Value of routine early post-operative computed tomography in determining short-term functional outcome after drainage of chronic subdural hematoma: An evaluation of residual volume

Hui Yu Ng, Wai Hoe Ng¹, Nicolas K. K. King¹

Department of Neurosurgery, Changi General Hospital, 2 Simei Street 3, National Neuroscience Institute, 11 Jalan Tan Tock Seng, Singapore

E-mail: Hui Yu Ng - ng_huiyu@yahoo.com; Wai Hoe Ng - wai_hoe_ng@nni.com.sg; *Nicolas KK King - nicolas_kon@nni.com.sg

*Corresponding author

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Abstract

Background: Computed tomography (CT) scans are widely used in managing chronic subdural hematoma (CSDH). Factors that determine early post-operative volume have not been examined. The value of routine early post-operative residual volume have not been evaluated. Our study aims to compare pre-operative and early post-operative CT findings to determine the factors affecting residual hematoma and evaluate if early post-operative CT scans are useful in the management of CSDH.

Methods: Forty-three patients who underwent burr hole drainage of unilateral CSDH from August 2006 to January 2013 and had routine post-operative CT scans within 48 hours of surgery were selected. Data regarding age, sex, neurological deficit, Glasgow Coma Scale (GCS), pre-existing medical conditions, use of antiplatelets or anticoagulation, operative time, usage of drains, and number of burr holes were obtained. The pre-operative CSDH volume, CSDH density, and midline shift were measured. Residual volume was calculated from early post-operative CT scans. Clinical outcome was evaluated with Glasgow Outcome Scale (GOS) at the time of discharge. Statistical analysis was performed to look for correlation between the pre-operative factors and residual volume, and the residual volume and GOS.

Results: Pre-operative volume was found to correlate significantly with post-operative residual volume. There was no significant correlation between all other pre-operative factors and residual volume. There was also no correlation between residual volume and GOS at discharge.

Conclusion: Routine post-operative CT brain for burr hole drainage of CSDH may be unnecessary in view of the good predictive value of pre-operative volume, and also because it is not predictive of the clinical outcome.

Key Words: Chronic, hematoma, outcome, post-operative computed tomography, residual volume, subdural

INTRODUCTION

Chronic subdural hematoma (CSDH) is a common neurosurgical disorder with an incidence of about 5 per 100,000 per year in the general population.¹⁰ The treatment is usually surgical, and a wide variety of surgical treatments has been proposed including twist drill, burr hole craniostomy, craniotomy, and even embolization
of the middle meningeal artery for refractory cases.\cite{15,7} Despite the range of available treatment options, there remains a substantial risk of recurrence varying from 9 to 33% depending on the series.\cite{11,12}

With the ever-increasing availability of computed tomography (CT), the ease of obtaining a CT scan has increased. The indications for doing an early CT scan are generally for the detection of significant residual hematoma before the delayed development of symptoms\cite{8} or as part of the routine post-operative management.\cite{14} Previous studies have also shown that the amount of residual hematoma or pneumocephalus is predictive of recurrence.\cite{12}

To the best of our knowledge, the factors determining the volume of residual hematoma and brain re-expansion post-drainage have not been previously examined. Similarly, the value of routine early post-operative CT scan to assess residual hematoma has not been previously evaluated.

In this study, we compared the pre-operative and early post-operative CT scan findings to determine the factors predictive of residual hematoma and, hence, the usefulness of early post-operative CT scan in the management of patients after drainage of CSDH.

**MATERIALS AND METHODS**

**Study population and characteristics**

During the period between August 2006 and January 2013, the records of 123 consecutive patients who underwent drainage of unilateral CSDH via burr hole drainage were reviewed at the Department of Neurosurgery, Changi General Hospital, Singapore. Ethics approval for the study was obtained from the Centralised Institutional Review Board (CIRB) of Singhealth. Based on the practice of the individual surgeons, a group of patients had routine post-operative CT of the brain within the first 48 h of the operation. The records of these patients were selected for further analysis. In all, there were 43 patients (29 males, 69%) who fulfilled these criteria, and the patients’ demographics are summarized in Table 1.

Clinical data were retrospectively retrieved from the patients’ medical records and operative notes. Information regarding the age of the patients, gender, pre-operative neurological deficit and Glasgow Coma Scale (GCS), pre-existing medical conditions, and use of antiplatelet medications or anticoagulation were obtained from their medical records. From their operative notes, the data on operative time, usage of drains, and number of burr holes made were recorded.

**Calculation of CT volumes and densities**

From the pre-operative CT brain images, the pre-operative volume of subdural hematoma (ml), the density of the CSDH, and midline shift were estimated. The volume of CSDH was calculated based on the XYZ/2 method described by Sucu et al.\cite{13} Briefly, this method involves using the product of the widest (X), longest (Y), and thickest (Z) dimensions, which are not necessarily on the same slice, of the CSDH divided by 2. The thickest dimension was calculated by multiplying the slices on which the hematoma was visible by the slice thickness (5 mm). Using this method, the length and width of the hematoma on the same central slice

| Table 1: Patient demographics and characteristics |
|-----------------------------------------------|
| **Characteristics**                            | **N=43** |
| Mean age (years)                              | 73±14   |
| Female sex (%)                                | 14 (32.5) |
| Co-morbidities (%)                            |         |
| Ischemic heart disease                       | 10 (23.2) |
| Diabetes                                      | 16 (37.2) |
| Cerebrovascular accident                     | 9 (20.9)  |
| Hypertension                                 | 31 (72.0) |
| Others                                       | 18 (41.8) |
| Hyperlipidemia                               | 8 (18.6)  |
| Atrial fibrillation                          | 3 (6.9)   |
| Antiplatelet/anticoagulation (%)              |         |
| Antiplatelet                                 | 17 (39.5) |
| Anticoagulation                              | 2 (4.7)   |
| Glasgow coma scale on admission (%)           |         |
| 13-15                                        | 33 (76.7) |
| 8-12                                         | 8 (18.6)  |
| 3-8                                          | 2 (4.6)   |
| Neurological deficit (%)                      |         |
| Hemiparesis                                  | 13 (30.2) |
| Confusion                                    | 3 (6.9)   |
| Aphasias                                     | 2 (4.6)   |
| Radiological findings                        |         |
| Pre-op volume (ml)                           | 153±53   |
| Pre-op density (HU)                          | 34±6     |
| Pre-op midline shift (mm)                    | 9.6±5.4  |
| Evan’s index                                 | 0.15±0.05 |
| Post-op residual volume (ml)                 | 60.1±33.1 |
| Laterality (%)                               |         |
| Left                                         | 20 (46.5) |
| Right                                        | 23 (53.5) |
| Intraoperative features                      |         |
| Median no of burr holes                      | 2        |
| Type of drain (%)                            |         |
| None                                         | 17 (39.5) |
| Subdural                                     | 13 (30.2) |
| Subgaleal                                    | 13 (30.2) |
| Length of stay (days)                        | 21.9±23.6 |
| Glasgow outcome scale (%)                    |         |
| Unfavorable (GOS 1-3)                        | 17 (39.5) |
| Favorable (GOS 4-5)                          | 26 (60.4) |

GOS: Glasgow outcome scale
were not used. It was also shown to have an excellent correlation with the gold standard of computer-assisted volumetric analysis.\(^5\) For calculation of the density of the CSDH, the averaged Hounsfield units (HU) of the widest portion of the CSDH (central slice) on the axial CT scan were measured. The relationship between the Hounsfield unit and the sequential change in density has previously been demonstrated.\(^3\)

From the early routine post-operative CT images, the post-operative residual volume of CSDH (ml) was calculated using the same method of XYZ/2 as previously described. All CT scans were performed within 48 h of the surgery.

**Outcome assessment**

Clinical outcome was evaluated at discharge using the Glasgow Outcome Scale (GOS), and recurrence was assessed based on our hospital electronic records.

**Statistical methods**

Data are presented as mean ± standard deviation or as percentages of the total number of patients. Data were entered into SPSS (IBM Corporation, Armonk, NY, USA) for analysis. Univariate analysis was performed using the independent sample t-test or Chi-squared test as appropriate. Correlation for our sample was calculated using the Pearson correlation (r) which is a measure of the linear correlation between two variables. The correlation coefficient is a value of −1 to +1 inclusive, where +1 is total positive correlation, 0 is no correlation, and −1 is total negative correlation. The factors used for outcome were entered into a multivariate logistic regression analysis and variables in the final model were selected according to a stepwise method. \(P < 0.05\) was considered statistically significant.

**RESULTS**

**Patient population and mean pre- and post-operative volumes**

There were 29 (67.5%) males and 14 (32.5%) females with a mean age of 73 years (±14 years). Twenty (46.5%) patients had left CSDH and 23 (53.5%) patients had right CSDH. The mean pre-operative volume of CSDH was 153 ± 53 ml and the mean post-operative volume of CSDH or residual volume was 60.1 ± 33.1 ml. The mean difference in volumes was 93 ± 48 ml (\(P < 0.0001\)). The baseline characteristics of our patients are summarized in Table 1.

**Correlation of residual volume with patient factors**

The large majority of the patients had two burr holes (79%); however, this was not significantly associated with a lower mean residual volume in this group of patients (85 ± 42.9 ml, \(P = 0.88\)). Patients who were using antiplatelet or anticoagulation medication pre-operatively (41.8%) had a higher mean residual volume than those who were not on such regular medication (89.2 ± 52.2 and 82.8 ± 38.4 ml, respectively). However, this was not found to be statistically significant (\(P = 0.646\)). There was also no correlation between residual volume and the usage of drains (\(P = 0.332\)). These results are shown in Table 2.

The Pearson correlation coefficients for the continuous variables were calculated for age (\(r = 0.274, P = 0.075\)), pre-operative GCS (\(r = 0.144, P = 0.356\)), pre-operative midline shift (\(r = 0.154, P = 0.324\)), and chronicity (\(r = 0.154, P = 0.324\)) [Figure 1]. There was no statistically significant association between these variables and residual volume. The mean length of stay was 21.9 ± 23.6 days. There was no significant correlation between residual volume and length of stay (\(r = 0.095, P = 0.54\)). However, the pre-operative

| Number of burr holes | Number of patients (N=43) | Mean residual volume (ml) | Significance (two-tailed) |
|----------------------|---------------------------|--------------------------|--------------------------|
| 1                    | 9                         | 87.5±51.5                | 0.880                    |
| 2                    | 34                        | 85±42.9                  |                          |

| Antiplatelet/anticoagulation | Number of patients (N=43) | Mean residual volume (ml) | Significance (two-tailed) |
|-----------------------------|---------------------------|--------------------------|--------------------------|
| Yes                         | 18                        | 89.2±52.2                | 0.846                    |
| No                          | 25                        | 82.8±38.4                |                          |

| Neurological deficit | Number of patients (N=43) | Mean residual volume (ml) | Significance (two-tailed) |
|----------------------|---------------------------|--------------------------|--------------------------|
| Yes                  | 16                        | 87.6±48.6                | 0.827                    |
| No                   | 26                        | 84.5±43.1                |                          |

| Use of drains | Number of patients (N=43) | Mean residual volume (ml) | Significance (two-tailed) |
|---------------|---------------------------|--------------------------|--------------------------|
| No            | 17                        | 92.4±47.2                | 0.332                    |
| Yes           | 26                        | 81.0±42.4                |                          |

**Figure 1:** Correlation of post-operative residual volume with clinical and CT features: (a) density (b) pre-operative volume (c) age (d) midline shift
volume of CSDH ($r = 0.485, P = 0.001$) was highly significantly associated with the post-operative volume of CSDH. On univariate analysis, it was shown that larger volumes of pre-operative CSDH were associated with a higher residual volume as well.

**Correlation of clinical outcome with patient factors**

A favorable clinical outcome, GOS of 4-5, was found in 26 patients (60.4%), while 17 (39.5%) patients had poor outcome defined as a GOS of 1-3. Six patients developed post-operative complications including myocardial infarction, wound infection, sepsis from pneumonia, stroke, and epilepsy (13%). There were two deaths (4%) from post-operative myocardial infarction and sepsis from pneumonia. There was no correlation between post-operative volume and presence of complications ($P = 0.558$).

Univariate analysis with the factors number of burl holes, use of antiplatelet or anticoagulation medication, neurological deficit, pre-operative GCS, pre-operative midline shift, and post-operative volume of CSDH was not significant ($P > 0.05$). The age of patients with good outcome and poor outcome was statistically significant ($69 \pm 13.0$ and $79 \pm 12.6$ years, respectively; $P = 0.017$). There was also a difference in chronicity between the groups with good outcome ($36.1 \text{ HU} \pm 5.73$) and poor outcome ($51.9 \text{ HU} \pm 6.9$) ($P = 0.039$). Multivariate analysis with stepwise forward logistic regression showed that age was the only significant factor ($P = 0.027$).

**DISCUSSION**

CT brain is one of the most useful diagnostic tests in the management of patients with CSDH. In addition to its role in deciding on the surgical management of the patients, previous studies have investigated the value of pre-operative CT in predicting post-op recurrence, post-op seizures, and clinical outcome. However, there have not been attempts to correlate these pre-operative characteristics with the immediate post-operative brain re-expansion and the relationship between brain re-expansion and clinical outcome. Furthermore, since CT scans are associated with a significant risk of radiation, knowledge of which radiological characteristics could be predictive of brain re-expansion and clinical outcome would help the clinician decide if a post-operative CT scan is necessary in the management of patients with CSDH.

The limitations inherent in our study are the retrospective nature of the study and the lack of a control group. Selection bias was eliminated as patients were selected consecutively and the outcomes of these patients were unknown when they were selected. There were no issues with loss to follow-up as the endpoint selected was GOS at the time of discharge from hospital or after rehabilitation. Performance bias was also eliminated as all the patients were operated on by only two surgeons. The aim of our study was to investigate early CT and its effect on early outcome and management, and hence, we do not have long-term outcome based on residual volumes. Based on previous studies on head trauma, early outcome at or soon after discharge is predictive of long-term outcome. However, we must interpret our study results to mainly indicate that residual volume failed to predict the short-term outcome of the patient on discharge and determination of residual volume had little impact on post-surgical management.

The results of our study show that there is strong positive correlation between pre-operative hematoma volume and total residual post-operative volume. This would suggest that the pre-operative hematoma volume is inversely related to the degree of brain re-expansion. Therefore, a routine post-operative CT brain may be unnecessary to assess brain re-expansion in view of the strong predictive value of pre-operative hematoma volume.

No corresponding relationship between residual post-operative volume and GOS at discharge was found. Based on this observation, we postulate that a lack of brain re-expansion may not necessarily mean a poorer clinical outcome. In our study, multivariate analysis showed that increasing age was the only predictor of poor outcome in our study population.

As CT scans are associated with significant radiation risk and costs, our study indicates that routine early post-operative CT scan provides little additional prognostic information that cannot be obtained from the patient’s pre-operative CT or age. Similar to the recent study by Garrett et al. where they retrospectively analyzed the use of CT in all neurosurgical patients, we concur that routine imaging without a change in neurological status would unlikely be helpful in patients after drainage of their CSDH.

However, individual surgeons may still elect to do an early post-op CT for reasons which may include assessment of complications, baseline CT to assess future decrease or increase of residual, and for documentation of surgical results. These factors remain at the discretion of the individual surgeons. In our study, we have shown that for those surgeons who do not routinely order an early post-operative CT, they can confidently continue to do so.

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REFERENCES

1. Chen CW, Kuo JR, Lin HJ, Yeh CH, Wong BS, Kao CH, et al. Early post-operative seizures after burr-hole drainage for chronic subdural hematoma: Correlation with brain CT findings. J Clin Neurosci 2004;11:706-9.

2. Garrett MC, Bilgin-Freiert A, Bartels C, Everson R, Afsarmanesh N, Pouratian N. An Evidence-Based Approach to the Efficient Use of Computed Tomography Imaging in the Neurosurgical Patient. Neurosurgery 2013;73:209-16.

3. King JT Jr, Carlier PM, Marion DW. Early Glasgow Outcome Scale scores predict long-term functional outcome in patients with severe traumatic brain injury. J Neurotrauma 2005;22:947-54.

4. Lee KS, Bae WK, Bae HG, Doh JW, Yun IG. The computed tomographic attenuation and the age of subdural hematomas. J Korean Med Sci 1997;12:353-9.

5. McMillan TM, Weir CJ, Ireland A, Stewart E. The Glasgow Outcome at Discharge Scale: An Inpatient Assessment of Disability after Brain Injury. J Neurotrauma 2013;30:970-4.

6. Melnick ER, Szlezak CM, Bentley SK, Dziura JD, Kotlyar S, Post LA. CT overuse for mild traumatic brain injury. Joint Commission journal on quality and patient safety. Jt Comm J Qual Patient Saf 2012;38:483-9.

7. Mino M, Nishimura S, Hori E, Kohama M, Yonezawa S, Midorikawa H, et al. Efficacy of middle meningeal artery embolization in the treatment of refractory chronic subdural hematoma. Surg Neurol Int 2010;1:78.

8. Moussa AH, Joshy N. The impact of computed tomography on the treatment of chronic subdural haematoma. J Neurol Neurosurg Psychiatry 1982;45:1156-8.

9. Rahimi-Movaghar V, Rasouli MR, Albright AL. Management of chronic subdural haematoma. Lancet 2010;375:195.

10. Santarius T, Hutchinson PJ. Chronic subdural haematoma: Time to rationalize treatment? Br J Neurosurg 2004;18:328-32.

11. Santarius T, Kirkpatrick PJ, Ganesan D, Chia HL, Jalloh I, Smielewski P, et al. Use of drains versus no drains after burr-hole evacuation of chronic subdural haematoma: A randomised controlled trial. Lancet 2009;374:1067-73.

12. Stanišić M, Hald J, Rasmussen IA, Pripp AH, Ivanović J, Kolstad F, et al. Volume and densities of chronic subdural haematoma obtained from CT imaging as predictors of postoperative recurrence: A prospective study of 107 operated patients. Acta Neurochir (Wien) 2013;155:323-33.

13. Sucu HK, Gokmen M, Gelal F. The value of XYZ/2 technique compared with computer-assisted volumetric analysis to estimate the volume of chronic subdural hematoma. Stroke 2005;36:998-1000.

14. Tahsim-Oglou Y, Beseoglu K, Hanggi D, Stummer W, Steiger HJ. Factors predicting recurrence of chronic subdural haematoma: The influence of intraoperative irrigation and low-molecular-weight heparin thromboprophylaxis. Acta Neurochir (Wien) 2012;154:1063-7.

15. Weigel R, Schmiedek P, Krauss JK. Outcome of contemporary surgery for chronic subdural haematoma: Evidence based review. J Neurol Neurosurg Psychiatry 2003;74:937-43.