13 vs 14/1	p=0.491 χ^2=0.47378	*none*
Gender (male vs female)	76/12 vs 26/2	p=0.358 χ^2=0.84397	*none*
Age (recurrence vs non-recurrence group)	70.7 vs 69.8	p=0.830 95 % CI (–7.1923. 8.939)	*none*
Anticoagulants	11/1 vs 91/13	p=0.675 χ^2=0.176	*none*
Antiplatelet agents	27/6 vs 75/8	p=0.203 χ^2=1.6239	*none*
Timing of surgery (urgent vs delayed)	36/8 vs 66/6	p=0.114 χ^2=2.4961	*none*
Hematoma side (left vs right)	51/8 vs 51/6	p=0.616 χ^2=0.25131	*none*
Duration of drainage (1–2 days vs 3–6 days)	44/9 vs 58/5	p=0.136 χ^2=2.2188	*none*
Internal hematoma architecture (homogeneous vs heterogeneous)	56/6 vs 46/8	p=0.397 χ^2=0.7178	*none*
Preoperative hematoma volume (recurrence vs non-recurrence group)	122.7 ml vs 95.6 ml	p=0.034 95 % CI (2.0595, 50.278)	*significant*
Post-evacuation hematoma cavity volume (recurrence vs non-recurrence group)	72.0 ml vs 49.8 ml	p=0.005 95 % CI (6.9585, 37.541)	*significant*
Extent of hematoma evacuation (recurrence vs non-recurrence group)	37.4 % vs 45.8 %	p=0.248 95 % CI (–5.9374, 22.706)	*none*
Pneumocephalus volume (recurrence vs non-recurrence group)	19.6 ml vs 6.4 ml	p=0.001 95 % CI (5.3541, 20.958)	*significant*

Tab. 5. Impact of morphological hematoma types on incidence of NASH recurrence.

Morphological types of NASH	Overall incidence	Side prevalence (left vs right)	Gender (male vs female)	Incidence of recurrence	Impact on recurrence of NASH
Homogeneous hypodense	25/24.5 %	17 vs 8 p=0.106 *No* χ^2=2.6153	20 vs 5 p=0.567 *No* χ^2=0.32801	1 / 4.0 %	1 vs 13 p=0.144 χ^2=2.1351 *None*
Homogeneous isodense	23/22.6 %	10 vs 13 p=0.572 *No* χ^2=0.31949	19 vs 4 p=0.411 *No* χ^2=0.67491	3 / 13.0 %	3 vs 11 p=0.925 χ^2=0.008887 *None*
Trabecular	19/18.6 %	11 vs 9 p=0.683 *No* χ^2=0.16726	16 vs 3 p=0.363 *No* χ^2=0.82711	5 / 26.3 %	5 vs 9 p=0.139 χ^2=0.7178 *None*
Separated	18/17.7 %	6 vs 12 p=0.192 *No* χ^2=1.7043	11 vs 7 p=0.241 *No* χ^2=1.3777	2 / 11.1 %	2 vs 12 p=0.755 χ^2=0.097479 *None*
Laminar	9/8.8 %	3 vs 6 p=0.338 *No* χ^2=0.91959	5 vs 4 p=0.220 *No* χ^2=1.5065	1 / 11.1 %	1 vs 13 p=0.834 χ^2=0.044141 *None*
Homogeneous hyperdense	8/7.8 %	4 vs 4 p=1.000 *No* χ^2=0.0000	5 vs 3 p=0.458 *No* χ^2=0.55115	2 / 25.0 %	2 vs 12 p=0.421 χ^2=0.64863 *None*

Tab. 6. Observed volumetric parameters.

Volumetric parameters	Hematoma side (left vs right)	Gender (male vs female)	Correlation with patient age	Internal hematoma architecture (homogenous vs heterogenous)
Preoperative hematoma volume	96.8 ml vs 103.5 ml p=0.435 95 % CI (–10.465, 23.955) *No*	103.6 ml vs 90.1 ml p=0.168 95 % CI (–5.7862, 32.79) *No*	R=0.135 p=0.177	93.0 ml vs 108.8 ml p=0.065 95 % CI (–0.97881, 32.552) *No*
Post-evacuation hematoma cavity volume	49.9 ml vs 55.7 ml p=0.287 95 % CI (–4.9517, 16.403) *No*	54.5 ml vs 47.8 ml p=0.230 95 % CI (–5.7912, 19.202) *No*	R=0.174 p=0.081	50.1 ml vs 56.0 ml p=0.287 95 % CI (–5.0438, 16.845) *No*
Extent of hematoma evacuation	44.2 % vs 45.1 % p=0.833 95 % CI (–7.9861, 9.8685) *No*	45.4 % vs 42.5 % p=0.615 95 % CI (–8.4757, 14.264) *No*	R=0.099 p=0.322	43.1 % vs 46.5 % p=0.501 95 % CI (–6.56, 13.336) *No*
Pneumocephalus volume	9.1 ml vs 7.3 ml p=0.519 95 % CI (–3.7104, 7.2516) *No*	8.7 ml vs 6.8 ml p=0.550 95 % CI (–4.524, 8.4448) *No*	R=0.219 p=0.027 *significant*	7.9 ml vs 8.6 ml p=0.813 95 % CI (–5.0074, 6.3683) *No*

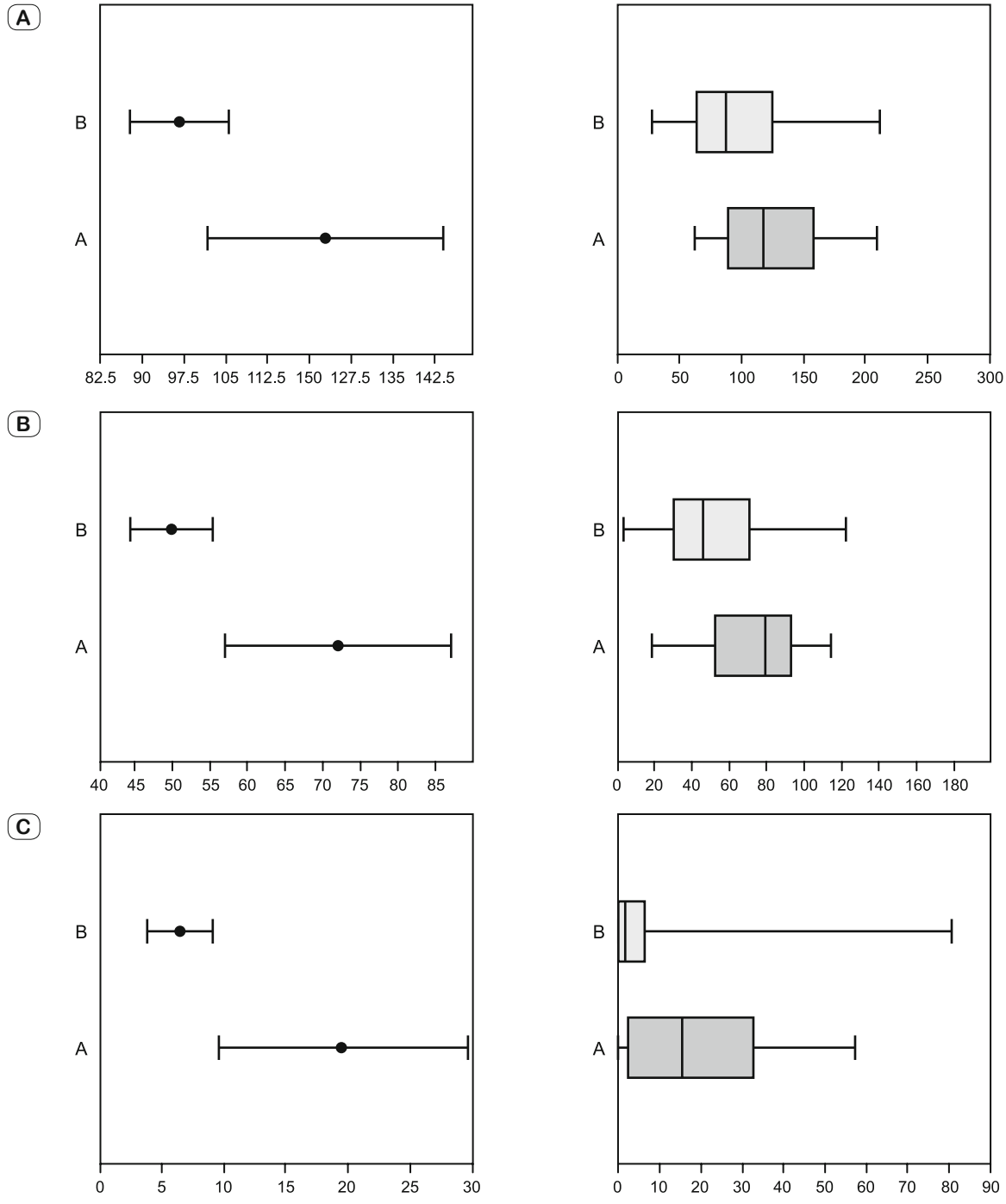

Fig. 3. A: The hematoma volume before surgery was significantly higher in patients with recurrence of NASH, p = 0.034 (A – recurrent group with mean volume of 122.7 ml, 95 % CI (99.264 – 146.16), B – non-recurrent group with mean volume of 95.6 ml, 95 % CI (87.547 – 105.54)). B: The volume of residual post-evacuation hematoma cavity was significantly higher in patients with recurrence of NASH, p=0.005 (A – recurrent group with volume mean of 72.0 ml, 95 % CI (55.384 – 88.616), B – non-recurrent group with volume mean of 49.8 ml, 95 % CI (44.14 – 55.36)). C: The volume of pneumocephalus after surgery was significantly higher in patients with recurrent NASH, p=0.001 (A – recurrent group with volume mean of 19.6 ml, 95 % CI (8.4769 30.637), B– non-recurrent group with volume mean of 6.4 ml, 95 % CI (3.7238 9.0784)).

rence between patients with subdural drainage duration of 1–2 days and 3–6 days (p = 0.136 chi² = 2.2188). The surgical technique of evacuation (number of burr holes, burr hole vs craniotomy), age of patients, gender, hematoma side, timing of surgery and homogeneity of the internal hematoma architecture had no significant effect on the incidence of NASH recurrence (Tab. 4). Patients taking antiplatelet agents before surgery had a higher incidence of NASH recurrence, but the difference was not significant (p = 0.203; chi² = 1.6239). The use of anticoagulants did not affect the incidence of NASH recurrence (p = 0.675; chi² = 0.176).

In the monitored group, homogeneous hypodense hematoma was the most common type (24.5 %), but also had the lowest incidence of recurrence (4.0 %). Trabecular and homogeneous hyperdense type of NASH had the highest incidence of recurrence (26.3 % and 25.0 %); the statistical relationship was, however, not confirmed (Tab. 5). HV, weakly but significantly positively, correlated with PCV (R = 0.299; p = 0.002). Hematoma side, gender and homogeneity of internal hematoma architecture did not have impact on HV, PHCV, EHE and PCV (Tab. 6). Homogenous NASH showed a smaller preoperative volume (PHV) than heterogeneous ones, but the difference was not significant (93.0 ml vs 108.8 ml; p = 0.065; 95 % CI (–0.97881, 32.552)). The significance of correlation of PCV with patient age was weakly positive (R = 0.219, p = 0.027). HV, PHCV and PCV had a significant impact on the incidence of NASH recurrence, but EHE did not (Tab. 4). The hematoma volume before surgery was significantly larger in the recurrence group of patients as compared to non-recurrence group (p = 0.034) (Fig. 3A). PHCV was significantly larger in recurrence group as compared to non-recurrence group (p = 0.005) (Fig. 3B). Also, PCV after surgery was significantly larger in patients with recurrent NASH (p = 0.001) (Fig. 3C).

Discussion

The recurrence rate of NASH is reported to be in wide range of 2.3 to 33.0 % (3, 6–18). In our study, the overall rate of NASH recurrence requiring surgery reached 13. 7 %. The highest recurrence rate of NASH was observed in patients with phatic disorder before surgery, but no preoperatively present clinical sign had any significant impact on the incidence of NASH recurrence. In the study of Hammer et al., the preoperative presence of phatic disorder was significantly associated with recurrence of NASH (19). Chon et al. found that preoperative presence of epilepsy was an independent predictor of NASH recurrence (3). The placement of drainage after NASH evacuation is associated with reduced risk of hematoma recurrence (8, 19). The role of duration of drainage in relation to recurrence rate is unclear; some studies have confirmed it while others have not (16, 20–22). The duration of drainage does not significantly affect the incidence of postoperative complications (20, 21). There was no significant difference in the duration of drainage in the subgroups with 1–2 days versus 3–6 days after surgery. Kale et al. report that the drainage duration of 2–4 days has a lower hematoma recurrence rate compared to the drainage duration of 5–7 days (20). Ohba et al found an association between the direction of the drainage tube and recurrence of NASH (14). Trabecular and homogeneous hyperdense type of NASH had the highest recurrence rate in our cohort group, but morphological hematoma type did not have a significant impact on recurrence incidence. Similarly, there was no difference in the incidence of recurrence between homogeneous and heterogeneous hematomas. Most studies state that the heterogeneous type of hematoma represents a risk factor for NASH recurrence (4, 5, 11, 14, 16, 19, 23, 24). In particular, the separated type is most often described as a risk factor (3, 14, 19, 23). The preoperative and postoperative findings of hematoma hyperdensity are also considered to be a significant risk factor for recurrence, as indicated by high recurrence rate of homogeneous hyperdense hematoma in our study (7, 9, 12, 17, 23, 18, 25).

None of the selected surgical techniques of NASH evacuation in our cohort were associated with a higher risk of recurrence. It seems that all 3 methods of evacuation are effective in hematoma draining (17). A lower incidence of recurrence after craniotomy with membranectomy is a logical precondition, which we observed in our previous study conducted in 2019. Craniotomy was, however, reported to be a risk factor for a worse outcome and postoperative complications (15). Maher Hulou et al report a six-fold higher probability of recurrent NASH after craniotomy as compared to trepanation (12). Gender and age of patients in our cohort were not observed to be risk factors for recurrence rate. Male sex is often referred to as a risk factor in other studies (10, 13). An explanation for this difference is the fact that in our study, men were significantly younger than women. Elderly patients have less potential for re-expansion of the cerebral hemisphere due to cerebral atrophy, but in our study, this assumption was not confirmed. In their study, Motoie et al report that patient age is an independent predictor of NASH recurrence (13).

Long-term intake of antithrombotic agents acted as a significant risk factor for the development of surgically significant acute extracerebral hematoma (15). The use of anticoagulant and antiplatelet agents was not a risk factor for recurrence rate in our cohort. The results of studies evaluating the effect of antithrombotic drugs on the incidence of NASH recurrence are contradictory (3, 7, 8, 13, 26–30). Meta-analysis of Wang et al demonstrated that both, anticoagulants and antiplatelet drugs represented a higher risk for recurrence rate, albeit did not increase mortality (29). Fornebo et al refer that patients on antiplatelet therapy at the time of diagnosis have similar recurrence and mortality rates as compared to patients without antithrombotic therapy but have an increased risk of higher morbidity (26). Motiei-Langroudi et al found that the use of clopidogrel or warfarin is the strongest predictor of re-operation (27). In the study of Zhang et al., anticoagulants are risk factors for NASH recurrence whereas antiplatelet drugs are not. Antithrombotic agents cause large hematoma volumes that aggravate the severity of NASH (30). Thus, most studies confirmed the adverse effect of antithrombotic drugs on the recurrence rate (3, 7, 27–31).

In our study, PHV, PHCV and PCV were significantly higher in patients with hematoma recurrence (p = 0.034, p = 0.005 and p = 0.001). PCV was higher in elderly patients and patients with higher PHV. The average PHV value in our cohort of patients

with recurrence was 122.7 ml. PHV greater than 80 ml occurs more frequently in the recurrence group (18). Uda et al report a significant effect of the preoperative hematoma volume on the recurrence rate (32), an observation similar to that of Stanišič (4) and us, even in our previous work describing bilateral non-acute subdural hematomas (24). In the study of Shen et al., the ratio of the postoperative pneumocephalus volume to the postoperative hematoma cavity volume was identified as an independent risk factor for predicting NASH recurrence (28). Motiei-Langroudi et al report that larger residual fluid volume on the first postoperative day at CT examination and lower decrease in hematoma size after surgery correlated with a significantly higher rate of reoperation (27). In the study of Stavrinou et al, the percentage of hematoma drained was also an independent risk factor for recurrence (17). In our study, the significant effect of the extent of the decrease on hematoma size after surgery was not confirmed. Kanazawa et al. also report that postoperative hematoma volume and postoperative significant residual air were identified as independent risk factors for potential NASH recurrence (9). Many studies have confirmed the significant effect of postoperative pneumocephalus on the incidence of recurrence (9, 14, 25, 28, 31, 33, 34). However, no correlation between cerebral atrophy and PCV has been demonstrated (31). Postoperative pneumocephalus prolongs the hospital stay and healing time and leads to deterioration of the neurological condition (25), even with the possibility of fatal consequences (35). Huang et al. reached the same finding as us, namely that PHV and patient age are positively correlated with PCV. At the same time, they found that age and PCV were positively correlated with the absorbing rate of pneumocephalus (36). According to most studies, the elimination of postoperative pneumocephalus should reduce the incidence of hematoma recurrence. The intraoperative aspiration of the pneumocephalus, which enhances hemispheric re-expansion, is an effective method for reduction of NASH recurrence (37).

In our study, the influence of factors such as use of drainage after trepanation, type of drainage (subdural versus subperiosteal) and the effect of irrigation of the subdural space on the incidence of NASH recurrence was not assessed since we use a similar technique of irrigation and subdural drainage in all included patients. Subdural drainage after evacuation through burr holes was used in all patients in the study group and thorough irrigation of the subdural space was always performed. In current literature, the type and positioning of subdural drains are a matter of debates. When comparing subdural and. subperiosteal drains, numerous studies have found no significant superiority of either of the methods (38, 39), while results of randomised trial (cSDH-Drain-Trial) slightly favoured subperiosteal drainage systems (40). Factors affecting the outcome and mortality after surgery could not be assessed because patient death (GOS 1) was an exclusion criterion. The effect of NASH bilaterality on the incidence of hematoma recurrence was also not evaluated because they were not included in the cohort group in order to maintain its homogeneity. Unilateral and bilateral NASH are not the same nosological entities. Bilateral NASH is often associated with the risk for increased recurrence rate (7, 16, 23). However, no other studies have confirmed this hypothesis (6,8). Agawa et al. report a worse clinical outcome in bilateral than in unilateral NASH due to brain herniation (5.7 % vs 0.3 %; p = 0.01). Bilateral NASH was associated with rapid progression that requires urgent surgery (6). Currently, various novel methods of treatment of NASH are being proposed and assessed, such as endoscopic evacuation (41–43), medical treatment via tranexamic acid in patients with mild symptoms (44, 45) or using dexamethasone (46, 47) – which has not been proven beneficial in randomised trial Dex-CSDH (48). One of the most promising methods seems to be the endovascular treatment via embolisation of the middle meningeal artery (49, 50). This treatment, based on blocking of the hematoma's membrane blood supply, has a potential to improve reabsorption and decrease the recurrence rate of NASH (49, 50, 51). Patients after embolization of the middle meningeal artery due to NASH were not included in this study since our institution started to use this modality in the late 2020. We currently use this modality in patients considered to be at high risk of NASH recurrence.

Conclusions

We have observed the incidence of NASH recurrence to be 13.7 %. Pre- and postoperative volumetric analyses in patients with NASH have a potential to improve prediction of clinically significant recurrence based on the measurements of preoperative hematoma volume and postoperative volume of hematoma cavity and pneumocephalus.

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Received June 30, 2022.
Accepted August 24, 2022.