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Midline Shift Threshold Value for Hemiparesis in Chronic Subdural Hematoma

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SUMMARY

Introduction Chronic subdural hematoma (CSDH) has a variety of clinical presentations, with numerous neurological symptoms and signs. Hemiparesis is one of the leading signs that potentially indicates CSDH.

Objective Purpose of this study was to determine the threshold (cut-off) value of midsagittal line (MSL) shift after which hemiparesis is likely to appear.

Methods The study evaluated 83 patients with 53 unilateral and 30 bilateral CSDHs in period of three years. Evaluated computed tomography (CT) findings in patients with CSDH were diameter of the hematoma and midsagittal line shift, measured on non-contrast CT scan in relation with occurrence of hemiparesis. Threshold values of MSL shift for both types of CSDHs were obtained as maximal (equal) sensitivity and specificity (intersection of the curves).

Results MSL is a good predictor for hemiparesis occurrence (total sample, AUROC 0.75, p=0.0001). Unilateral and bilateral CSDHs had different threshold values of the MSL for hemiparesis development. Results suggested that in unilateral CSDH the threshold values of MSL could be at 10 mm (AUROC=0.65; p=0.07). For bilateral CSDH the threshold level of MSL shift was 4.5 mm (AUROC=0.77; p=0.01).

Conclusion Our study pointed on the phenomenon that midsagittal line shift can predict hemiparesis occurrence. Hemiparesis in patients with bilateral CSDH was more related to midsagittal line shift compared with unilateral CSDH. When value of midsagittal line shift exceed the threshold level, hemiparesis occurs with certain probability.

Keywords: subdural hematoma; midsagittal line shift; threshold; hemiparesis

INTRODUCTION

Chronic subdural hematoma (CSDH) is a common neurological, radiological and neurosurgical entity that is the topic of many researches [1-4]. On computed tomography, this encapsulated extra-axial hemorrhagic collection may appear in the form of unilateral (Figure 1) or bilateral (Figure 2). It is usually connected with elderly, which have comorbidities and risk factors for developing CSDH more than younger patients. Symptoms and signs of these lesions are changeable – from mild to severe – and depend on the type and location of the hematoma within the brain [5]. Accepted view is that clinical symptoms do not appear until they reach the critical level. One of the most frequent neurological dysfunctions in patients with CSDH is hemiparesis [6]. Why motor deficit appears in some patients and what the major cause for developing hemiparesis is remain open and not entirely understood questions. The causative mechanism was investigated in the study of Ikeda et al. [7], but other authors have studied the influence of diameter of hematoma and midsagittal line (MSL) shifts on clinical outcome and its connection with restauration of consciousness [8, 9] in order to obtain precise data for optimal treatment, although there are no evidence based on the CSDH cut-off size of thickness [5] or midsagittal line shift that indicate necessity of surgery.

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OBJECTIVE

Since neurological status of patients with radiologically proven CSDHs is particularly important for the decision of surgery treatment, the authors attempted to identify a connection between midsagittal line shift and the development of hemiparesis. This fact gave rise to the idea to determine the threshold (cut-off) value of midsagittal line shift for hemiparesis occurrence.

METHODS

We analyzed 83 patients with 53 unilateral and 30 bilateral subdural hematomas with one or several clinical signs and symptoms on hospital admission such as headache, vomiting, seizure, hemiparesis, speech disturbances, mental deterioration or coma. Clinical symptoms and signs of all patients with CSDH were documented, with the greatest attention on patients with hemiparesis. Patients with concomitant head traumatic lesions, brain tumors, infections or histological confirmed subdural empyemas were excluded from this study. Data were collected over a period of three years, between 2010 and 2013, in the Centre for Radiology, Clinical Centre of Vojvodina. The Ethical Committee of Clinical Centre of Vojvodina approved the study. All patients were diagnosed

Figure 1. Brain CT scan: unilateral chronic subdural hematoma on the right side with compression on lateral ventricle and midsagittal line shift to the left

Figure 2. Brain CT scan: bilateral chronic subdural hematoma

using non-contrast CT scan (Somatom Emotion 16 and Cardiac Sensation 64, Siemens, Germany). The CT brain protocol included axial slices parallel to the infraorbitomeatal line, from the foramen magnum to the apex of skull, with slice thickness 5 mm [10]. Patients were divided into two groups: one group with unilateral CSDHs and the other with bilateral CSDHs. For this study important CT findings were the diameter of the hematoma and the shift of midsagittal line (MSL) caused by compression of CSDH

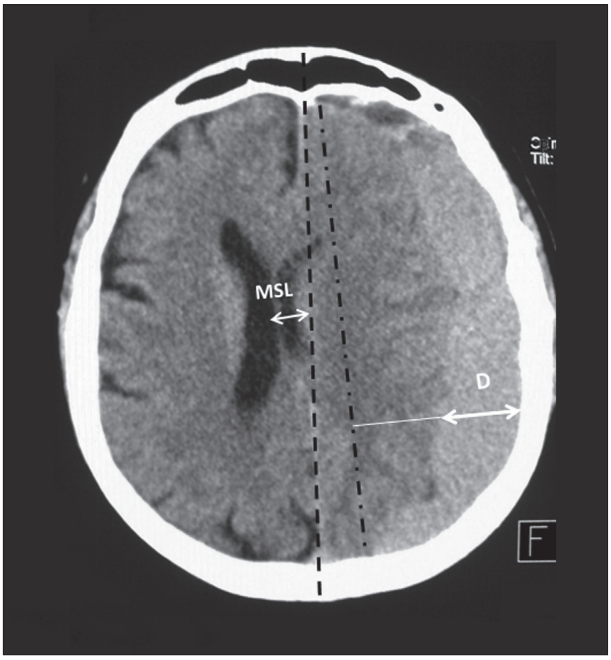


Figure 3. Measure of diameter (D) and midsagittal line shift (MSL); unilateral chronic subdural hematoma on the left side with MSL shift to the right

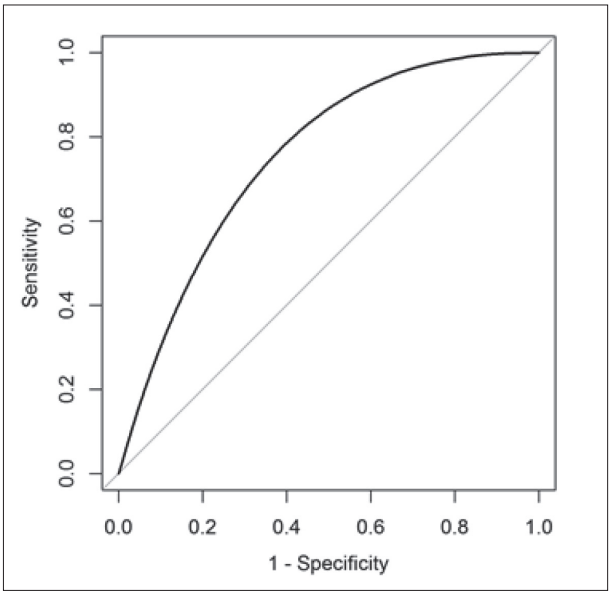
and connection with hemiparesis occurrence in patients. A diameter of hematoma (D) was measured as the maximal thickness of the hematoma perpendicular to the line connecting the two most distant points of subdural collection (Figure 3, dash-dotted line) on axial CT scan according to Gebel et al. [11, 12]. The diameter of bilateral CSDH was measured as the sum of both sides. MSL shift was measured as a deviation of septum pellucidum from median position (line that connects crista galli and occipital protuberance (Figure 3, dashed line) on axial CT slices [13]. Statistical analysis used in this study were Fisher's exact test (p-value<0.05 was considered statistically significant difference) and receiver operating characteristic (ROC) [14, 15, 16]. R statistical package (R Development Core Team, 2012) was applied in this study [17]. Threshold values of MSL shift for both types of CSDH were obtained as maximal (equal) sensitivity and specificity (at the intersection of the curves) [18, 19, 20].

RESULTS

Age of the patients in the study was between 39 and 90 years (mean 69.7 years). There were 55 male and 28 female patients (ratio M:F=1.9:1). In line with two groups, there were 53 patients with unilateral CSDH and 30 patients with bilateral. Hemiparesis was diagnosed in 58 patients (44 patients with unilateral and 14 patients with bilateral

Table 1. Distribution of patients with unilateral and bilateral chronic subdural hematoma and shift of midsagittal line (MSL)

MSL	Yes	No
Unilateral	48 patients	5 patients
Bilateral	20 patients	10 patients
p-value (Fisher's exact test)	0.009	



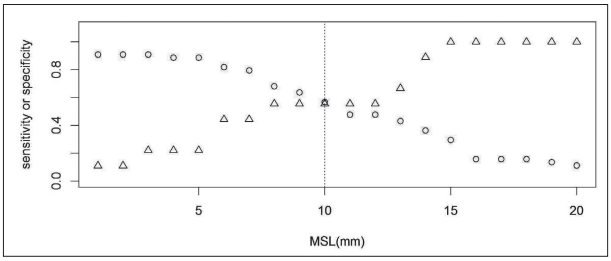
Graph 1. ROC curve for midsagittal line shift as a good predictive factor for hemiparesis occurrence (AUROC=0.75; p=0.0001)

CSDH), where hemiparesis was contralateral to the side of the thicker hematoma layer in bilateral CSDHs.

Motor deficit was diagnosed in a period of about 13 days for unilateral, equal to the bilateral CSDHs. None of the patients in the study had an ischemic stroke in the area supplied by the large arteries in the brain or hemorrhagic brain infarction.

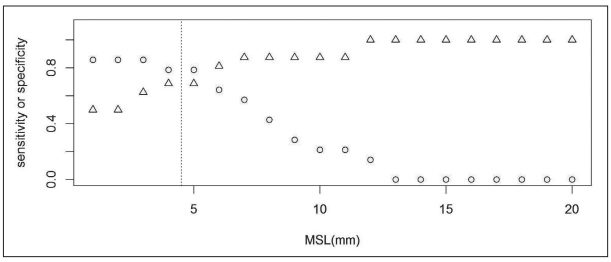
There was a statistically significant difference in number of patients between the groups with and without midsagittal shift (MSL=0) in unilateral and bilateral CSDH according to Fisher's exact test (p=0.009<0.05). Patients with unilateral hematomas had MSL shifts more often (Table 1).

Using ROC analysis, MSL shift showed high value of prediction for hemiparesis occurrence: Area under the ROC-AUROC=0.75, p=0.0001<0.05 for unilateral and bilateral hematoma (Graph 1). For unilateral hematoma AUROC=0.65, p=0.07>0.05, but for bilateral hematoma AUROC=0.77, p=0.01<0.05. If we look at unilateral CSDHs, the value of threshold of MSL shift was 10 mm. In the group of bilateral CSDHs, the threshold values of MSL



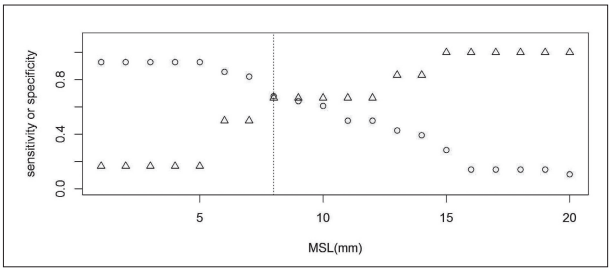
Graph 2. The threshold value of midsagittal line shift in unilateral chronic subdural hematoma

x-axis – diameter of midsagittal line shift (MSL); y-axis – value of sensitivity and specificity; circle – sensitivity; triangle – specificity



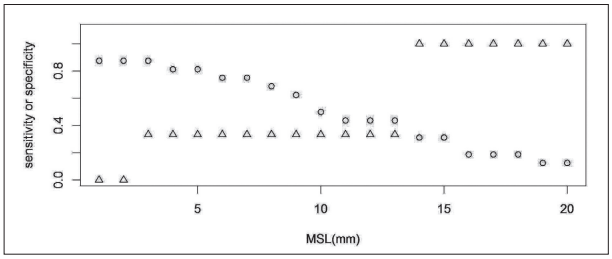
Graph 3. The threshold value of midsagittal line shift in bilateral chronic subdural hematoma

x-axis – diameter of midsagittal line shift (MSL); y-axis – value of sensitivity and specificity; circle – sensitivity; triangle – specificity



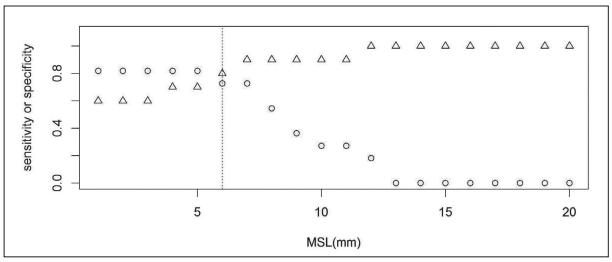
Graph 4. Sensitivity and specificity in subdivided male group of patients with unilateral chronic subdural hematoma

x-axis – diameter of midsagittal line shift (MSL); y-axis – value of sensitivity and specificity; sensitivity – circle; specificity – triangle



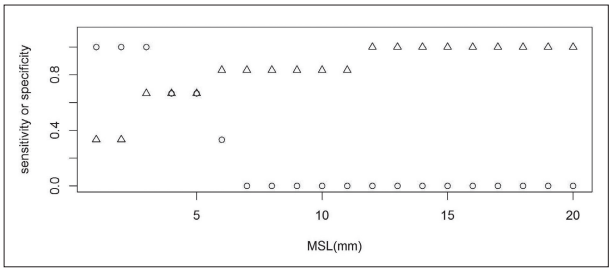
Graph 5. Sensitivity and specificity in subdivided female group of patients with unilateral chronic subdural hematoma

x-axis – diameter of midsagittal line shift (MSL); y-axis – value of sensitivity and specificity; sensitivity – circle; specificity – triangle



Graph 6. Sensitivity and specificity in subdivided male group of patients with bilateral chronic subdural hematoma

x-axis – diameter of midsagittal line shift (MSL); y-axis – value of sensitivity and specificity; sensitivity – circle; specificity – triangle



Graph 7. Sensitivity and specificity in subdivided female group of patients with bilateral chronic subdural hematoma

x-axis – diameter of midsagittal line shift (MSL); y-axis – value of sensitivity and specificity; sensitivity – circle; specificity – triangle

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shift for hemiparesis manifestation was 4.5 mm (Graphs 2 and 3). In subsample of males and females within unilateral and bilateral group of patients with CSDH (Graphs 4–7), MSL shift showed good predictive value for males in both cases. AUROC for unilateral CSDH for males was 0.71 (p=0.05), and for bilateral CSDH was 0.8 (p=0.008<0.05). In the female group for both types of CSDHs p-value was high and without statistical significance (unilateral p=0.43 and bilateral p=0.14).

DISCUSSION

Van Havenbergh et al. [8] in their study showed that MSL shift and hematoma volume did not have predictive values for clinical outcome of patients using Glasgow outcome score (GOS). Juković [21] in her thesis showed that there was no relation between the diameter of the hematoma and the MSL shift, i.e. increasing of the midsagittal shift did not follow the increase in diameter of CSDH and vice versa. The possible reason for this is the fact that brain cortical atrophy promotes enlargement of extracerebral fluid space. Consequently, it produces more capacity for accumulation of the substantial hemorrhagic collection without critical brain compression and midline shift [22]. Additionally, Juković et al. [10] showed that hemiparesis was more frequent in unilateral than bilateral CSDHs, which correlated with results of Huang et al. [13]. It is an interesting fact that an average value of MSL shift in unilateral CSDHs was twice bigger than that in bilateral, while hemiparesis in bilateral CSDHs appeared after half the value of MSL shift. The reason for this could be due to the possibility that bilateral brain compression with small MSL shift leads to a stronger compression of pyramidal tract than in unilateral CSDHs, which in turn leads to motor deficit. In Graph 2, the intersection of sensitivity and specificity with indicated threshold value of MSL shift where hemiparesis was expected can be seen. Bilateral CSDHs were stronger related to MSL shift in comparison to unilateral CSDHs. For unilateral CSDHs p-value of AUROC test was 0.07, which was not significant (p>0.05). Underestimation of diagnostic accuracy in unilateral hematomas could be data-driven, caused by sample size. Bachmann et al. [23] and Leeflang et al. [24] showed that sample size below 200 could be a diagnostic problem. Subgroup of males had higher values of AUROC (AUROC=0.71 for uni- and 0.8 for bilateral CSDH with p<0.05) in comparison to women. Relatively small number of females (28 patients) may be the reason for absence of relation between MSL shift and hemiparesis. However, there was significant correlation between MSL shift and hemiparesis occurrence in analyzed patients with CSDH. It meant that hemiparesis was developed when the values of MSL shifts exceeded the threshold value (4.5 mm for bilateral and probably 10 mm for unilateral CSDH). Yokoyama et al. [25] assumed that compressive effect of CSDH has influence on corticospinal tract whose dysfunction leads to motor deficit and hemiparesis, but Ikeda et al. [7] stated that possible connection with neurological dysfunction in patients had circulatory disturbance in the area of underlying brain cortex being pressed by hematoma and neural distortion in the compressed hemisphere. Kwak et al. [26] maintained that recovery of deficit depended on localization and the degree of compression by hematoma on corticospinal tract. It can be concluded that the compression on the corticospinal tract in specific location could have importance for hemiparesis occurrence. In addition, physiological processes and brain metabolism, especially changes in fractional anisotropy in the brain grey matter (caudate nucleus and putamen) on the ipsilateral side of CSDH cannot be overlooked [27].

CONCLUSION

Our study pointed on the phenomenon that MSL shift can predict hemiparesis occurrence. Hemiparesis in patients with bilateral CSDH was more related to MSL shift compared with unilateral. When the value of MSL shift exceeds the threshold level, hemiparesis occurs. The threshold level of MSL for bilateral CSDH was 4.5 mm and probably 10 mm for unilateral.

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Граничне вредности помераја медиосагиталне линије за хемипарезу код хроничног субдуралног хематома

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КРАТАК САДРЖАЈ

Увод Хронични субдурални хематом (ХСДХ) се одликује различитом клиничком сликом уз бројне неуролошке симптоме и знаке. Хемипареза је један од водећих знакова који може указивати на постојање ХСДХ код болесника.

Циљ рада Циљ истраживања је био да се утврди праг вредности помераја медиосагиталне линије (МСЛ) после којег постоји могућност да дође до хемипарезе.

Методе рада Студија је обухватила 83 болесника: 53 с једностраним и 30 с обостраним ХСДХ у периоду од три године. Испитивани параметри компјутеризоване томографије (*CT*) код болесника са ХСДХ били су пречник хематома и померај МСЛ, мерени на неконтрастном *CT*, ради утврђивања повезаности с настанком хемипарезе. Вредности прага помераја МСЛ за оба типа ХСДХ мерени су као максималне (једнаке) вредности сензитивности и специфичности (добијене на пресеку линија).

Резултати МСЛ је добар предиктор за појаву хемипарезе (у укупном узорку *AUROC*=0,75; *p*=0,0001). Једностранi и обострани ХСДХ су имали различите граничне вредности помераја МСЛ при којима се код болесника појавила хемипареза. Резултати су показали да код једностраних ХСДХ гранична вредност помераја МСЛ може бити на 10 *mm* (*AUROC*=0,65; *p*=0,07), а код обострaних на 4,5 *mm* (*AUROC*=0,77; *p*=0,01).

Закључак Хемипареза је важан клинички знак код особа са ХСДХ. Ова чињеница може значајно допринети клиничким лекарима да увек размишљају о могућности постојања ХСДХ када имају болесника с хемипарезом. Наша студија је указала на феномен да померај МСЛ има предиктивну вредност у односу на појаву хемипарезе. Хемипареза код особа с обостраним ХСДХ је била у јачој вези са померајем МСЛ у поређењу с једностраним ХСДХ. Када вредности помераја МСЛ премаше праг, долази до појаве хемипарезе с извесном вероватноћом.

Кључне речи: субдурални хематом; померај медиосагиталне линије; гранична вредност; хемипареза

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