Elevated Blood Urea Nitrogen are associated with Recurrence of post-operative Chronic Subdural Hematoma

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Abstract

Background: Chronic subdural hematoma (CSDH) is fundamentally treatable with about 2-31% recurrence rate. Recently, there has been renewed interest in the association between Blood Urea Nitrogen (BUN) and intracranial lesion. Therefore, this paper attempts to show the relationship between BUN and CSDH recurrence.

Methods: A total of 653 CSDH cases with Burr-hole Irrigation (BHI) were enrolled from December 2014 to April 2019. The analyzed parameters included age, gender, comorbidities, laboratory investigations, medication use and hematoma location. The cases were divided into recurrence and non-recurrence groups while postoperative BUN concentration was further separated into quartiles (Q1 ≤ 4.0 mmol/L, 4.0 < Q2 ≤ 4.9 mmol/L, 4.9 < Q2 ≤ 6.4 mmol/L, Q4 > 6.4 mmol/L). Restricted cubic spline regressions and logistic regression models were performed to estimate the effect of BUN on CSDH recurrence.

Results: CSDH recurrence was observed in 96 (14.7%) cases. Significant distinctions were found between recurrence and non-recurrence groups in postoperative BUN quartiles of cases (P=0.003). After adjusting for the potential confounders, the odds ratio of recurrence was 3.069 (95%CI =1.488–6.330, p = 0.002) for the highest quartile of BUN compared with the lowest quartile. In multiple-adjusted spline regression, high BUN level visually showed significantly high OR value of recurrence risk.

Conclusions: Elevated BUN at post-operation is significantly associated with the recurrence of CSDH, and it is indicated that high levels of serum BUN after evacuation may be served as a risk factor for CSDH recurrence.

Background

Chronic subdural hematoma (CSDH) is a frequently encountered neurosurgical disorder which is common to the old people. The incidence of CSDH is estimated to be 8.2-17.6 per 100,000 persons per year which increases along with increasing age[1-3]. Burr-hole irrigation (BHI) is most widely used to treat CSDH with a relatively good outcome, but about 2%-31% of patients relapse after the initial operation[1].

Factors found to influence CSDH recurrence have been reported in several studies, including age, Glasgow coma score (GCS), antiplatelet or anticoagulant agents, bilateral hematomas, postoperative pneumocephalus, and other certain relative computed tomography (CT) findings[4-7]. However, the findings about the connection between laboratory investigation and CSDH recurrence is still scarce.

Blood urea nitrogen (BUN) concentration is an easily overlooked investigation. Interestingly, there is a growing amount of literature that recognizes high BUN/creatinine(Cr) as an independent risk factor of poor outcomes in acute ischemic stroke (AIS) patients[8-10]. Furthermore, elevated BUN concentration was revealed to increase in-hospital mortality in AIS patients[11]. These studies indicated that BUN was associated with intracranial disorders. But very little attention has been paid to the relationship between BUN and CSDH recurrence so far.

In this paper, variables associated with CSDH recurrence were investigated, focusing on the postoperative BUN concentrations of patients with CSDH who underwent evacuation at a single facility from 2014 to 2019. The aim of this research was to explore the relationship between serum BUN levels and CSDH recurrence and may provide a new orientation to study the pathophysiology of CSDH.

Methods

Patients and parameters

This study enrolled patients with the diagnosis of CSDH admitted to the First Affiliated Hospital of Wenzhou Medical University, Zhejiang province, China, between December 2014 and April 2019. Patients with CSDH were diagnosed by head magnetic resonance imaging (MRI) and CT. Following exclusive criteria were used:(1) without surgical treatment;(2) younger than 18 years old;(3) severe epilepsy; (4) severe renal or blood diseases;(5) hematoma organized or bad operation result;(6) craniotomy or evacuated by other departments;(7) lack of laboratory investigation;(8) hospital mortality. Patient with twice operations was defined as two cases.

The following clinical characteristics were analyzed: age, gender, demographic parameters, comorbidities, postoperative laboratory investigations, postoperative medication use, location of hematoma, and preoperative BUN level. Glasgow outcome scale (GOS) at discharge was performed to evaluate the neurologic function of patients.

Surgery procedure and follow-up

All patients underwent BHI with general anesthesia. After burr-hole exposure, dura incision and irrigation, we used closed system drainage with a subdural catheter connected to a vacuum plastic bag. Most catheters were withdrawn within 72h after the operation. Head CT was enforced within the first 48 hours and on day 6 or 7 postoperatively. For good measure, patients were followed up with head CT at 3 months at the outpatient service.

Definition of recurrence and grouping

CSDH recurrence was evaluated by radiological criteria, which included an increased volume of the subdural collection and brain compression on either side within 3 months compared with those first measured after surgery through CT scans, and clinical criteria in which preoperative symptoms and signs abided or recurred (Figure 2). The classification of recurrence was rated by two experienced neurosurgeons who were blinded with respect to the study.

At first, the cases were divided into 2 groups according to recurrence and non-recurrence to investigate the risk factors for CSDH recurrence. For the sake of identifying the specific effect of postoperative BUN, it was further divided into quartiles to explore the different influences on the CSDH recurrence in each category. The local ethics committee ruled that no formal ethics approval was required in this particular study.

Statistical analysis

Data for continuous variables were showed as mean ± standard deviation or medians and interquartile range. To verify whether the data follows a normal distribution or not, Kolmogorov-Smirnov test was enforced. Categorical variables were showed as relative frequencies and percentages. Normally distributed variables were compared by Student's t-test, wheras the Mann–Whitney U test used for the asymmetrically distributed continuous variables. χ^2 test was used to compare categorical variables. Statistical comparisons among BUN concentrations stratification were estimated by one-way analysis of variance (ANOVA) or Kruskal–Wallis test for continuous variables, and Pearson's chi-square test for categorical variables where appropriate. Wilcoxon signed-rank test was performed to compare the difference between pre and post-operative BUN levels. Odds ratio (OR) and 95% confidence interval (CI) for recurrence risk were calculated by performing multivariate-adjusted binary logistic regression. Restricted cubic spline regressions model was built to examine the linear relation between serum BUN concentration and the risk of recurrence. In this study, a two-tailed *p*-value less than 0.05 ($P< 0.05$) was considered as statistical significance. All statistical analyses were implemented using SPSS (version 23.0, IBM Corp.) and STATA software (version 12, StataCorp LP) was performed to analyze the restricted cubic spline regressions.

Results

Baseline characteristics of all cases in the recurrence group and Non-recurrence group

A total of 653 CSDH cases were enrolled in this study at last (Figure 1). This study group included 561 male cases (85.9%) and 92 female cases (14.1%). Patient’s age ranged from 21 to 100 years with a median of 72 years (interquartile range 64 to 80 years). (Table 1). 8 patients with hospitalized mortality were excluded and there was no mortality at following up in this study.

The descriptive characteristics between groups with and without recurrence are exhibited in Table 1, including the demographics, laboratory, imaging, medication and comorbidity characteristics. In this study, 96 (14.7%) cases were diagnosed as CSDH recurrence, including 16 patients who needed a second operation. Compared with non-recurrence, the cases in the group of recurrence were more likely to be older and have lower level of serum leukocyte, neutrophil and platelet counts. In the meanwhile, lower serum fibrinogen concentration was examined in recurrence cases ($p<0.05$). Moreover, there was a statistical difference exhibited for serum BUN concentration of both pre and post-operation between two groups ($p=0.001$ and $p<0.001$,respectively). Table 2 revealed that the BUN level of preoperation was significantly higher than the postoperative BUN level in the non-recurrence group ($p<0.001$) while it showed no obvious difference in the recurrence group.

Baseline characteristics of all cases in BUN quartiles

For further exploration, the cases were divided into 4 groups on the basis of quartiles of the postoperative BUN concentration. The cut-off points for this stratification of the BUN concentration into quartiles were:

Q1 ≤ 4.0 mmol/L, 4.0 < Q2 ≤ 4.9 mmol/L, 4.9 < Q2 ≤ 6.4 mmol/L and Q4 > 6.4 mmol/L. Table 3 summarized the characteristics of the CSDH cases by the quartiles of BUN. Cases with different postoperative BUN concentration appeared to be similar in most features except for age, Cr, erythrocyte and hemoglobin. These factors would be adjusted for multivariate-adjusted binary logistic regression for good measure. 22 (14%) of 157 patients in the highest quartile of BUN suffered moderate disability at discharge which was statistically higher than in other quartiles.

Association between the BUN concentrations and recurrence

Significant differences were got between the recurrence and non-recurrence groups in BUN concentration quartiles of cases (P = 0.003). The proportion of cases in the lowest quartile (≤4.0 mmol/L) was dramatically low in the recurrence group (P = 0.027), whilst the proportion of cases in the highest quartile (>6.4 mmol/L) was significantly high in the recurrence group (P = 0.012) (Table 4).

In Table 5, with all cases taken as a whole, the condition that CSDH recurrence was interpreted as a dependent variable and the lowest quartile was interpreted as the reference was used for postoperative BUN level in the binary logistic regression models. The highest quartile of BUN concentration (>6.4 mmol/L) was independently estimated as a risk factor of CSDH recurrence with an unadjusted OR of 3.315 (95%CI:1.711–6.423, p<0.001). After adjusting for the confounders including sex, age, current alcohol drinking, current smoking, comorbidities (hypertension, diabetes mellitus, coronary heart disease), medicine (Atorvastatin and PAMBA),and laboratory investigation (platelet, fibrinogen, leukocyte, erythrocyte, hemoglobin, Cr), the highest quartile of BUN remained significantly and independently associated with CSDH recurrence (model 1: OR=2.892, 95% CI:1.463–5.717, p=0.002; model 2: OR=2.939, 95% CI:1.480–5.836, p=0.002; modal 3: OR=3.069, 95%CI:1.488–6.330, p=0.002). There was no multicollinearity between the independent variables in model 3. Furthermore, restricted cubic spline regressions were used to explore the linear relationship between BUN concentration and the risk of CSDH recurrence (Figure 3). Most importantly, it could be observed visually that the highest quartile had significantly high OR value.

Discussion

To the best of our knowledge, this is the first study to investigate the association between BUN concentration and the recurrence of CSDH after evacuation. Our results indicated that high postoperative BUN concentration was related to the prevalence of CSDH recurrence within 3 months after operation. Therefore, our findings revealed the postoperative BUN concentration could be an available risk factor for CSDH recurrence.

BUN is a waste product of protein catabolism which has been found to be linked with poor outcome and mortality in acute or chronic heart failure[12]. In addition, a study of 3355 AIS patients by You et al observed that higher BUN had a 3.75-fold higher risk of in-hospital mortality[11]. In the present study, we found that patients with relative higher level of BUN were more likely to be moderate disabled at discharge. It was consistent with the previous studies that elevated BUN level during hospitalization was

related to poor outcome. In reviewing the literature, little data was found on the relationship between BUN and recurrence of CSDH. In this study, we observed that cases with a higher BUN level presented a trend toward a higher recurrence rate of CSDH. Furthermore, elevated BUN was significantly in accord with an enhancive risk of CSDH recurrence and cases with highest postoperative BUN (>6.4 mmol/L) seemed to have a 3.069-fold increase in danger of CSDH recurrence exactly after adjusting for the potential confounders. The normal range of BUN level in the research hospital is 2.8-7.2 mmol/L which means the majority of patients presented with BUN level in the normal range. The BUN levels reflected not only the renal function but also other reactions that were mentioned below. In this study, the Cr level was found to have nothing to do with the recurrence of CSDH which meaned there was no direct association between renal function and CSDH recurrence. The cutoff value of the postoperative BUN level in this study is 6.4 mmol/L and it indicated that the normal range of BUN level for intracranial lesion might be different from systematic level. Furthermore, elevated preoperative BUN level also showed association with the recurrence of CSDH after logistic regression (supplemental table). With the comparison between pre and post-operative BUN level, we found that the BUN of patients in the non-recurrence group significantly decreased after evacuation while it did not occur in the recurrence group. It further confirmed the relationship between BUN and CSDH recurrence.

The precise mechanisms underlying the association between elevated BUN and CSDH recurrence remained unclear. A potential explanation for this might be that a systemic increase in serum BUN induces intracranial multiple responses, which in turn can produce hematoma expansion and bring out CSDH recurrence. Some studies have revealed that the predictive value of BUN may be induced by its connection with other variables, such as protein intake, protein catabolism, nitrogen production and neurohormonal activation[12, 13]. On the other hand, CSDH was recently suggested to be formatted through complex processes including angiogenesis, fibrinolysis and inflammation[14], and the recurrence of CSDH follows the same process as formation. Strong evidence has been provided that vascular endothelial growth factor (VEGF) was related to the generation and steady increase of CSDH fluid volume[15-17] as well as the risk of CSDH recurrence[18]. Interestingly, Lin et al observed VEGF expression was positively correlated with BUN[19]. These discoveries might explain the relatively good correlation between elevated BUN and CSDH recurrence.

Compared with CSDH cases without recurrence, our result also showed that CSDH cases with recurrence had significantly high age, which is consistent with the reports of previous studies[7, 20]. However, we found that the older cases were associated with higher BUN and the difference of patient age was not statistically significant after multivariate logistic regression analysis . It is indicated that age affects the recurrence of CSDH through the change of BUN.

In addition, decreased fibrinogen level was found to be associated with the CSDH recurrence. In fact, fibrinogen has been proven to be a potentially available risk factor for postoperative intracranial bleeding[21, 22]. Elevating serum fibrinogen was considered as a valid therapy for intracranial hemorrhage[23]. Moreover, high levels of fibrinogen degradation products (FDPs) have been examined in CSDH fluid[24, 25] and fresh red cells were clearly identified within CSDH fluid[24], suggesting that

bleeding is an essential part of CSDH formation. On the other hand, this study did not reveal significant difference between postoperative atorvastatin use and CSDH recurrence, which is contrary to existing studies[26, 27]. The relationship between atorvastatin administration and CSDH recurrence is still puzzling.

There were also some limitations recognized in the present study. Firstly, this study is a retrospective study and the selection bias is inevitable. Secondly, this is only a single-center clinical finding, which may impact the generalization of the results, thus a further prospective research with planty of patients might be required. Finally, considering that the role BUN plays in the CSDH recurrence is still confusing, more studies need to be pursued to further and better delineate CSDH formation in the future.

Conclusion

The most obvious finding to emerge from this study was that elevated BUN at post-operation was independently associated with the recurrence of CSDH. The result suggested that high level of postoperative BUN might be served as a risk factor of CSDH recurrence, so the determination of serum BUN after evacuation is important for patients with CSDH. Further prospective studies need to be undertakn in order to validate the causal relationship between BUN and CSDH recurrence.

Abbreviations

CSDH: chronic subdural hematoma; BUN: Blood Urea Nitrogen; BHI: burr-hole irrigation; GCS: glasgow coma score; CT: computed tomography; MRI: magnetic resonance imaging; AIS: acute ischemic stroke ; GOS: Glosgow Outcom Scale;ANOVA: analysis of variance; OR: odds ratio; CI: confidence interval; Cr: creatinine; PAMBA: para-aminomethylbenzoic acid; SBP: systolic blood pressure; DBP: diastolic blood pressure; INR: international normalized ratio; VEGF: vascular endothelial growth factor; FDPs: fibrinogen degradation products.

Declarations

Ethical approval and consent to participate

The ethics committee of Wenzhou Medical University First Affiliated Hospital ruled that no formal ethics approval was required in this retrospective study and determined that informed consent was not required.

Consent to publish

Not applicable.

Availability of data and materials

The datasets used and analysed during the current study are available in supported additional file 4 and the confidential patient data was erased.

Competing interests

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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Authors' contributions

NW, JH and AO wrote the manuscript. AO revised the manuscript. NW performed the statistical analyses. NW, XZ and YL gathered the data and are responsible for the integrity of registered data. LR, JY and QZ designed and coordinated the study. SY contributed to the analysis and interpretation of data. All authors read and approved the submitted version.

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Tables

Table 1

Clinical and Demographic Characteristics of Patients With and Without Recurrence of CSDHs after initial evacuation.

Variables	All patients (N=653)	Recurrence (n=96)	Non-Recurrence (n=557)	*p*-value
Postoperative BUN (mmol/L)	4.9 (4,6.4)	5.9 (4.4,6.9)	4.9 (3.9,6.3)	<0.001
Demographic parameters				
Age (years)	72 (64,80)	75 (69,82)	71 (63,80)	0.012
Gender				0.263
Male, n (%)	561 (85.9%)	86 (89.6%)	475 (85.3%)	
Female, n (%)	92 (14.1%)	10 (10.4%)	82 (14.7%)	
Current drinking, n (%)	234 (35.8%)	34 (35.4%)	200 (35.9%)	0.926
Current smoking, n (%)	237 (36.3%)	33 (34.4%)	204 (36.6%)	0.672
Baseline SBP (mmHg)	138 (126,153)	135 (124,151)	140 (127,153)	0.122
Baseline DBP (mmHg)	79 (71,87)	77 (71,84)	79 (71,87)	0.091
Laboratory investigation				
Blood glucose (mmol/L)	5.5 (4.7,6.6)	5.7 (5,6.7)	5.4 (4.7,6.6)	0.265
Cr (μmol/L)	67 (58,77)	68 (60,80)	66 (57,77)	0.097
Leukocyte (X10^9/L)	6.94 (5.81,8.43)	6.51 (5.52,7.55)	7.01 (5.85,8.62)	0.010
Neutrophil (X10^9/L)	4.62 (3.68,6.15)	4.30 (3.51,5.31)	4.70 (3.71,6.26)	0.012
Lymphocyte (X10^9/L)	1.46 (1.10,1.81)	1.46 (1.17,1.83)	1.47 (1.1,1.81)	0.650
Erythrocyte (X10^12/L)	4.23 ± 0.51	4.19 ± 0.52	4.24 ± 0.51	0.379
Hemoglobin (g/L)	132 (120,142)	132 (119,142)	132 (119,140)	0.442
Platelet (X10^9/L)	211 (172,249)	194 (164,239)	213 (175,251)	0.010
Prothrombin Time(s)	13.3 (12.8,13.9)	13.4 (12.8,14.0)	13.3 (12.8,13.9)	0.642
INR	1.02 (0.97,1.08)	1.02 (0.98,1.10)	1.02 (0.97,1.07)	0.719
Fibrinogen (g/L)	3.61 (3.09,4.28)	3.50 (2.89,4.15)	3.64 (3.15,4.30)	0.046
Comorbidities				

Hypertension, n (%)	252 (38.6%)	40 (41.7%)	212 (38.1%)	0.503
Diabetes mellitus, n (%)	77 (11.8%)	11 (11.5%)	66 (11.8%)	0.913
Cardiovascular disease, n (%)	42 (6.4%)	6 (6.3%)	36 (6.5%)	0.937
Medication use				
Atorvastatin therapy, n (%)	478 (73.2%)	74 (77.1%)	404 (72.5%)	0.352
PAMBA therapy, n (%)	189 (28.9%)	26 (27.1%)	163 (29.3%)	0.663
Hematoma location				0.957
Unilateral left, n (%)	288 (44.1%)	42 (43.8%)	246 (44.2%)	
Unilateral right, n (%)	216 (33.1%)	31 (32.3%)	185 (33.2%)	
Bilateral, n (%)	149 (22.8%)	23 (24.0%)	126 (22.6%)	
Postoperative bleeding	136 (20.8%)	22 (22.9%)	114 (20.5%)	0.585
GOS at discharge				0.549
5, n (%)	593 (90.8%)	90 (93.8%)	503 (90.3%)	
4, n (%)	48 (7.4%)	5 (5.2%)	43 (7.7%)	
3, n (%)	12 (1.8%)	1 (1.0%)	11 (2.0%)	
Preoperative investigation	N=632	n=95	n=537	
BUN (mmol/L)	5.3 (4.4,6.5)	5.9 (4.8,6.9)	5.2 (4.3,6.4)	0.001

NOTE. SBP, systolic blood pressure; DBP, diastolic blood pressure; Cr, creatinine; INR, international normalized ratio; PAMBA, para-aminomethylbenzoic acid; BUN, blood urea nitrogen; GOS, Glasgow Outcome Scale.

Table 2

The comparison between pre- and post-operative BUN level.

Variable	Preoperative BUN (mmol/L)	Postoperative BUN (mmol/L)	*p*-value
Total (n=632)	5.3 (4.4,6.5)	4.9 (4.0,6.4)	<0.001
Recurrence (n=95)	5.9 (4.8,6.9)	5.85 (4.4,6.9)	0.177
Non-Recurrence (n=537)	5.2 (44.3,6.4)	4.9 (3.9,6.25)	<0.001

BUN, blood urea nitrogen;

Table 3

Baseline Characteristics of Patients with Chronic Subdural Hematoma according to postoperative BUN quartile.

Variables	BUN quartiles				
	quartile 1 n=170（≤4.0）	quartile 2 n=162 （>4.0,≤4.9）	quartile 3 n=164 （>4.9,≤6.4）	quartile 4 n=157（>6.4)	*P*-value
BUN (mmol/L)	3.4 (3.0,3.7)	4.5 (4.3,4.8)	5.7 (5.3,6.0)	7.4 (6.9,8.3)	<0.001
Demographic parameters					
Age (years)	68 (61,76)	72 (63,79)	73 (66,82)	76 (69,83)	<0.001
Gender, male, n (%)	140 (82.4%)	148 (91.4%)	141 (86.0%)	132 (84.1%)	0.103
Current drinking, n (%)	61 (35.9%)	62 (38.3%)	58 (35.4%)	53 (33.8%)	0.866
Current smoking, n (%)	68 (39.4%)	56 (34.6%)	63 (38.4%)	51 (32.5%)	0.526
Baseline SBP (mmHg)	138.4 ± 19.4	139.3 ± 19.7	141.0 ± 20.6	142.5 ± 21.0	0.274
Baseline DBP (mmHg)	79 (71,87)	79 (73,86)	77 (72,88)	78 (71,87)	0.984
Laboratory investigation					
Blood glucose （mmol/L)	5.5 (4.8,6.5)	5.6 (4.7,6.6)	5.6 (4.7,6.8)	5.4 (4.5,6.7)	0.818
Cr (μmol/L)	60 (54,68)	66 (57,75)	69 (60,80)	74 (63,87)	<0.001
Leukocyte (X10^9/L)	7.00 (6.14,8.45)	6.97 (5.81,8.62)	6.98 (5.73,8.33)	6.77 (5.55,8.39)	0.677
Neutrophil (X10^9/L)	4.78 (3.84,6.31)	4.68 (3.76,6.30)	4.52 (3.59,5.92)	4.52 (3.60,5.95)	0.369
Lymphocyte (X10^9/L)	1.50 (1.10,1.80)	1.40 (1.10,1.71)	1.50 (1.11,1.87)	1.45 (1.10,1.81)	0.518
Erythrocyte (X10^12/L)	4.30 ± 0.51	4.27 ± 0.50	4.24 ± 0.52	4.12 ± 0.52	0.008
Hemoglobin (g/L)	133 (120,144)	133 (123,142)	132 (120,144)	130 (116,139)	0.047
Platelet (X10^9/L)	219 (174,259)	206 (175,250)	203 (175,243)	201 (162,249)	0.183
Prothrombin Time (s)	13.3 (12.7,13.8)	13.2 (12.9,13.9)	13.4 (12.9,13.9)	13.4 (12.9,14.1)	0.523
INR	1.02 (0.97,1.07)	1.02 (0.97,1.08)	1.03 (0.97,1.08)	1.03 (0.97,1.10)	0.484

Fibrinogen (g/L)	3.55 (3.11,4.38)	3.71 (3.10,4.35)	3.61 (2.97,4.18)	3.67 (3.12,4.26)	0.740
Comorbidities					
Hypertension, n (%)	61 (35.9%)	61 (37.7%)	60 (36.6%)	70 (44.6%)	0.355
Diabetes mellitus, n (%)	18 (10.6%)	18 (11.1%)	17 (10.4%)	24 (15.3%)	0.480
Cardiovascular disease, n (%)	9 (5.3%)	10 (6.2%)	11 (6.7%)	12 (7.6%)	0.853
Medication use					
Atorvastatin therapy, n (%)	124 (72.9%)	118 (72.8%)	114 (69.5%)	122 (77.7%)	0.427
PAMBA therapy, n (%)	40 (23.5%)	45 (27.8%)	53 (32.3%)	51 (32.5%)	0.222
Hematoma location					0.367
Unilateral left, n (%)	68 (40.0%)	82 (50.6%)	75 (45.7%)	63 (40.1%)	
Unilateral right, n (%)	62 (36.5%)	48 (29.6%)	55 (33.5%)	51 (32.5%)	
Bilateral, n (%)	40 (23.5%)	32 (19.8%)	34 (20.7%)	43 (27.4%)	
GOS at discharge					0.042
5, n (%)	160 (94.1%)	149 (92.0%)	152 (92.7%)	132 (84.1%)	
4, n (%)	8 (4.7%)	10 (6.2%)	8 (4.9%)	22 (14%)	
3, n (%)	2 (1.2%)	3 (1.9%)	4 (2.4%)	3 (1.9%)	

NOTE. SBP, systolic blood pressure; DBP, diastolic blood pressure; Cr, creatinine; INR, international normalized ratio; PAMBA, para-aminomethylbenzoic acid; BUN, blood urea nitrogen; GOS, Glasgow Outcome Scale.

Table 4

BUN quartiles of patients.

Variable	Recurrence (n=96)	Non-Recurrence (n=557)	c^2	*p*-value
BUN (mmol/L)			14.308	0.003
Quartile 1（≤4.0）	14 (14.6%)	156 (28.0%)	4.870	0.027
Quartile 2（>4.0,≤4.9）	22 (22.9%)	140 (25.1%)	0.132	0.717
Quartile 3（>4.9,≤6.4）	24 (25.0%)	140 (25.1%)	0.000	0.983
Quartile 4（>6.4)	36 (37.5%)	121 (21.7%)	6.283	0.012

BUN, blood urea nitrogen;

Table 5

Multivariate adjusted odds ratios for the association between BUN levels and Recurrence.

	Quartile	OR[a]	95%CI	*p*-value
Unadjusted	Middle	1.751	0.863-3.554	0.121
	Higher	1.910	0.951-3.837	0.069
	Highest	3.315	1.711-6.423	<0.001
Model 1[b]	Middle	1.590	0.778-3.252	0.204
	Higher	1.713	0.842-3.483	0.137
	Highest	2.892	1.463-5.717	0.002
Model 2[c]	Middle	1.612	0.788-3.299	0.191
	Higher	1.768	0.866-3.611	0.118
	Highest	2.939	1.480-5.836	0.002
Model 3[d]	Middle	1.612	0.780-3.333	0.197
	Higher	1.733	0.837-3.590	0.139
	Highest	3.069	1.488-6.330	0.002

OR, odds radio; CI confidence level; Cr, creatinine; Recurrence of postoperative CSDH.

[a] Reference OR (1.000) is the lowest quartile of BUN for Recurrence of CSDH.

[b] Model 1: adjusted for age, sex, current smoking, current alcohol drinking.

[c] Modal 2: adjusted for covariates from Model 1 and further adjusted for medical history (coronary heart disease, diabetes mellitus, hypertension)and medicine(Atorvastatin and PAMBA)

[d] Modal 3: adjusted for covariates from Model 2 and further adjusted for Platelet, Fibrinogen, Leukocyte, Erythrocyte, Hemoglobin, Cr.

Figures

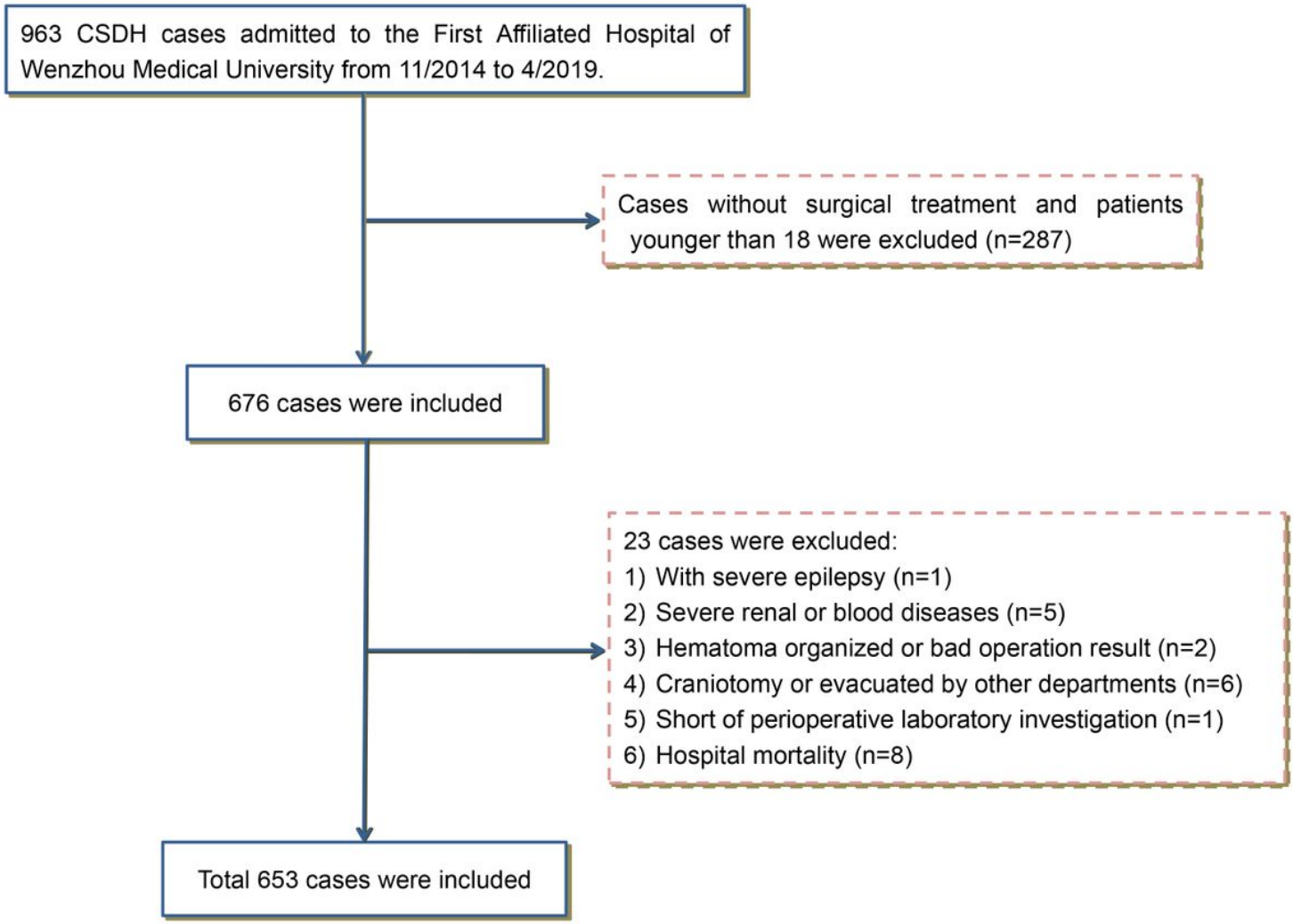

Figure 1

Study flow diagram. CSDH, chronic subdural hematoma.

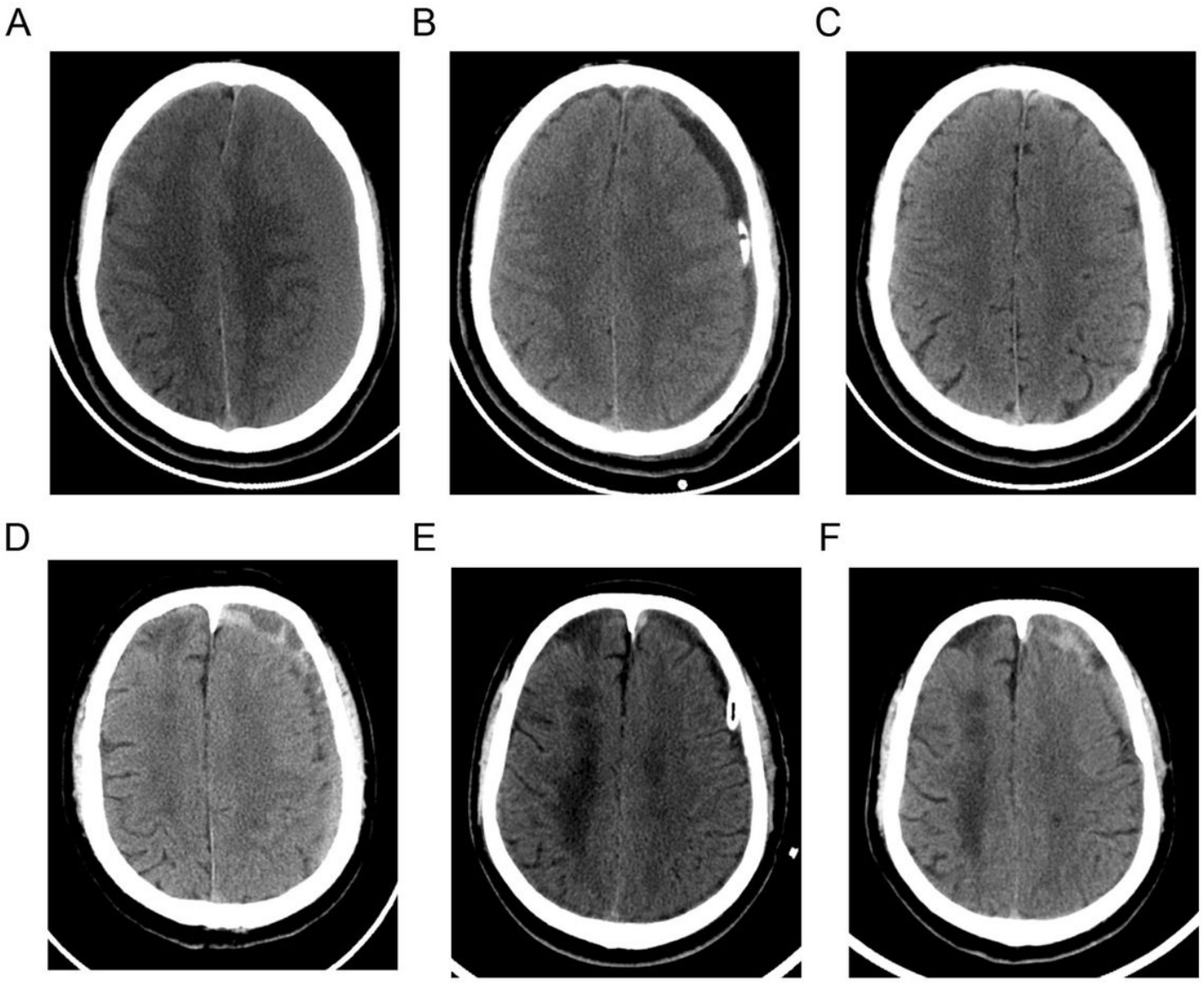

Figure 2

CT imagings of two typical patients without and with recurrence of CSDH. A, the preoperative presentation of patient A without recurrence; B, the imaging of the same patient within 48 hours postoperatively; C, the CT scan at 3-month follow-up of the patient A; D, the presurgical imaging of patient B with recurrence of CSDH; E, the presentation of patient B within 48 hours postoperatively; F, the CT scan of patient B at 2 months after operation, a significant increase volume of subdural collection could be seen in left side.

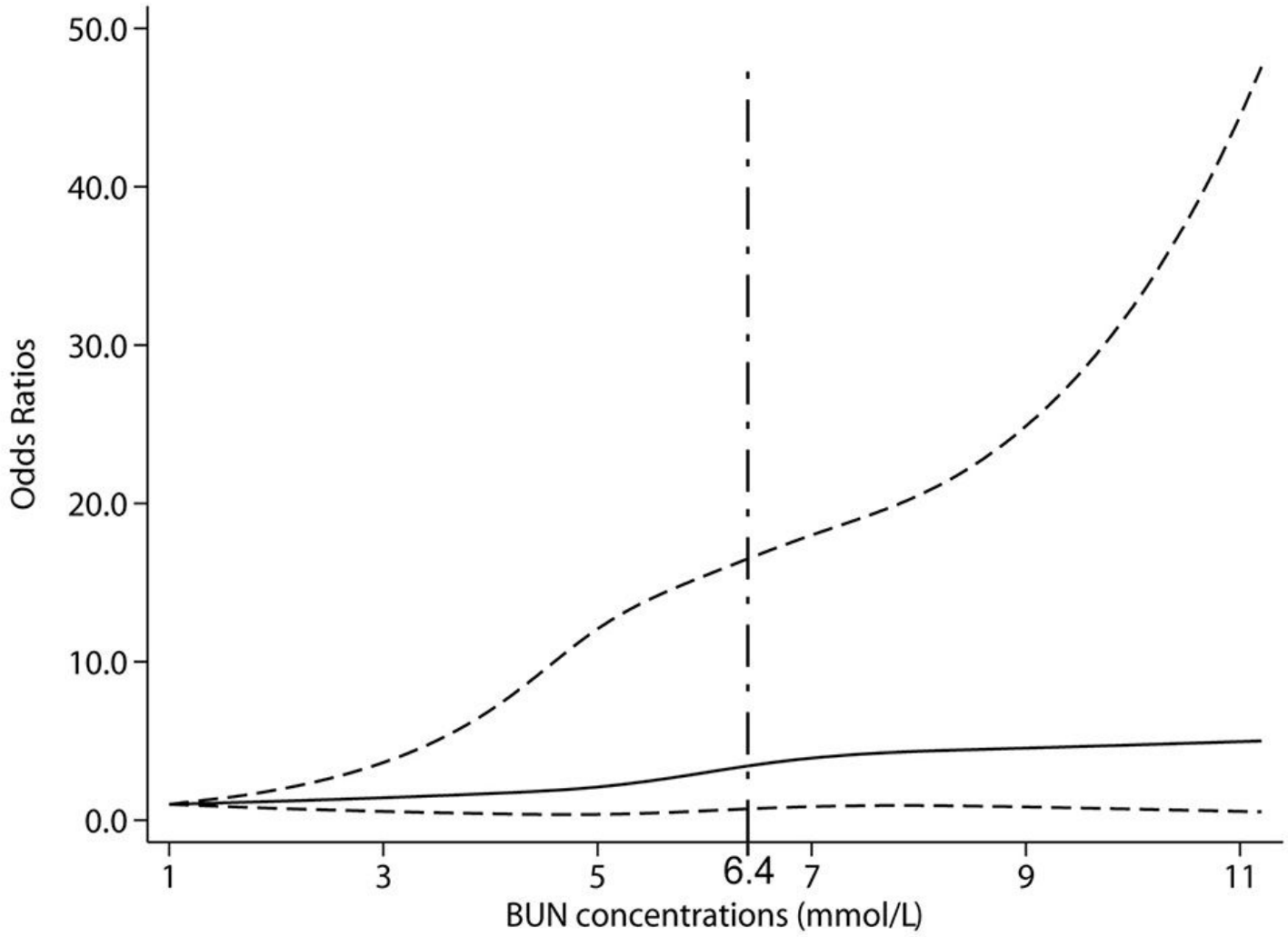

Figure 3

Association of BUN levels with risk of Recurrence. Dashed lines are 95% confidence intervals. Dotted line is where BUN concentration is 6.4 mmol/L. Odds ratios and 95% confidence intervals derived from restricted cubic spline regression. Odds ratios were estimated using logistic regression modeling, adjusting for the same variables as model 3 in Table 5.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- supplementaltable.docx
- completedataset.xlsx