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ORIGINAL RESEARCH

Controlled Nutritional Status Score and Prognostic Nutritional Index for the Prediction of Postoperative Subdural Hematoma

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Objective: To evaluate the predictive value of the prognostic nutritional index (PNI) and controlled nutritional status score (CONUT) on the neurological outcomes of patients with chronic subdural hematoma (CSDH) following burr-hole drainage.
Methods: A retrospective analysis of patients with CSDH was conducted. The CONUT and PNI values and the modified Rankin scale (mRS) scores were calculated based on the patients' conditions at the time of hospital discharge. The poor prognosis was defined as an mRS score of 3. Receiver operating characteristic (ROC) curves were plotted to evaluate the predictive value of CONUT and PNI for the postoperative prognosis of CSDH. Nutritional risk was defined using established cutoffs: PNI < 45 and CONUT ≥ 2.
Results: In 205 patients with CSDH, 17 patients (8.3%) had a poor prognosis. On ROC curve analysis, the area under the curve (AUC) for the CONUT in predicting poor prognosis of CSDH was 0.719 (95% Confidence Interval [CI]: 0.5867–0.8523, P=0.002). The AUC for the PNI and combined CONUT and PNI were 0.803 (95% CI: 0.7031–0.9042, P<0.001) and 0.805 (95% CI: 0.7039–0.9059, P<0.001), respectively. Moreover, multivariate logistic regression analysis showed that CONUT (OR=1.485, 95% CI: 1.096–2.011) and PNI (OR=0.850, 95% CI: 0.763–0.947) were independent risk factors for poor prognosis of CSDH following surgical intervention, after adjusting for age, hypertension, and pre-discharge intracranial fluid volume.
Conclusion: The combined score of PNI and CONUT displayed higher sensitivity and specificity, compared to PNI or CONUT alone. Therefore, the combined score might be useful in predicting the prognosis of CSDH.
Keywords: chronic subdural hematoma, controlling nutritional status score, prognostic nutritional index, nutritional status

Introduction

Chronic subdural hematoma (CSDH) is a common condition where there is a collection of blood between the dura mater and the arachnoid membrane.[1,2] Unlike acute subdural hematomas, which occur shortly after a traumatic brain injury, CSDHs have a slow onset and are often detected after manifestation of neurological symptoms, such as dizziness and tinnitus, memory loss, headache, nausea, and vomiting. The persistent hematoma compresses the brain tissue, leading to necrosis and neurological dysfunction. This can cause limitations in limb movement, cognitive impairment, speech confusion, and memory loss.[3,4]

Surgical treatments for CSDH include puncture drainage, craniotomy for hematoma removal, burr-hole drainage, and endoscopic-assisted drilling drainage. Compared to craniotomy, drilling and drainage methods are often preferred due to their less invasive nature.[5,6] A burr hole drainage is the most frequently used surgery for CSDH. Organized chronic subdural hematoma (OCSDH) is a rare form of chronic CSDH. While typical CSDHs are effectively treated with burr hole trephination and hematoma drainage, OCSH usually requires craniotomy and membranectomy, as it is not responsive to burr hole drainage.[7–9] CSDH predominantly occurs in middle-aged and elderly patients, who are also at risk of malnutrition from neurological conditions like stroke, traumatic brain injuries, and intracranial tumors. Good

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nutrition is essential for healing, reducing complications, and improving outcomes after surgery. The patient's nutritional status plays an important role in their overall surgical response and prognosis after surgery for CSDH.[10–12]

The controlled nutritional status score (CONUT) is an indicator of malnutrition, which is calculated based on three key clinical indicators, 1) Serum albumin levels: Albumin is a protein produced by the liver, and low levels often indicate poor nutritional status, liver disease, or inflammation. It's a key marker for assessing protein nutrition; 2) Total lymphocyte count (TLC): Lymphocytes are a type of white blood cell involved in the immune response. A low count can indicate malnutrition or weakened immunity affecting recovery and susceptibility to infection; 3) Total cholesterol levels: Cholesterol levels can provide insight into overall nutritional health. Low cholesterol levels are often associated with malnutrition or illness.[13] CONUT is used as a prognostic marker in various medical conditions, including malignant tumors within specific elderly populations.[14,15] The Prognostic Nutritional Index (PNI) is another widely used tool to assess nutritional status and predict outcomes in patients, particularly in relation to surgery, chronic diseases, and conditions where malnutrition can significantly affect prognosis. The PNI reflects nutritional and inflammatory status in patients undergoing gastrointestinal surgery; it is calculated based on serum albumin concentration and peripheral blood lymphocyte count. The PNI has demonstrated prognostic value in patients with stroke, head and neck tumors, and breast cancer.[16–18] Both the CONUT and PNI eliminate the influence of subjective factors because they are based on objective measurements, providing an accurate reflection of the nutritional status of patients.

CSDH is frequently seen in elderly patients, who are often at risk for nutritional deficiencies. The potential nutritional risk may significantly influence the clinical outcomes of elderly patients with CSDH.[19] While CONUT and PNI have been studied in various medical conditions to predict prognosis, nutritional status, and outcomes, their role in predicting the prognosis or recurrence of CSDH has not been thoroughly explored. Therefore, this study aims to evaluate the nutritional risk in CSDH patients using CONUT and PNI and to predict the prognosis of CSDH following surgical intervention.

Methods

Study Design and Patients

This retrospective study analyzes the clinical data from patients diagnosed with CSDH. These patients were admitted to the neurosurgery department of Affiliated Hospital of Chengde Medical University hospital between December 2017 and December 2022 and underwent surgical treatment. The inclusion criteria were as follows. 1) Patients aged 18 years or older; 2) Patients who had a clear diagnosis of CSDH by CT scan; 3) Patients who underwent burr-hole drainage as their initial surgical procedures; 4) Patients with complete clinical data; and 5) Patients who received necessary follow-up care after hospital discharge. The exclusion criteria were as follows: 1) Patients who had received transfusions of blood products, including whole blood, RBCs, plasma, and albumin before hospital admission; 2) Patients with concurrent infectious diseases; 3) Patients with chronic diseases, including cirrhosis of the liver, hyperlipidemia, and anemia; 4) Patients with a previous history of craniotomy; 5) Patients who had psychiatric and psychological disorders concurrently; and 6) Patients with incomplete clinical data or who failed to follow-up.

Patients identified as at risk of malnutrition received individualized nutritional guidance. Personalized nutrition treatment plans were developed by a registered dietitian, incorporating high-protein dietary recommendations and, when indicated, enteral nutrition support. Nutritional interventions were tailored based on the patient's clinical condition, nutritional risk score, and tolerance to oral intake.

This study was conducted in accordance with the ethical principles of the Declaration of Helsinki and its later amendments. It was approved by the Ethics Committee of the Affiliated Hospital of Chengde Medical University. The requirement for informed consent was waived due to the retrospective nature of the data analysis. All patient data were anonymized and handled with strict confidentiality in compliance with institutional and data protection guidelines to ensure the privacy and rights of all individuals involved.

Data Collection

Data was collected regarding the patient's age, sex, height, weight, smoking history, drinking history, and medical history, including any illnesses, such as hypertension and diabetes. Information on the use of lipid-lowering, anticoagulant, and antiplatelet medications was also gathered. Additionally, preoperative laboratory values were retrieved, including serum albumin (ALB), hemoglobin (HB), blood glucose levels, peripheral lymphocyte counts, neutrophil counts, total cholesterol, triglyceride levels, percentage of peripheral mononuclear cells, and fibrinogen levels. Details about the hematoma were also documented, including its location, volume, density, width, midline shift, subdural space, and the amount of intracranial fluid and pneumoperitoneum present before discharge. Intracranial fluid volume refers to the volume of intracranial fluid (eg, residual hematoma, cerebrospinal fluid, or other fluid collections) present in the brain after the surgical procedure to evacuate the CSDH before the hospital discharge.

Prognostic Score

Patients were assessed using the modified Rankin scale (mRS) at hospital discharge, and their prognosis was categorized based on their mRS scores. The classifications were as follows. 0: completely asymptomatic; 1: symptomatic but not functionally impaired; 2: mildly handicapped, able to care for themselves but with some limitations; 3: moderately handicapped, unable to fully care for themselves but able to walk independently; 4: severely handicapped and unable to walk independently; 5: bedridden; and 6: diseased.[20] Based on the mRS at discharge, patients were divided into two groups: a poor prognosis group (mRS of ≥3) and a good prognosis group (mRS of <3).

CONUT Calculation

The CONUT was determined based on three parameters: preoperative ALB (g/L), peripheral blood lymphocyte count ($\times 10^9$ cells/L), and serum total cholesterol value (mg/dl), and the scoring criteria for each parameter were as follows. 1) Peripheral blood lymphocyte count ($\times 10^9$ cells/L) was divided into four levels, $\geq 1.60\times 10^9$ cells/L, $(1.20–1.59)\times 10^9$ cells/L, $(0.80–1.19)\times 10^9$ cells/L, and $<0.80\times 10^9$ cells/L. $\geq 1.60\times 10^9$ cells/L, $(1.20–1.59)\times 10^9$/L, $(0.80–1.19)\times 10^9$/L, and $<0.80\times 10^9$/L were scored 0, 1, 2, and 3 points, respectively. 2) Serum albumin levels were grouped into ≥35.0 g/L, 30.0–34.9 g/L, 25.0–29.9 g/L, and <25.0 g/L, and were scored as 0, 2, 4, and 6 respectively. 3) The serum total cholesterol levels were categorized into four groups, >4.68 mmol/L, 3.64–4. 68 mmol/L, 2.6–3. 63 mmol/L, and < 2.6 mmol/ L, with scores of 0, 1, 2, and 3, respectively. To calculate the CONUT, the points from the three parameters were added together. The resulting score was categorized as follows: 0–1: Normal; 2–4: Slightly Abnormal; 5–8: Moderately Abnormal; and 9 and above: Severely Abnormal.[21] A CONUT of ≥2 indicated nutritional risk, while a score of <2 indicated no nutritional risk.

PNI Calculation

PNI was calculated, using the formula, PNI=ALB (g/L)+5×lymphocyte count (10^9/L), with reference to the criteria developed by Onodera et al, PNI of ≥45 was considered no nutritional risk, and PNI of <45 was considered a nutritional risk.[22]

Statistical Analysis

Statistical analysis was conducted using SPSS version 29.0. Data were expressed as mean ± standard deviation. A *t*-test was utilized to determine differences between the poor prognosis and good prognosis groups when the data was normally distributed. The Mann–Whitney *U*-test was applied to see the differences between the groups when the data was non-normally distributed. Count data represented as percentages (%) were analyzed using the chi-square (χ^2) test. In cases where the data exhibited a hierarchical distribution, the rank-sum test was applied to assess differences between the groups. Receiver operating characteristic (ROC) curves were generated to evaluate the predictive value of CONUT and PNI on the post-operative prognosis of patients with chronic CSDH. Additionally, univariate and multivariate logistic regression analyses were performed to identify risk factors associated with CSDH. A p-value of <0.05 was considered statistically significant.

Results

Patient Characteristics

This study examined 205 patients who underwent surgery for CSDH (Table 1). Among these patients, 17 (8.3%) had a poor prognosis. The mean age of the group with a poor prognosis was significantly higher (72.82 ± 8.85 years, P<0.05) compared to the group with a good prognosis, whose mean age was 65.49 ± 12.82 years. In the poor prognosis group, there were 11 cases (64.7%) identified with nutritional risk (PNI<45), and 16 cases (94.1%) had a CONUT of ≥2. Conversely, in the good prognosis group, 36 cases (19.1%) had nutritional risk (PNI<45), and 62 cases (33%) had a CONUT of ≥2. The PNI and CONUT scores between the two groups showed significant differences (P < 0.05).

Table 1 Demographic and Clinical Characteristics of Patients

Parameters	Poor Prognosis, n=17	Good Prognosis, n=188	t/x^2	*P*-value
Age (years)	72.82±8.85	65.49±12.82	2.306	0.022
BMI	22.90±2.74	23.14±1.95	−0.464	0.643
Sex [n (%)]			0.027	0.87
Male	15 (88.2)	157 (83.5)		
Female	2 (11.8)	31 (16.5)		
Diabetes mellitus [n (%)]			1.003	0.317
Yes	3 (17.6)	14 (7.4)		
No	14 (82.4)	174 (92.6)		
Hypertension [n (%)]			3.269	0.071
Yes	9 (52.9)	59 (31.4)		
No	8 (47.1)	129 (68.6)		
Smoking [n (%)]			0.196	0.658
Yes	8 (47.1)	99 (52.7)		
No	9 (52.9)	89 (47.3)		
Drinking [n (%)]			0.376	0.540
Yes	7 (41.2)	92 (48.9)		
No	10 (58.8)	96 (51.1)		
Atorvastatin used [n (%)]			0.004	0.951
Yes	8 (47.1)	87 (46.3)		
No	9 (52.9)	101 (53.7)		
Anti-coagulation used [n (%)]			0	0.997
Yes	1 (5.9)	5 (2.7)		
No	16 (94.1)	183 (97.3)		
Electrolyte disturbance [n (%)]			0.902	0.342
Yes	10 (58.8)	88 (46.8)		
No	7 (41.2)	100 (53.2)		
Urokinase [n (%)]			0.015	1.000
Yes	14 (82.4)	157 (83.5)		
No	3 (17.6)	31 (16.5)		
PNI [n (%)]			15.824	<0.001
≥45	6 (35.3)	152 (80.9)		
<45	11 (64.7)	36 (19.1)		
CONUT [n (%)]			5.377	0.020
≥2	16 (94.1)	126 (67.0)		
<2	1 (5.9)	62 (33.0)		

Note: Data presented as the number of patients (mean± standard deviation).
Abbreviations: BMI, Body mass index; CONUT, Controlling nutritional status score; PNI, Prognostic nutritional index.

Laboratory Indicators

In comparison to the group with a good prognosis, the poor prognosis group showed decreased levels of albumin (ALB), hemoglobin (HB), and triglycerides, while fibrinogen levels were elevated (P<0.05). However, there were no statistically significant differences observed in blood glucose levels, neutrophil count, platelet count, or lymphocyte count (Table 2).

Imaging Characteristics

All patients underwent cranial CT scans to confirm a diagnosis of CSDH (Table 3). There was no statistically significant difference between the two groups regarding hemorrhage location, hematoma width, midline shift, pre-discharge subdural space, hematoma volume, and pre-discharge intracranial pneumatization. However, there was a statistically significant difference in hematoma density and pre-discharge intracranial fluid volume between the two groups (*P*<0.05).

To further illustrate the changes in hematoma before and after surgery, Figure 1 presents representative cranial CT images of patients with left-sided, right-sided, and bilateral CSDH. The images show the hematoma appearance in the

Table 2 Laboratory Indicators

Parameters	Poor Prognosis Group, n=17	Good Prognosis Group, n=188	*t*	*P*-value
Hypoglycemia (mmol/L)	6.35±1.58	6.74±2.42	−0.647	0.518
ALB (g/L)	36.17±5.29	41.65±3.92	−5.34	<0.001
TC (mmol/L)	3.61±1.14	4.07±0.86	−1.608	0.126
Triglyceride (mmol/L)	1.07±0.35	1.53±1.09	−3.926	<0.001
HDL (mmol/L)	1.06±0.43	1.14±0.31	−0.805	0.431
Uric acid	284.52±108.58	307.56±89.21	−1.001	0.318
HB (g/L)	127.24±10.57	140.61±15.20	−3.546	<0.001
Lymphocyte (10^9/L)	1.24±0.40	1.50±0.54	−1.919	0.056
Neutrophil (10^9/L)	6.01±2.97	4.86±1.91	1.571	0.134
Blood platelet (10^9/L)	201.94±63.81	229.74±60.92	−1.795	0.074
Percentage of peripheral mononuclear cells (%)	7.34±2.71	7.12±2.59	0.331	0.741
Fibrinogen (g/L)	4.09±1.36	3.08±0.80	3	0.008

Note: Data presented as mean ± standard deviation.
Abbreviations: TC, total cholesterol; HDL, high-density lipoprotein; HB, hemoglobin; ALB, serum albumin.

Table 3 Imaging Characteristics

	Poor Prognosis Group, n=17	Good Prognosis Group, n=188	t/x^2	*P*-value
Location of hematoma [n (%)]			0.83	0.741
Left	10 (58.8)	93 (49.5)		
Right	4 (23.5)	64 (34.0)		
Bilateral	3 (17.6)	31 (16.5)		
Hematoma density [n (%)]			23.27	<0.001
High	3 (17.6)	10 (5.4)		
Middle	4 (23.6)	146 (77.6)		
Low	10 (58.8)	32 (17.0)		
Preoperative hematoma width (mm)			0.011	0.917
≥20	8 (47.1)	86 (45.7)		
<20	9 (52.9)	102 (54.3)		
Preoperative midline shift [n			0.638	0.425
≥10	4 (23.5)	62 (33.0)		
<10	13 (76.5)	126 (67.0)		
Subdural space before discharge [n (%)]			0.160	0.689
≥10	12 (70.6)	141 (75)		
<10	5 (29.4)	47 (25)		
Hematoma volume (mL)	200.58±42.20	195.82±48.72	0.390	0.797
Intracranial air volume before discharge (mL)	9.06±2.15	6.45±0.66	1.157	0.261
Pre-discharge intracranial fluid volume (mL)	89.41±34.55	61.30±37.99	2.941	0.004

Note: Data presented as the number of patients (mean± standard deviation).

preoperative, postoperative, and re-examination phases. In each row, the progressive reduction and eventual resolution of the subdural hematoma following burr-hole drainage can be observed. This figure demonstrates the typical radiological evolution of CSDH in different locations after surgical intervention.

Predictability of CONUT and PNI for the Prognosis of CSDH

The ROC curve analysis indicated that the area under the curve (AUC) for CONUT in predicting the prognosis of CSDH was 0.719 (95% CI: 0.5867–0.8523, P=0.002). The optimal cutoff value for CONUT was determined to be 3.5, which resulted in a sensitivity of 84.0%, a specificity of 47.1%, and a false-positive rate of 52.9%. For the PNI, the AUC was 0.803 (95% CI:

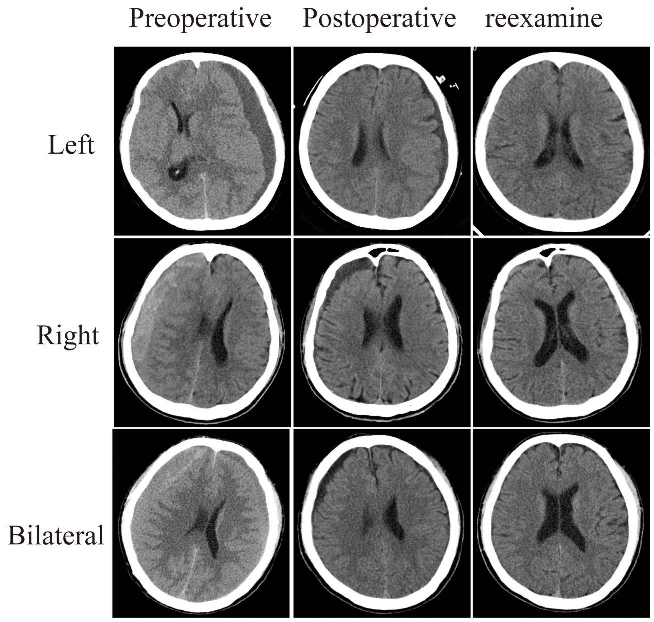

Figure 1 Representative cranial CT images showing radiological evolution of chronic subdural hematoma (CSDH) before and after surgical intervention. Each row presents images from a patient with left-sided, right-sided, or bilateral CSDH, respectively. Columns correspond to three time points: preoperative, postoperative, and re-examination phases. The images illustrate the typical reduction and resolution of subdural hematoma following burr-hole drainage across different hematoma locations. These serial CT scans highlight the radiological changes and treatment response at each stage of management.

0.7031–0.9042, P<0.001). The optimal PNI value was found to be 44.69, with a sensitivity of 81.0%, a specificity of 64.5%, and a false-positive rate of 35.3%. When combining both CONUT and PNI, the AUC increased to 0.805 (95% CI: 0.7039–0.9059, P<0.001). This combination yielded a sensitivity of 92.5%, a specificity of 76.5%, and a false-positive rate of 23.5%. In summary, while CONUT demonstrated higher sensitivity and a greater false-positive rate compared to PNI, PNI exhibited better specificity. The combined use of CONUT and PNI yielded the most favorable results, with the highest sensitivity and specificity as well as the lowest false-positive rate (Figure 2 and Table 4).

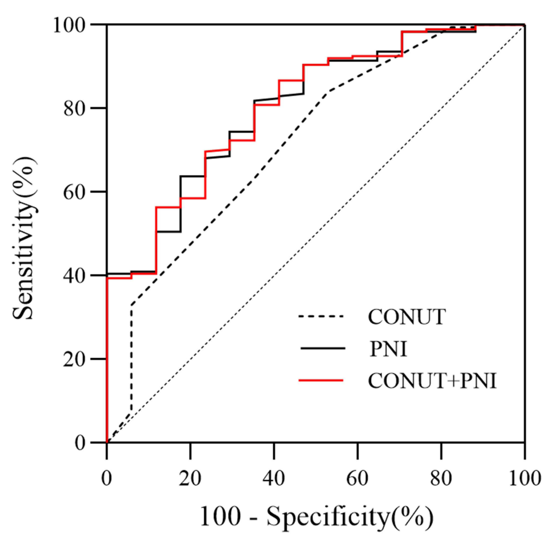

Figure 2 Receiver operating characteristic (ROC) curves for CONUT, PNI, and the combined CONUT+PNI in predicting poor prognosis of chronic subdural hematoma (CSDH). The ROC curves display the diagnostic performance of the Controlling Nutritional Status (CONUT) score (solid line), Prognostic Nutritional Index (PNI) (dashed line), and the combination of CONUT and PNI (dotted line). The curves plot sensitivity against 1-specificity for each index. The area under the curve (AUC) values for each predictor are shown, demonstrating the comparative prognostic accuracy of these nutritional indices for postoperative outcomes in CSDH patients.

Table 4 Predictive Value of CONUT and PNI for the Prognosis of CSDH

Indices	Cut-Off	95% CI	AUC	Sensitivity (%)	Specificity (%)	False-Positive Rate (%)	False-Negative Rate (%)	You den's Index (%)	*P*-value
CONUT	3.5	0.5867–0.8523	0.719	84.0	47.1	52.9	16.0	0.311	0.002
PNI	44.69	0.7031–0.9042	0.803	81.9	64.7	35.3	18.1	0.466	<0.001
CONUT+PNI		0.7039–0.9059	0.805	92.5	76.5	23.5	7.5	0.462	<0.001

Abbreviations: AUC, area under the curve; CI, confidence interval; CONUT, Controlling nutritional status score; PNI, Prognostic nutritional index.

Risk Factors Predicting Poor Prognosis of CSDH After Surgical Intervention

The univariate logistic regression was conducted to identify factors predicting poor prognosis in CSDH following burr-hole drainage. In this analysis, poor prognosis was treated as the dependent variable, while various factors from general clinical data, laboratory tests, and CT results were considered independent variables (Table 5). The findings revealed that age, albumin level (ALB), PNI, CONUT score, total cholesterol (TC), and the amount of intracranial fluid present before discharge were significant risk factors for poor prognosis in patients undergoing burr-hole drainage for CSDH (P<0.05). Multivariate analyses indicated that CONUT (OR=1.485, 95% CI: 1.096–2.011) and PNI (OR=0.850, 95% CI: 0.763–0.947) were independent risk factors for poor prognosis of CSDH following surgical intervention, after adjusting for age, hypertension, and pre-discharge intracranial fluid volume (Tables 6 and 7).

Table 5 Univariate Binary Logistic Regression Analysis for a Poor Prognosis of CSDH

Parameters	β	SE	Wald χ 2	*P*-value	OR (95% CI)
Sex	−0.393	0.778	0.255	0.614	0.675 (0.147–3.103)
Age	−0.055	0.024	5.132	0.023	0.946 (0.902–0.993)
BMI	0.061	0.131	0.217	0.642	1.063 (0.822–1.375)
Hypertension	−0.900	0.511	3.106	0.078	0.407 (0.149–1.106)
ALB	0.313	0.073	18.199	<0.001	1.368 (1.185–1.580)
Lymphocyte	1.090	0.573	3.626	0.057	2.975 (0.969–9.138)
TC	0.626	0.314	3.987	0.046	1.870 (1.011–3.460)
CONUT	−0.550	0.153	12.843	<0.001	0.577 (0.427–0.779)
PNI	0.248	0.059	17.574	<0.001	1.281 (1.141–1.438)
CONUT+PNI	2.838	0.305	86.846	<0.001	17.085 (9.405–31.035)
Preoperative hematoma width	−0.008	0.038	0.044	0.834	0.992 (0.921–1.068)
Hematoma density	0.261	0.541	0.233	0.629	1.299 (0.450–3.749)
Pre-discharge intracranial fluid volume	−0.018	0.007	7.648	0.006	0.982 (0.970–0.995)
Subdural space before discharge	−0.028	0.024	1.362	0.243	0.973 (00.929–1.019)

Abbreviations: BMI, Body mass index; ALB, serum albumin; CONUT, Controlling nutritional status score; PNI, Prognostic nutritional index; TC, total cholesterol.

Table 6 The Multivariate Logistic Regression Analysis with CONUT

	β	SE	Wald χ 2	*P* value	OR (95% CI)
Age	0.033	0.026	1.585	0.208	1.034 (0.982–1.088)
Hypertension					
Yes	0.588	0.540	1.187	0.276	1.801 (0.625–5.191)
No	ref				
CONUT	0.395	0.155	6.526	0.011	1.485 (1.096–2.011)
Pre-discharge intracranial fluid volume	0.001	0.001	0.016	0.899	1.001 (0.987–1.015)

Notes: Variables with P<0.1 from the univariate analysis were included in the multivariate model. After adjusting for age, hypertension, and pre-discharge intracranial fluid volume, CONUT was an independent risk factor for poor prognosis (MRS score of ≥3).

Table 7 The Multivariate Logistic Regression Analysis with PNI

	β	SE	Wald χ 2	*P* value	OR (95% CI)
Age	0.024	0.028	0.762	0.383	1.024 (0.970–1.082)
Hypertension					
Yes	0.726	0.543	1.784	0.182	2.066 (0.712–5.991)
No	ref				
PNI	−0.162	0.055	8.690	0.003	0.850 (0.763–0.947)
Pre-discharge intracranial fluid volume	0.003	0.007	0.207	0.649	1.003 (0.989–1.018)

Notes: Variables with P<0.1 from the univariate analysis were included in the multivariate model. After adjusting for age, hypertension, and pre-discharge intracranial fluid volume, PNI was an independent risk factor for poor prognosis (MRS score of >3).

Discussion

In the study, it was found that 64.7% of patients exhibited nutritional risk based on the PNI, while 94.1% of patients in the poor prognosis group had abnormal results when assessed by the CONUT. In contrast, among patients in the good prognosis group, only 19.1% showed nutritional risk based on PNI and 33% had abnormal CONUT.

The incidence of CSDH is rising among the elderly population, largely due to their frequent use of anticoagulants and antiplatelet medications.[23,24] Factors such as abnormal coagulation, neovascularization, and inflammatory responses may contribute to the onset and progression of CSDH. This condition can lead to neurological disorders due to increased intracranial pressure, epilepsy, stroke, hemiparesis, and other abnormal neurological responses. Surgical interventions, such as drilling and draining, are commonly employed to remove the hematoma, alleviate pressure on the brain, and decrease intracranial pressure. However, the recurrence following these procedures remains high, often resulting in a poor prognosis. Elderly patients with CSDH also face a heightened risk of nutritional deficits. Nutritional risk has been observed in various neurological disorders, including craniocerebral injuries, subarachnoid hemorrhage, and gliomas, and the patient's nutritional status has been correlated with their clinical outcomes.[25–27] The PNI and CONUT are both scoring systems widely used to assess the nutritional status of patients, particularly with their prognosis and potential outcomes in various clinical settings, including surgical interventions and chronic diseases. This study has identified a relationship between preoperative nutritional status, as assessed by the CONUT and PNI, and postoperative prognosis in patients with CSDH.

In addition to the nutritional indices, our study also provides representative cranial CT imaging findings to illustrate the typical radiological evolution of CSDH after surgical intervention. The serial CT scans from selected patients with left-sided, right-sided, and bilateral CSDH demonstrate the progressive reduction and eventual resolution of subdural hematoma following burr-hole drainage. These images highlight the dynamic changes in hematoma volume and density at different stages: preoperative, postoperative, and during follow-up.[28] Including these imaging examples offers a visual reference for understanding the typical course of CSDH after treatment and supports the clinical findings of our cohort.

The CONUT, derived from preoperative albumin (ALB), peripheral blood lymphocyte count, and serum total cholesterol (TC), was closely linked to the prognosis of various malignancies.[29,30] Serum ALB levels indicate the body's nutritional status, while pro-inflammatory cytokines inhibit albumin synthesis, which correlates with tumor necrosis.[31] Previous studies have demonstrated a strong relationship between serum total cholesterol levels and patient survival after surgical treatment for renal cell carcinoma.[32]

The total lymphocyte count reflects the immune status of the body, and a lower lymphocyte count has been associated with poorer prognoses for colon tumors.[33] In CSDH, decreased levels of ALB and lymphocyte counts were associated with a higher risk of complications.[34] Additionally, factors such as age, comorbidities, and the use of anticoagulant medications were linked to the recurrence of CSDH.[35] In our study, we found that the poor prognosis group had significantly higher ages and greater amounts of intracranial effusion before hospital discharge, while their serum ALB, triglyceride levels, and hemoglobin (HB) were significantly lower. According to the CONUT analysis, 94.1% of patients in the poor prognosis group were at nutritional risk, compared to 67% in the good prognosis group.

Recent studies have emphasized the prognostic value of nutritional indices such as CONUT and PNI in various clinical settings, including surgical and neurological diseases. In our study, the ROC analysis demonstrated that both CONUT and PNI are valuable predictors of poor prognosis in patients with CSDH following surgery, with the combined use of both scores further enhancing predictive accuracy. This finding aligns with previous research in other neurological and oncological populations, where the CONUT score has been shown to predict postoperative complications and mortality.[14,27,28] For example, Liu et al[14,] and López Espuela et al[21,] both reported that higher CONUT scores were independently associated with increased in-hospital mortality and worse outcomes after stroke or traumatic brain injury, highlighting the broader applicability of this tool.

Similarly, our observation that the PNI is associated with postoperative prognosis is consistent with studies in patients undergoing gastrointestinal and hepatobiliary surgery, as well as those with malignancies and cerebrovascular diseases.[16,17,22,31,36,37] Tsukagoshi et al[22] and Mohri et al[31] found that lower PNI scores correlated with higher rates of postoperative complications and poorer long-term survival, emphasizing the importance of preoperative nutritional assessment.

Notably, our results suggest that the combined use of CONUT and PNI provides better discrimination for poor prognosis than either index alone. While previous studies have typically evaluated these indices separately, our data support the approach advocated by Kanemoto et al[38] who suggested that integrating multiple nutritional markers may yield a more robust risk stratification model for surgical patients. Moreover, as in our cohort, several studies have found that nutritional risk, as reflected by low PNI or high CONUT scores, is particularly prevalent among elderly and neurologically compromised populations, further underscoring the need for routine nutritional screening.[10,14,18,25] Despite these promising findings, it is important to acknowledge that, as reported in the literature, nutritional indices may be influenced by unmeasured confounders such as perioperative nutritional interventions or the recurrence of hematoma.[38,39] Future prospective studies should therefore incorporate standardized nutrition management protocols to clarify the causal relationship between nutritional status and clinical outcomes.

This study has several limitations. It is a single-center retrospective analysis with a small sample size. Additionally, the CONUT and PNI were calculated solely based on laboratory results, without any subjective evaluation of the patients. Therefore, future studies should involve a larger sample size and a multicenter design to validate these findings. A key limitation is the lack of preoperative assessment of ADL and frailty. As these are important confounding factors that may influence both nutritional status and clinical outcomes, their absence limits the interpretation of CONUT and PNI as independent predictors. Due to the retrospective design and incomplete data, we were unable to supplement this information in the current study. Future research should incorporate standardized frailty and functional assessments to better clarify their relationship with nutritional status and prognosis. Furthermore, our study did not systematically document whether any nutritional interventions were provided to patients during hospitalization. The potential effect of in-hospital nutritional support on patient outcomes could not be evaluated in this analysis. Future prospective studies should collect detailed data on perioperative nutritional interventions to more accurately assess their impact on prognosis.

Conclusion

This study evaluated the nutritional status of patients with CSDH using the PNI and the CONUT. It also analyzed the relationship between these scores and the poor prognosis of CSDH following surgical intervention. Both PNI and CONUT demonstrated high sensitivity in predicting patient outcomes. However, the highest sensitivity and specificity were achieved when the two scores were combined, suggesting that using both PNI and CONUT together has significant value in forecasting the prognosis of CSDH. Thus, their clinical usefulness is enhanced when used in combination. These findings highlight the potential utility of PNI and CONUT as practical tools for preoperative risk stratification in elderly patients with CSDH, and future prospective, multicenter studies incorporating standardized frailty assessments are warranted to validate and expand upon these results.

Abbreviations

CSDH, Chronic subdural hematoma; CONUT, Controlling nutritional status score; PNI, Prognostic nutritional index; ROC, Receiver operating characteristic curve; ALB, Albumin.

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Disclosure

The authors report no conflicts of interest in this work.

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