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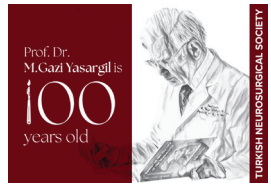

Thromboelastography in Patients with Chronic Subdural Hematoma: A Prospective Pilot Study

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ABSTRACT

AIM: To evaluate association between chronic subdural hematoma (CSDH) and thromboelastography (TEG).

MATERIAL and METHODS: A prospective pilot study was conducted on 52 patients with CSDH. The primary outcomes were CSDH severity, recurrence rate, and outcome. The secondary outcome was the association between TEG parameters and the risk factors of CSDH.

RESULTS: The association between the preoperative TEG parameters and the primary outcomes was compared. Results revealed no statistically significant association between the primary outcomes and admission modified Rankin scale score and follow-up GOS score. The R values significantly differed between patients with recurrence and those without (p=0.045). Further subgroup analysis of TEG parameters revealed that patients with R values ≥ 5 had a significantly high incidence of recurrence (1.231, 95% confidence interval [CI]: 0.973–1.557], p=0.025). However, further logistic regression analysis did not reveal significant results (1.198, 95% CI: 0.855–1.680, p=0.293). Moreover, the association between the preoperative TEG parameters and the secondary outcomes was compared. Results revealed a statistically significant association between the secondary outcomes and hematoma thickness and LY30 values (p=0.039), midline shift and Angle (p=0.043), and multiplicity of the hematoma cavity and MA (p=0.022). Further, the secondary outcomes were also significantly associated with postoperative TEG parameters such as multiplicity of the hematoma cavity and LY 30 value (p=0.011) and residual hematoma at follow-up (MA, p=0.001).

CONCLUSION: Due to the small sample size, the efficacy of TEG parameters in predicting CSDH recurrence is unclear. However, TEG parameters are associated with the imaging characteristics of CSDH, and they can also be used to predict the absorption of hematoma. Nevertheless, large-scale prospective cohort studies should be performed to further validate the findings of this study.

KEYWORDS: Chronic subdural hematoma, Thromboelastography, Blood coagulation, Risk factors, Recurrence

ABBREVIATIONS: CSDH: Chronic subdural hematoma, **CI:** Confidence interval, **DM:** Diabetes mellitus, **GOS:** Glasgow Outcome Scale, **IQR:** Interquartile range, **INR:** International normalized ratio, **mRS:** Modified Rankin scale, **OR:** Odds ratio, **PT:** Prothrombin time, **RCT:** Randomized controlled trials, **TEG:** Thromboelastography

INTRODUCTION

Chronic subdural hematoma (CSDH) is a common type of neurosurgical disease in elderly patients, and the incidence of CSDH is increasing annually (11). Thromboelastography (TEG) is a technique that can reflect the dynamic change in blood coagulation. Compared with the conventional methods for coagulation function detection, it can assess the coagulation function of patients more comprehensively and effectively. At present, it is widely used in various clinical aspects such as cardiopulmonary bypass surgery, liver transplantation surgery, traumatic hemorrhagic shock, cardiac

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surgery, prediction of risk factors related to the expansion of hypertensive cerebral hemorrhage hematoma, and individualized platelet therapy guidance, which can monitor the coagulation function of patients and guide treatment (12,15,27). However, the possible association between TEG parameters and CSDH is still unclear. The association between TEG parameters and the primary and secondary outcomes of CSDH was compared. The primary outcome was CSDH severity (based on the admission modified Rankin scale [mRS] score), recurrence rate, and prognosis (according to the mRS score and Glasgow Outcome Scale [GOS] score). The secondary outcome was the association between TEG parameters and the risk of CSDH. Relevant papers on the factors associated with CSDH recurrence, which include hematoma multiplicity, hematoma thickness, and degree of midline shift, were examined (16). Thus far, no relevant studies have reported an association between TEG parameters and CSDH.

MATERIAL and METHODS

Patients

The current study was approved by the ethical committee of our institution (approval number: 2021-XM013), and informed consent was obtained from all patients. In total, 60 patients with CSDH underwent surgery from February 2021 to June 2022, and blood samples were collected for TEG before and 3–5 days after emergency surgery. Some patients were excluded due to the following reasons: accidental death during follow-up (n=1), lack of preoperative TEG (n=2), inconsistent detection methods used in TEG (n=2), and unwillingness to return to the hospital for head CT scan after recovering well that resulted in incomplete data (n=3). Finally, 52 patients, including 39 men (75%), 13 women (25%), 1 with preoperative aspirin, 1 treated with preoperative aspirin and clopidogrel, and 1 receiving preoperative warfarin anticoagulation, were examined.

Variables and criteria

The case report form and imaging findings of 52 patients were analyzed. Further, the following parameters were examined: clinical variables – demographic characteristics (sex and age), previous medical history, neurological assessment at admission and discharge (mRS score), and GOS score at the 3-month follow-up (Table I); imaging data – multiplicity of the hematoma cavity, hematoma thickness, and midline shift (Table I); and laboratory data – all TEG parameters, primarily R value, K value, Angle, MA, confidence interval (CI), and LY 30 value (Table I). Head CT scans were performed within 24 h after surgery. Meanwhile, the number of complications in perioperative patients was recorded (Table II).

The inclusion criteria were patients with CSDH confirmed on head CT scan or magnetic resonance imaging, with clear surgical indications. The exclusion criteria were as follows: patients with an acute subdural hematoma and those who underwent craniotomy.

Surgical procedures and general management

The procedure was as follows: All patients underwent emergency surgery within 24 h of admission. The cranium at the thickest part of the CSDH, usually at the parietal tuber of the skull, was perforated. After a dural incision, a silicon drainage tube (Medtronic) was inserted into the subdural hematoma cavity for drainage (no negative pressure drainage), and irrigation was then performed. Air was replaced with saline after skin suture to prevent recurrence (23).

Routine brain CT scan was performed at 1, 3, 9, and 90 days after the surgery. Recurrence was defined as a patient with CSDH who developed another hematoma in the ipsilateral subdural space within 3 months after the initial surgery and developed symptoms requiring re-surgery.

TEG parameters

The TEG device and reagent were produced by Guizhou Jinjiu Biotech Co., Ltd. The TEG parameters were determined in accordance with the reagent instructions. The normal ranges for each parameter were as follows: R value, 5–10 min; K value, 1–3 min; Angle, 53°–72°; MA value, 50–70 min; CI, –3 to 3; and LY30 value, 0%–8%.

Statistical Analysis

Data were assessed independently by double-person and double-computer enrollment and analyzed using the Statistical Package for the Social Sciences software version 23.0. The means ± standard deviation for quantitative data with a normal distribution and two independent sample *t*-tests were used to compare data between groups. Quantitative data with a non-normal distribution were expressed as medians (interquartile ranges, IQR), and the Mann–Whitney *U* test was used for between-group comparisons. Qualitative data (categorical variables) were expressed as frequency and percentage and were compared using the X^2 test or the Fisher's exact test. Linear regression analysis, logistic regression analysis, and subgroup analysis was performed to evaluate the associations between TEG parameters and CSDH. The differences in these tests were statistically significant with $p<0.05$.

RESULTS

This prospective study included 52 patients. In total, 3 (5.8%) patients were classified under the recurrence group (mean age: 77.0 ± 8.0 years; two men/ratio: 66.4%) and 49 under the non-recurrence group (mean age: 67.2 ± 13.6 years; 37 men/ratio: 75.5%). Table I shows the basic clinical data between the two groups.

Each preoperative TEG parameter was a quantitative variable, normal test against the normal distribution. The Mann–Whitney *U* test was used to compare the association between CSDH recurrence and non-recurrence as well as sex, age, hypertension, diabetes mellitus (DM), smoking and trauma history, R value, K value, Angle, MA, CI, and LY 30 value (Table I). Results showed that R values, history of DM, and mRS score at discharge were significantly associated with recurrence (Table I). Further subgroup analyses showed that an R value ≥ 5 and mRS score ≥ 2 at hospital discharge were associated with recurrence, with p values of 0.025 and 0.005, respectively (Table III). However, linear and logistic regression

Table I: Basic Information of the Patients in Two Groups

Variables	No Recurrence	Recurrence	Total	p-value
No. (%)	49 (94.2)	3 (5.8)	52 (100)	
Sex, n (%)				1.000
Male	37 (75.5)	2 (66.7)	39 (75)	
Female	12 (24.5)	1 (33.3)	13 (25)	
Age in yrs, mean ± SD*	67.2 ± 13.6	77.0 ± 8.0	67.8 ± 13.4	0.225
Age group, yrs, n (%)				0.246
≥75	15 (30.6)	2 (66.7)	17 (32.7)	
<75	34 (69.4)	1 (33.3)	35 (67.3)	
Medical history, n (%)				
Hypertension	14 (28.6)	2 (66.7)	16 (30.8)	0.221
Diabetes	1 (2.0)	2 (66.7)	3 (57.7)	0.007[a]
Antithrombotic use, n (%)				1.000
No	46 (93.9)	3 (100)	52 (100)	
Antiplatelet	2 (4.1)	0 (0)	2 (3.8)	
Warfarin	1 (2.0)	0 (0)	1 (1.9)	
Smoking, n (%)	15 (30.6)	0 (0)	15 (28.8)	0.548
Trauma, n (%)	33 (67.3)	3 (100)	36 (69.2)	0.544
Radiological findings, n (%)				
Preop hematoma width ≥ 20 mm	27 (55.1)	0 (0)	27 (51.9)	0.104
Preop hematoma width, median (IQR)	22.0 (11.0)	16	20.4 (10.8)	0.201
Preop midline shift ≥ 10 mm	16 (32.7)	1 (33.3)	16 (30.8)	1.000
Preop midline shift, median (IQR)	7.0 (6.0)	5.0	7.0 (6.0)	0.453
Multiplicity of hematoma cavity	29 (59.2)	3 (100)	32 (61.5)	0.276
Trabecular type, n (%)	23 (46.9)	1 (33.3)	24 (46.2)	1.000
Side of op, n (%)				0.129
Unilat	39 (79.6)	1 (33.3)	40 (76.9)	
Bilat	10 (20.4)	2 (66.7)	12 (23.1)	
Urokinase Instillation	23 (46.9)	1 (33.3)	24 (46.2)	1.000
Drain insertion, n (%)	49 (100)	3 (100)	52 (100)	
Surgical details (continued)				
No. of hours until drain removal, median (IQR)	40.0 (25.5)	40.0 (25.0)	40.0 (25.5)	0.502
Postop pneumocephalus	17 (34.7)	3 (100)	20 (38.5)	0.052
Preop mRS score, mean ± SD*	2.80 ± 1.21	4.00 ± 0.00	2.87 ± 1.21	0.077
mRS score at discharge, mean ± SD*	0.71 ± 0.94	2.00 ± 0.11	0.79 ± 0.96	**0.013**[a]
GOS score, mean ± SD*	4.90 ± 0.31	4.67 ± 0.58	4.88 ± 0.32	0.228
Preop TEG parameters, mean ± SD*				
R	4.5 ± 2.3	6.0 ± 0.8	4.6 ± 2.3	**0.045**[a]
K	2.2 ± 1.4	2.7 ± 0.9	2.2 ± 1.4	0.199
Angle	62.3 ± 11.8	55.5 ± 6.3	61.9 ± 11.7	0.152
MA	57.3 ± 11.7	57.9 ± 7.1	57.3 ± 11.4	0.969
CI	0.4 ± 3.1	-1.5 ± 1.2	0.3 ± 3.1	0.063
LY30	1.6 ± 7.0	0.03 ± 0.06	1.5 ± 6.8	0.596

** Values are expressed as means ± standard deviations.* ***IQR:*** *interquartile range;* [a] *Significant.*

analyses revealed no significant association between R values and mRS score at discharge, with p values of 0.293 and 0.914, respectively (Tables IV and V). Meanwhile, univariate and multivariate logistic regression analyses revealed that patients with DM who developed CSDH significantly differed from those without DM (p=0.007). Moreover, further univariate logistic analysis (0.010, 95% CI: 0.0004–0.234, p=0.004) and multivariate logistic analysis (0.023, 95% CI: 0.001–0.770, p=0.035) indicated significant differences.

Table II: Complications Observed in the Perioperative Period

Complications	No. of Pts
Acute SDH	1
Acute EDH	2
ICH	0
Seizures	0
Subdural empyema	0
Bacterial infection	0
Viral encephalitis	1
Postop pneumocephalus	20

***SDH:** Subdural hematoma; **EDH:** Epidural hematoma; **pts:** Patients; **ICH:** Intracerebral hemorrhage.*

Further, 52 patients who had a follow-up GOS score and good prognosis were included in the analysis, and there was no significant association between the TEG parameters and prognosis (Table VI). This might be attributed to the combined use of postoperative urokinase treatment and oral atorvastatin (2,11).

Table III: Subgroup Analysis of Recurrence of CSDH

Variables	OR	95% CI	p-value
Age group, yrs			
≥75	1.101	0.917-1.322	0.246
≥70	1.047	0.912-1.201	0.603
R group			
≥5	1.231	0.973-1.557	**0.025** [a]
≥4.5	1.143	0.982-1.329	0.092
Preop hematoma width ≥20 mm	0.880	0.761-1.017	0.104
Preop midline shift ≥10 mm	1.002	0.867-1.157	0.704
mRS score at discharge≥2	0.143	0.072-0.284	**0.005** [a]

***OR:** Odds ratio; **CI:** Confidence interval; [a] Significant.*

Table IV: Univariable and Multivariable Logistic Regression Analysis of the Association between CSDH Recurrence and Various Variables

Variables	Univariate Analysis		Multivariate Analysis	
	OR (95% CI)	p-value	OR (95% CI)	p-value
Age≥75	1.079 (0.955-1.218)	0.223	0.071 (0.0004-11.516)	0.309
Sex (Male)	0.649 (0.054-7.802)	0.733	1.056 (0.019-58.923)	0.979
Diabetes (Yes)	0.010 (0.0004-0.234)	**0.004** [a]	0.023 (0.001-0.770)	**0.035** [a]
R	1.198 (0.855-1.680)	0.293	1.469 (0.769-2.803)	0.244
Preop mRS score	3.077 (0.715-13.230)	0.131	4.808 (0.044-529.884)	0.513
GOS score	0.227 (0.019-2.977)	0.259	0.249 (0.005-11.482)	0.477

***OR:** Odds ratio; **CI:** Confidence interval; [a]Significant.*

Table V: Univariable and Multivariable Linear Regression Analyses of the Association between TEG Parameter R Value and Various Variables

Variables	Univariate Analysis		Multivariate Analysis	
	B (95% CI)	p-value	B (95% CI)	p-value
Age	-0.037 (-0.085-0.011)	0.124	-0.037 (-0.086-0.013)	0.140
Drainage time	0.023 (0.002-0.043)	**0.030** [a]	0.021 (0.001-0.042)	**0.043** [a]
mRS score at discharge	-0.037 (-0.723-0.649)	0.914	0.202 (-0.562-0.965)	0.598
GOS score	0.843 (-1.178-2.864)	0.838	0.508 (-1.725-2.742)	0.649

*B, coefficient from linear regression model; **CI:** Confidence interval; [a] Significant.*

Results revealed a significant association between the secondary outcomes and TEG parameters such as sex (R value, p=0.004); K value, p=0.001), Angle (p=0.009), MA (p=0.016), CI (p=0.0004), hematoma thickness and LY30 value (p=0.039), midline shift and Angle (p=0.043), and multiplicity of the hematoma cavity and MA (p=0.022) (Table VI).

The postoperative TEG parameters were measurement data, and the normality test indicated that the R value, K value, and MA did not have a normal distribution, and Angle and CI had a normal distribution. Differences between the two groups were assessed using the Mann–Whitney U test or t-test. The postoperative TEG parameters were not significantly associated with primary outcomes such as preoperative mRs score, recurrence, and prognosis (Table VI). There was a significant comparison between the secondary outcomes and postoperative TEG parameters such as sex (K value, p=0.001; Angle, p=0.026), multiplicity of the hematoma cavity and LY 30 value (p=0.011), and residual hematoma at follow-up (MA, p=0.001).

In addition, the association between R value, K value, Angle, MA, CI, and LY 30 values before and after surgery was compared. Results showed that the K values and CI significantly differed before and after surgery, with *P* values of 0.028 and 0.049, respectively (Table VII).

Table VI: Relationship between TEG Parameters and the Primary and Secondary Outcome Variables

TEGs Variables	median (IQR)or mean ± SD*	Preop mRS score	Recurrence	mRS score at discharge	GOS score	Sex	Hematoma width	Midline shift	Multiplicity of hematoma	Residual hematoma
Preop R	4.3 (2.3)	0.985	**0.045** [a]	0.798	0.367	**0.004** [a]	0.206	0.738	0.792	0.394
Preop K	1.8 (1.1)	0.208	0.199	0.405	0.639	**0.001** [a]	0.851	0.113	0.511	0.985
Preop Angle	63.9 (14.9)	0.535	0.152	0.508	0.148	**0.009** [a]	0.280	**0.043** [a]	0.836	0.697
Preop MA	58.3 (12.3)	0.255	0.969	0.844	0.875	**0.016** [a]	0.657	0.056	**0.022** [a]	0.420
Preop CI	0.3 (2.9)	0.257	0.063	0.915	0.650	**0.0004** [a]	0.407	0.088	0.202	0.542
Preop LY30	0.0 (0.4)	0.591	0.596	0.444	0.304	0.575	**0.039** [a]	0.990	0.728	0.765
Postop R	4.0 (1.9)	0.373	0.979	0.638	0.198	0.462	0.632	0.783	0.836	0.804
Postop K	1.4 (0.9)	0.468	0.422	0.893	0.244	**0.001** [a]	0.894	0.360	0.467	0.353
Postop Angle	67.5 ± 8.8	0.833	0.703	0.901	0.387	**0.026** [a]	0.448	0.755	0.786	0.105
Postop MA	60.5 (10.7)	0.671	0.317	0.961	0.207	0.110	0.105	0.364	0.386	**0.001** [a]
Postop CI	1.2 ± 2.6	0.898	0.398	0.790	0.615	0.172	0.483	0.820	0.745	0.057
Postop LY30	0.5 ± 0.8	0.837	0.459	0.647	0.789	0.591	0.928	0.231	**0.011** [a]	0.965

**Values are expressed as means ± standard deviations or median (IQR); Mann–Whitney analysis or T-test; [a] Significant.*
***R:** Reaction time, **K:** Clot formation time, **MA:** Maximum amplitude, **CI:** Coagulation index , **LY30:** Lysis at 30 minutes.*
***Additional Notes:** K is also termed Fibrin Polymerization Time in some contexts, emphasizing fibrinogen conversion kinetics*

Table VII: Clinical and Biochemical Data of the Patients in Two Groups Comparison of R, K, Angle, Ma, Ci And LY30 before and after Operation

Variables	Preop TEG parameters, mean ± SD*	Postop TEG parameters, mean ± SD*	Total	p-value
R	4.6 ± 2.3	3.8 ± 2.0	4.2 ± 2.2	0.124
K	2.2 ± 1.4	1.9 ± 1.75	2.1 ± 1.5	**0.028** [a]
Angle	61.9 ± 11.7	66.9 ± 10.4	64.1 ± 11.3	**0.038** [a]
MA	57.3 ± 11.4	57.6 ± 13.6	57.5 ± 12.3	0.339
CI	0.3 ± 3.1	1.4 ± 2.4	0.8 ± 2.8	**0.049** [a]
LY30	1.5 ± 6.8	2.9 ± 15.8	2.2 ± 11.6	0.332

**Values are expressed as means ± standard deviations; [a] Significant.*
***R:** Reaction time, **K:** Clot formation time, **MA:** Maximum amplitude, **CI:** Coagulation index , **LY30:** Lysis at 30 minutes.*

DISCUSSION

The bleeding source, pathogenesis, and factors responsible for CSDH recurrence are not well understood. The formation of mixed hematomas may be related to fibrinolytic factors, as reported in the literature (28). Excessively clogged hematomas are believed to be responsible for relapse and progressive enlargement of CSDH. Previous studies have revealed that coagulation factor XIII (FXII) deficiency may play a pathophysiological role in spontaneous CSDH (22). Excessive fibrinolysis and hyperfibrinolysis were observed in CSDH, and a high expression of fibrinogen degradation products (FDPs) was detected in hematomas, with a decrease in the production of coagulation factors II, V, VII, VII, VIII, IX, X, XI, and XII. As reported in the literature (9), the conventional coagulation test parameters APTT, PT, and INR were associated with CSDH severity. This indicates that coagulation dysfunction can be related to CSDH. TEG is a real-time whole-coagulation test that provides dynamic information about total hemostasis. To evaluate the association between TEG parameters and subdural hematoma, no similar studies have been published. We assessed the impact of preoperative demographic and clinical characteristics, imaging findings, postoperative clinical data, imaging data, and recurrence rate at follow-up and outcomes with respect to TEG parameters and CSDH-related factors. Studies have shown that TEG is a rapid, real-time complete coagulation test that may help to predict the severity of CSDH and assess whether the hematoma is well absorbed.

The incidence rate of CSDH recurrence varies with surgical treatment, ranging from 2.3% to 38.7% (16). The risk of coagulation dysfunction recurrence was doubled (14). Of the 52 patients in this group (excluding those with incomplete data), three presented with recurrence, with a recurrence rate of 5.8%. The low recurrence rate in this group may be attributed to the use of urokinase and atorvastatin (2,11). Results showed that patients with a previous history of diabetes may be more likely to relapse. This is probably because hyperglycemia can increase the anaerobic glycolysis of nerve cells in the ischemic area of compressed brain tissues, and then produce high levels of lactic acid, causing a strong oxidative stress response. By contrast, due to the continuous increase in blood glucose levels, patients can maintain higher blood glucose levels, can increase blood viscosity and oxygen levels during brain metabolism, can cause the accumulation of lactate content in the body, enhance the production of vascular endothelial cells due to acidic conditions, promote capillary permeability, and increase the risk of blood leakage in the outer membrane. By contrast, based on previous studies (6,24), lactate levels can increase the production of MMP-3 and MMP-9, which, in turn, disrupts the blood–brain barrier. MMPs may be involved in the angiogenesis of CSDH, causing recurrence (8). Hyperglycemia is a risk factor of CSDH recurrence, which is consistent with previous studies (3,17,25).

The coagulation reaction time (R) refers to the time from the start of the coagulation system to the start of fibrin clot formation. This reflects the comprehensive effect of coagulation factors and the reserve of coagulation factors. A prolonged R value indicates the lack of coagulation factors, hypocoagulability state, and high bleeding risk. On the contrary, it shows the enhanced activity of coagulation factors, hypercoagulability state, and high thrombotic risk. There was a statistically significant difference in terms of R values between the recurrence and nonrecurrence groups. A subgroup analysis revealed that patients with a R value ≥ 5 had a significantly increased recurrence rate. However, further logistics regression analysis did not show statistically significant results. The final results did not significantly differ, which might be caused by the small sample size. Therefore, large-scale case studies should be performed to further validate the efficacy of R values in predicting CSDH recurrence. The author believes that the consumption of coagulation factors and the formation of hematoma can lead to the development of CSDH. Patients without recurrence have a low R value, and the consumption of coagulation factors leads to the hypercoagulability state of the blood. A subgroup analysis showed that an R value ≥ 5 was a risk factor for recurrence, possibly due to the abnormal consumption process of coagulation factors. This mechanism results in the abnormal consumption mechanism of potential coagulation factors, which ultimately affects CSDH recurrence. Nevertheless, further studies must be confirmed to validate our results. In addition, the long retention time of the drainage tube after CSDH will lead to an increased risk of infection, and there was a statistically significant difference between the R value and drainage time. The preoperative R value could predict the retention time of the drainage tube (Table V).

Previous reports in the literature have revealed that stroke is related to coagulation function in both sexes (19). Notably, the TEG parameters are related to sex, which indicates that sex is also a factor affecting the coagulation mechanism of CSDH. Previous studies have found that the preoperative CSDH severity and prognosis were significantly related to the thickness of hematoma, the degree of midline shift, and the multiplicity of hematoma (7,16,26). If the hematoma is thicker and there is a greater midline shift, the condition is more serious. The preoperative LY 30 value was associated with hematoma thickness, the degree of midline shift and Angle value, and hematoma multiplicity and MA value. This indicated that the TEG parameter might indirectly reflect the severity of CSDH. CSDH and postoperative residual hematoma are a risk factor of recurrence (26), and whether the hematoma can be fully absorbed during follow-up is still challenging to predict. Meanwhile, the postoperative MA value can predict whether the complete absorption of hematomas can be achieved within 3 months after surgery. MA is the maximum strength or hardness of reactive blood clots, mainly reflecting the number and function of platelets. This may indicate that blood clots formed by repeated chronic bleeding in CSDH are more rigid and, therefore, more difficult to absorb. Therefore, more studies with a larger sample size should be performed.

Previous studies have revealed that the parameters related to blood routine and traditional coagulation tests are associated with CSDH (1,4,18). Among them, the neutrophil-to-lymphocyte ratio (NLR), peripheral blood eosinophil levels, and serum FDP upon admission were associated with CSDH relapse. Meanwhile, APTT, PT, and INR were associated with the severity of CSDH (9). In addition, differences in fibrinogen

and D-dimer concentrations were observed in different types of CSDH hematoma fluid. These differences were related to CSDH hematoma density (18). Perioperative may affect the coagulation function has been confirmed (13,21), and whether before and after surgery will affect coagulation function in CSDH patients is unclear. Therefore, the association between the pre- and postoperative R, K, Angle, MA, CI, and LY 30 values was compared. Based on this finding, the K and CI values significantly differed before and after surgery. Hence, the CSDH perioperative coagulation status will change.

Previous research has confirmed that plasminogen activator inhibitor type I (PAI-1) deficiency may cause CSDH recurrence (20). Moreover, PAI-1 deficiency can be treated with oral aminohexanic acid to reduce the recurrence rate. Antifibrinolytic drugs can stop bleeding by inhibiting plasminogen activation and plasmin activity. In clinical cases and retrospective studies (5,10), tranexamic acid, as an antifibrinolytic agent, was an effective treatment for CSDH as it promotes hematoma absorption and reducing relapse. However, it was not effective in the treatment of CSDH in other studies. The author hypothesized that this may be related to the influence of cases. In particular, if there is a greater number of patients with hyperfibrinolysis, the treatment seems effective. However, if the number of patients with hyperfibrinolysis is low, the results may appear invalid. Therefore, patients with coagulation-related abnormalities should be further screened. According to the presence of hyperfibrinolysis, individualized medications may be provided to patients with hyperfibrinolysis to reduce hematoma, reduce recurrence. Meanwhile, patients without hyperfibrinolysis should avoid taking tranexamic acid because antifibrinolytic drugs will increase the incidence of thrombosis. Preoperative CT scan imaging density is correlated with LY 30 values, which can reflect the fibrinolytic state. A high LY 30 value increases hyperfibrinolysis. Therefore, further studies with a larger sample size must be conducted to evaluate the association between TEG and subdural hematoma, which can then provide theoretical support for the use of tranexamic acid in CSDH treatment.

Limitations

The current study had several limitations. First, this was a single-center prospective study, with a small sample size and uneven sample distribution. Hence, some bias might have existed, and the ability to demonstrate statistical significance could have been limited. Second, it is challenging to completely unify the follow-up time. The average follow-up time of this group was 3 months. Third, some patients were lost to follow-up, resulting in incomplete clinical data collection. Therefore, a prospective, multicenter clinical trial with a large sample size should be performed to further explore the association between TEG parameters and CSDH.

CONCLUSION

TEG is a rapid, real-time complete coagulation test, and TEG parameters are associated with the risk of CSDH. Due to the small sample size, whether TEG can predict CSDH recurrence was unclear. However, the preoperative LY 30 value, Angle, and MA values are related to hematoma thickness, midline shift degree, and multiplicity of the hematoma cavity, respectively, which may be an indirect indicator of CSDH severity. MA can be a risk factor for poor hematoma absorption in responsive patients. Moreover, the presence of DM is still a risk factor of CSDH recurrence. Therefore, large-scale case studies should be performed to further validate these findings.

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Declarations

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AUTHORSHIP CONTRIBUTION

Study conception and design: XD, KZ

Data collection: CW, RJ, XDe, JC, CZ

Analysis and interpretation of results: XD, KZ

Draft manuscript preparation: XD, CW, RJ, XDe, JC, CZ

Critical revision of the article: XD, CW, RJ, XDe, JC, CZ, KZ

Other (study supervision, fundings, materials, etc...): XD, CW, RJ, XDe, KZ

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