Original Article

Chronic Subdural Hematoma: Predicting Postoperative Recurrence Using a Correlation of Computerized Tomographic Volume with Intraoperative Volume

Abstract

Background: Chronic subdural hematoma (CSDH) recurrence is the most common complication following surgery. **Objective:** To predict postoperative recurrence of CSDH using a correlation of the calculated preoperative brain computerized tomographic (CT) volume with the intraoperative volume. **Materials and Methods:** A prospective study was conducted over 14 months in a tertiary hospital in southwestern Nigeria. History with focused examination findings and patient grading using Markwalder classification were documented preoperatively. Preoperative CSDH CT volume was documented and compared with the intraoperative volume. Patients were followed up clinically for features of recurrence at 1, 3, and 6 months postoperatively, and repeat brain CT was done when recurrence was suspected clinically. **Results:** Forty-seven out of 51 patients recruited completed the study, and four were lost to follow-up. Thirty-three (70.2%) were males, and the average age was 51.4 years. Most of the patients were in the 5th and 7th decades of life. Three patients had recurrence (6.5%), and one patient died (2.1%). Trauma was the most common cause of CSDH (35 out of 47 [74.5%]), spontaneous in 11 (23.4%), and anticoagulant related in 1 (2.1%) patient. Most patients (37/47; 78.7%) presented with headache. The mean brain CT volume and intraoperative volume of CSDH were 102.58 ± 54.13 and 87.74 ± 46.6 mL, respectively, with no significant difference between them ($P = 0.104$). The receiver operating characteristics curve of intraoperative volume predicted the recurrence of CSDH at a volume >130 mL, with a sensitivity of 66.7%. **Conclusion:** The calculated preoperative CT volume had a positive linear correlation with intraoperative volume. Intraoperative CSDH volume >130 mL was associated with an increased risk of recurrence.

Keywords: *Chronic subdural hematoma, computerized tomographic volume, intraoperative volume, recurrence*

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Introduction

Chronic subdural hematoma (CSDH) is a slow-growing encapsulated collection of blood and its breakdown products located between the dura mater and the arachnoid.[1,2]

The incidence of CSDH increases with age, and it ranges from 3.4 per 100,000 in patients younger than 65 years of age to 8.58 per 100,000 in those older than 65 years.[1]

Risk factors for CSDH include advancing age due to global cerebral atrophy and increased fragility of the bridging veins, use of anticoagulants, alcohol ingestion, trauma (30%–50% of cases), and seizures among others. The pathophysiology of CSDH can be explained with two theories, the osmotic theory and recurrent bleeding from the hematoma capsule theory, the latter being more widely accepted.[3,4]

Symptoms at presentation include altered mental state, focal neurological deficit, headaches, falls, and seizures.[3]

Computed tomography scan (CT scan) of the brain is the gold standard for diagnosing CSDH, defining it as hypo-dense subdural (extra-axial crescentic) collection, compared with the brain parenchyma.[1,5-7]

Operative and nonoperative options of treatment have been used for CSDH; however, surgical treatment usually results in rapid relief of neurologic symptoms with good prognosis.[6-8] CSDH recurrence is the most common complication following surgery, accounting for 10%–28.8% of postoperative complications.[5,9,10] Imaging

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methods and surgical strategies have not substantially improved postoperative recurrence rate; therefore, there is a need to identify patients at significant risk of recurrence for better patient care.[7]

There is a paucity of knowledge about the use of calculated preoperative CT hematoma volume and intraoperative volume estimation to predict the recurrence of CSDH in our environment, and such prediction will help determine the subset of patients that require closer monitoring and maintenance of a high index of suspicion in such patients.

Subjects and Methods

A prospective cohort study of adult patients with CSDH was done between September 2016 and October 2017. Approval for the study was obtained from Health Research and Ethics committee.

Patients with clinical features and brain CT confirmed diagnosis of CSDH (>18 years) were recruited for the study. The clotting profile and International Normalized Ratio were documented before surgery.

Patients with recurrent CSDH and those with hemophilia or other hematological disorders were excluded from the study.

The neurological state of patients was evaluated according to the Markwalder classification and the Glasgow Coma Scale (GCS).[11,12]

Calculation of preoperative CSDH volume was done by an independent radiologist using a single-blind method as the surgeon was not aware until after the surgery to reduce bias. CT Scan was done with a Toshiba CXL Aquillon, 128 slices scanner, manufactured in 2013, and "DICOM WORKS" computer program was used to calculate CT volume using the formula $XYZ/2$[13] where:

X = depth of hematoma which is slice thickness multiplied by the number of slides where hematoma is present. Y = maximum length of hematoma on the CT slice. Z = maximum width of hematoma on the CT slice.

A single burr hole craniostomy with a closed drainage system was used for all patients under standard operating conditions using local anesthesia with conscious sedation. A single dose of prophylactic broad-spectrum antibiotics was given at skin preparation.

Sterile gauze was placed on the dependent side of burr hole to estimate CSDH spillage. The neo-membrane was incised just enough to accommodate a catheter (size eight soft feeding tube), and it was immediately occluded with the thumb of the nondominant hand to reduce spillage of hematoma. The drain was inserted, and aspiration of the hematoma was done using a five cubic centimeter syringe with minimal negative pressure, and the volume was measured. Patients were observed for a day after drain removal and discharged home if stable and were followed up in the clinic for features of recurrence at 1, 3, and 6 months postoperatively. CSDH recurrence was defined as the recurrence of previous or new clinical features, and brain CT confirmed subdural collection on the operated side with compression of the brain within 6 months of initial burr hole drainage.

Data were analyzed using version 22 of IBM SPSS Statistics, Chicago, Illinois. Statistical analyses were done using descriptive and inferential statistics. Data were presented as frequency, mean, and standard deviation. Comparisons were made using independent samples t test and linear-logistic regression, receiver operating characteristics (ROC) curve was used to determine sensitivity, and a P value <0.05 was taken as significant.

Results

Fifty-one patients were recruited for the study, but 47 completed the study and 4 were lost to follow-up.

Age and gender distribution

Thirty-three (70.2%) patients were males, and 14 (29.8%) were females, with a male-to-female ratio of 2.4:1. Peak occurrence was between 41 and 50 years in men (11 of 33 [33.3%]) and between 61 and 70 years in women (6 of 14 [42.9%]).

Clinical characteristics and severity of chronic subdural hematoma

Headache was the most common clinical feature, present in 37 patients (78.7%), followed by hemiparesis/hemiplegia in 27 (57.4%) and speech abnormality in 24 (51.1%). The frequencies of neurological features are shown in Figure 1.

GCS score was 15 in 9 patients (19.2%), 9–14 in 34 patients (72.3%) and ≤8 in 4 patients (8.5%).

The preoperative Markwalder grades are shown in Figure 2. Most patients presented with a score of 2.

Presumed etiology of chronic subdural hematoma

There was a history of trauma (minor and major) in 35 (74.5%) patients, spontaneous in 11 (23.4%), and anticoagulant related in 1 (2.1%) patient. The average age of those with a history of trauma and those with spontaneous hematoma was 53.7 years and 60.5 years, respectively. The frequency of traumatic CSDH in males was 72.7% (24/33) compared to 78.6% (11/14) in females. This difference was not statistically significant (P = 0.49).

Brain imaging characteristics of chronic subdural hematoma

CSDH was bilateral in 7 cases (14.9%) and unilateral in 40 (85.1%). The most frequently involved location was the parietal lobe, which affected all the patients.

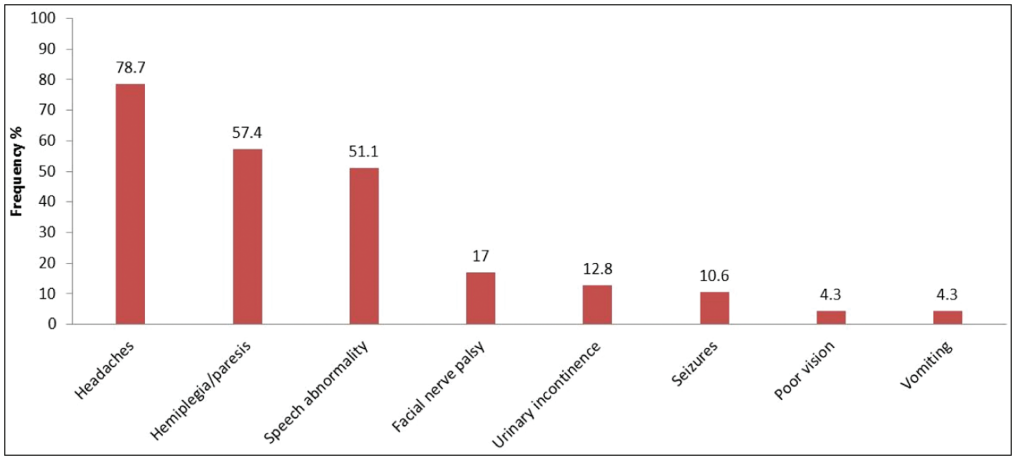

Figure 1: Clinical features in patients with CSDH

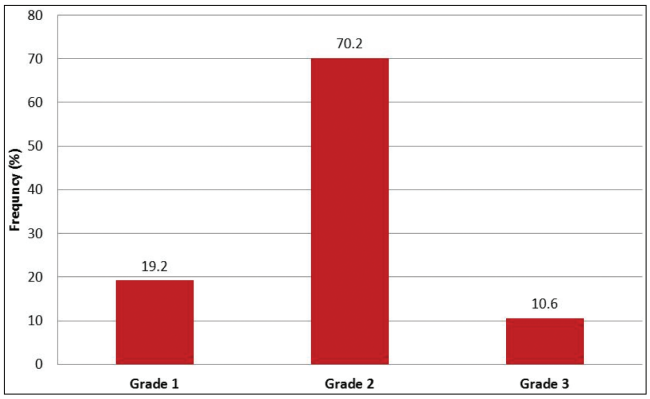

Figure 2: Markwalder grade of severity of CSDH

Brain computerized tomographic hematoma volumes and intraoperative hematoma volumes

Figure 3 compares the average brain CT hematoma volume (102.6 ± 54.1) and the intraoperative hematoma volume (87.7 ± 46.6). There was no statistically significant difference between the two volumes (P = 0.064). Using Pearson correlation analysis, there was a significant correlation between both volumes (P = 0.03; R = 0.27) [Figure 5].

The white solid line within boxplot represents the mean hematoma volume. Error bars represent the standard deviation of the mean. Outliers indicated by star and circle within the graph.

Postoperative outcome of chronic subdural hematoma

Case fatality rate was 2.13% in this study, and a single death occurred prior to the initial scheduled follow-up. The cause of death was not known as the patient didn't have an autopsy.

Three (6.4%) patients had recurrence at 3 months, with no further recurrence at 6 months follow-up. All three cases with recurrent CSDH had unilateral CSDH. Eight (17%)

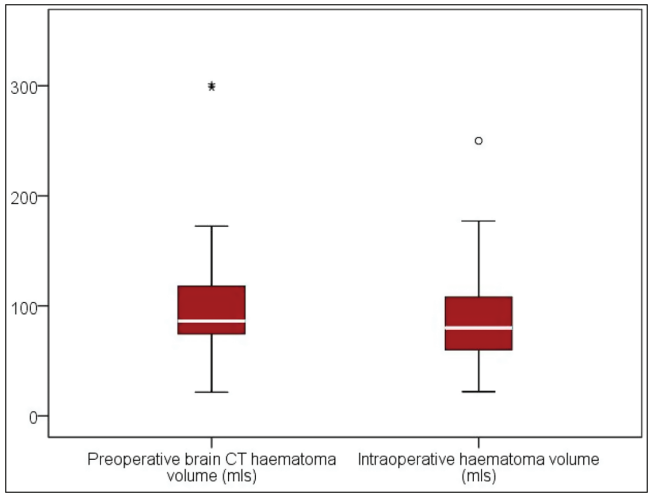

Figure 3: Comparison of mean preoperative brain CT hematoma volume and intraoperative hematoma volume

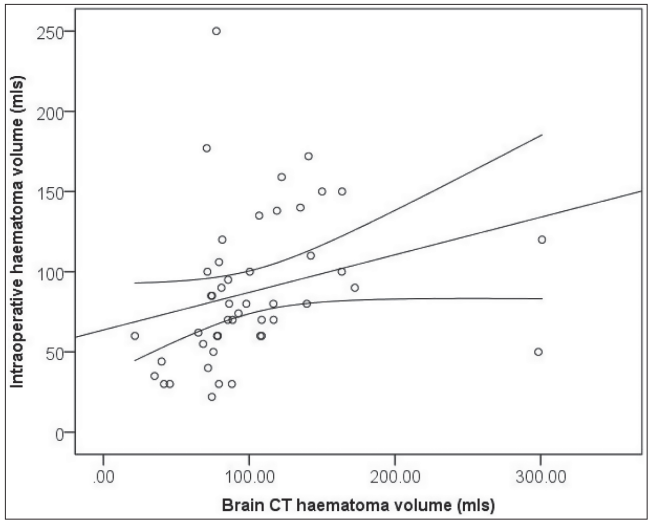

Figure 4: Linear trend of association between preoperative brain CT hematoma volume and intraoperative hematoma volume

patients had residual hemiparesis at discharge, and two-thirds of those with recurrence had residual hemiparesis at discharge. The characteristics of the patients with and without recurrence (excluding the single fatality) are shown in Table 1.

Prediction of recurrence using various hematoma volumes

A higher mean value in intraoperative volume (130.0 ± 26.5) as compared to brain CT volume was observed in patients with recurrence. Intraoperative volume of less than 100 mL was seen in patients without recurrence (81 ± 39.3, $P = 0.04$) [Table 1]. Patients with intraoperative volume >130 mL (area under the curve [AUC] 0.857, confidence interval [CI] 0.73–0.99) are likely to have a recurrence within the first 3 months after surgery.

Intraoperative volume has a large AUC, $P = 0.041$, which is statistically significant.

Intraoperative volume curve is to the left of the reference line with a sensitivity of 0.67. This shows that intraoperative volume is a more reliable variable in predicting recurrence.

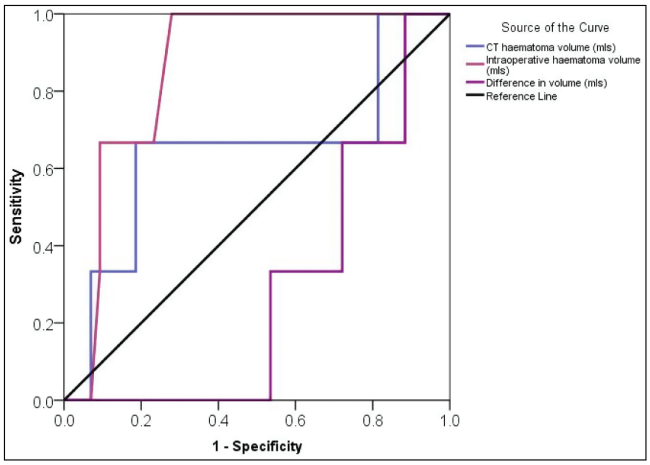

Figure 5: Receiver operating characteristic (ROC) curve analysis of prediction of hematoma recurrence at 3 months postoperatively

Discussion

Age and gender distribution

The majority of patients presented in the 5th and 7th decades of life, which was comparable to previous reports from the West African subregion with an average age of 49.7 years at presentation.[14] In Nigeria, Mezue *et al.*[15] reported that most of their patients were seen in the 6th decade. Most of the males (11; 33.3%) were in the younger age group (41–50 years), while more of the female (6; 42.9%) were in the older age group of 61–70 years. This pattern may be explained by the fact that men in the productive age group are more active and, therefore, more prone to trauma, which is a leading cause of CSDH, as seen in this study. The mean age distribution was 55.5 ± 14.6 years [Table 2] with a male:female ratio of 2.4:1, which was the pattern in most studies with a ratio of 3:1.[10,14,16] Older females (mean age 65.1 ± 15.5) tend to present more frequently with CSDH. This has been attributed to the fact that postmenopausal women lose the protective effect of estrogen hormone on capillaries, increasing the chances of bleeding in them.[17]

Clinical characteristics and severity of chronic subdural hematoma

Headache was the modal presenting complaint (78.7%) and was followed by hemiparesis (57.4%) and speech abnormality (51.1%). Other authors reported similar findings, with headache topping the list of presenting complaints.[16,18,19] Mezue *et al.* also reported a high frequency of hemiparesis with an altered level of consciousness as one of the leading presenting complaints among a cohort of 132 patients. These findings were corroborated by other authors.[15,20,21] Bankole *et al.*[16] reported similar presentation patterns to this study, with headache and motor deficit being the most common presenting symptom. The percentage of patients that presented with seizure was similar in their study and ours, 10.4% and 10.6%, respectively. Poor vision was seen in two patients (4.3%); both had anisocoria and papilledema. This may have been due to the rapidity of expansion of preexisting nonsymptomatic CSDH in these patients.

Table 1: Comparison of selected characteristics in recurrent versus nonrecurrent chronic subdural hematoma

Variable	Recurrent CSDH $n = 3$	Nonrecurrent CSDH $n = 43$	P value
Mean age ± SD (years)	53.0 ± 15.0	55.4 ± 14.6	0.79
Brain CT hematoma volume (mL)	123.4 ± 47.3	101.7 ± 55.3	0.51
Intraoperative hematoma volume (mL)	130.0 ± 26.5	81.0 ± 39.3	0.04
Difference in CT and IOP volume (mL)	6.6 ± 21.3	20.7 ± 56.2	0.41
Prothrombin time	12.8 ± 1.0	12.6 ± 1.3	0.44
International normalized ratio	1.11 ± 0.09	1.1 ± 0.1	0.73

IOP, intraoperative

Results for deceased patient ($n = 1$): Aged 68 years, CT hematoma volume was 77.1 mL, and intraoperative hematoma volume was 250 mL.

Table 2: Age and gender distribution of patients with chronic subdural hematoma

Variable	All (n = 47)	Male (n = 33)	Female (n = 14)	Statistics (P value)
Age range	34–88	34–72	39–88	NA
Mean age ± SD (years)	55.5 ± 14.6	51.4 ± 12.2	65.1 ± 15.5	0.002
Age category (n, %)				
31–40 years	9 (19.1)	8 (24.2)	1 (7.1)	0.034
41–50 years	13 (27.7)	11 (33.3)	2 (14.3)	
51–60 years	6 (12.8)	5 (15.2)	1 (7.1)	
61–70 years	13 (27.7)	7 (21.2)	6 (42.9)	
71–80 years	3 (6.4)	2 (6.1)	1 (7.1)	
81–90 years	3 (6.4)	0 (0.0)	3 (21.4)	

Table 3: Area under the curve (AUC) for ROC analysis of prediction of recurrence of CSDH

Variable	AUC	Standard error	Asymptotic significance	Asymptotic 95% CI
Brain CT hematoma volume (mL)	0.643	0.194	0.410	0.26–1.00
Intraoperative hematoma volume (mL)	0.857	0.066	0.041	0.73–0.99
Difference in CT and IOP volume (mL)	0.287	0.101	0.221	0.09–0.48

IOP, intraoperative

Brain imaging and intraoperative characteristics of chronic subdural hematoma

Huang *et al.*[5] in an Asian population, reported an average calculated CT volume of 119.6 mL (±62.2) among a cohort of 94 patients, slightly higher than 102.6 mL (±54.1) in this study. However, the volume range was similar in both studies, 100–150 mL.

There is a paucity of literature comparing intraoperative volume with preoperative CT volume of patients with CSDH. There was a statistically significant (P = 0.03, R = 0.27) positive linear correlation between preoperative brain CT scan volume and intraoperative volume, but there was no statistically significant difference between intraoperative and brain CT volume measurements (P = 0.064), as shown in Figure 4. This implies that the preoperative CT volume provides an estimate of the intraoperative volume of the hematoma to be expected and may help to determine if a significant volume of hematoma has been drained at the surgery or not.

Postoperative outcome of chronic subdural hematoma

The low recurrence rate of 6.5% in this study may be because the majority of patients (28; 61%) had an intraoperative volume that was less than 100 mL. Intraoperative volume >130 mL was found to be a major factor in predicting recurrence in this study. Furthermore, most of the patients were relatively younger people with relatively high brain volume that re-expanded post drainage and, as such, reduced the risk of recurrence. Two-thirds (66.7%) of the patients with recurrence were in the 6th and 7th decade of life, and both had residual hemiparesis at discharge. Increasing age, cortical atrophy with reduced re-expansion of the brain, and high volume greater than 100 mL may have combined to lead to recurrence.[19-21] Residual hemiparesis may be a function of delayed presentation leading to prolonged compression of the underlying brain and may be due to incomplete hematoma drainage. The use of a drainage tube in our center allows for residual collections to drain out while the brain re-expands. Severe atrophy with failure to re-expand predisposes the patient to reaccumulation and in addition to large hematoma volume may account for recurrence being higher among patients in the 6th and 7th decades of life.

Ohaegbulam[22] reported no recurrence in a cohort of 132 patients about four decades ago. The patients who had recurrence had unilateral CSDH, which was contrary to the findings of Stanišić *et al.*[7] in a cohort of 107 patients over a 12-month period. They reported that recurrence was higher among patients with bilateral CSDH (11.9% [10 out of 84] in the unilateral group and 30.4% [7 out of 23] in the bilateral group), and the recurrence was unilateral, but it was not stated if the recurrence was on the side with a larger hematoma volume. The difference was statistically significant (P = 0.031). Their finding may be because the total number of patients who had unilateral CSDH was more than three times the total number of patients with bilateral CSDH.

Patients with voluminous hematoma tend to have brain atrophy, which leads to poor brain expansion after surgery and creates potential space for reaccumulation of the hematoma.[22] This study showed that the intraoperative volume of CSDH was a significant risk factor for the recurrence of CSDH ($P = 0.04$) [Table 3]. ROC curve of intraoperating hematoma volume revealed an AUC of 86% with a CI of 0.73–0.99 and a standard error of 0.066 [Figure 5]. Patients with intraoperative volume >130 mL are at increased risk of recurrence, with a sensitivity of 66.7%. Contrary to our finding, Huang *et al.*[5] reported that calculated brain CT volume of the CSDH was not associated with recurrence but that layering of the hematoma was the only independent risk factor on CT images associated with recurrence of CSDH.

Limitation of study

A relatively small size may have impacted the power of this study.

Conclusion

The average calculated CT volume was greater than the actual intraoperative volume though there was a positive linear relationship. Intra-operative CSDH volume of >130 mL was found to be associated with an increased risk of recurrence, especially within the first 3 months postoperatively.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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