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만성 경막하 출혈 환자의 천두술 중 식염수 세척 유무에 따른 재발률

조선대학교 대학원

의 학 과

김 학 성

만성 경막하 출혈 환자의 천두술 중 식염수 세척 유무에 따른 재발률

Recurrence of the chronic subdural hematoma after burr-hole trephination with or without intra-operative saline irrigation

2023년 2월 24일

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Abstract

Recurrence of the chronic subdural hematoma after trephination with or without intra-operative saline irrigation

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Objective : 만성 경막하 출혈은 노령 인구에서 흔히 발생하는 질환으로 보통 천두술을 통한 배액술을 통한 수술적 치료를 시행한다. 다양한 수술적 치료 방법이 알려져 있지만, 현재 최적의 수술법에 대해서는 적립이 되지 않았다. 본 연구에서는 만성경막하 출혈에 대하여 천두술을 통한 혈종 배액술 치료 시행시 식염수 세척술의 유무에 따른 재발율을 비교하여 보다 더 효과적인 수술법을 확인하고자 하였다.

Methods : 2019년 1월부터 2021년 12월까지 본원에서 만성 경막하 출혈에 대한 수술적 치료를 시행한 126명의 환자, 145개의 수술 증례의 자료를 수집하였다. 수술 중 식염수 세척술을 시행하지 않는 91건의 집단과 식염수 세척술을 시행한 54건의 집단을 분류하여, 각 집단의 인구통계학적 특성, 과거병력, 영상학적 특성 및 만성 경막하 출혈의 재발율과 재수술율을 확인하였다.

Results : 만성 경막하 출혈에 대해서 수술적 치료를 시행한 145건의 증례에서 총 33건(22.76%)에서 재발을 확인하였으며, 이중 6건(4.1%)에서 재수술을 시행하였다. 수술 중 세척술을 시행하지 않은 집단에서 25건(27.47%)에서 재발되었으며, 이중 5건(5.49%)에서 재수술을 시행한 반면, 수술 중 세척술을 시행한 집단에서는 8건(14.81%)에서 재발되었으며, 이중 1건(1.85%)에서만 재수술을 시행하였다. 또한, 세척술을 시행한 집단에서 글라스코코마스케일에서 보다 더 좋은 임상적 호전을 확

인하였다. 이외 만성경막하 출혈에 대하여 재발을 일으키는 위험 요인으로 심실세동의 병력으로 항응고제를 복용하는 경우, 수술 전 영상 검사상 비균질성 혈종이 확인되었다.

Conclusion : 본 연구에서는 만성 경막하 출혈의 천두술을 통한 혈종 배액술 시행 중 식염수 세척술을 같이 시행한 경우에 유의한 재발율 및 재수술율의 감소와 임상적 증상의 호전을 확인하였다.

KEY WORDS : 만성 경막하 출혈, 세척술, 재발율

Introduction

Chronic subdural hematoma (CSDH) is one of the most common neurosurgical disease that can occur after head injury, especially in elderly patients[2,14]. In many cases, trauma history is accompanied, but trauma history is often not confirmed. The prevalence of CSDH is increasing with the aging of society[16]. In the past, the cause of CSDH was thought to the repetitive hemorrhage owing to rupture of cortical bridging veins by minor head injury[34]. However, a different opinion has been suggested recently. It is believed that the occurrence of CSDH is not caused by simple trauma, but by the repetition of complex inflammatory reactions and re-bleeding that occur after trauma.[4,6,11,15,29]. This compositive inflammatory reaction is thought to be the main mechanism of CSDH formation.

Approximately, more than 60% of patients have a history of minor head injury[10]. However in many cases, minor trauma is not remembered in elderly patients. Usually small CSDH can be absorbed spontaneously, if neurological deficits are accompanied, surgical treatment is required. The treatment of CSDH is successfully performed through simple surgical procedures such as burr-hole trephination without accompanying disease or additional cerebral hemorrhage. Among the neurosurgical treatments, it is included in relatively simple procedure and requires relatively short learning curve. But the high recurrence rate is a main complication. Its recurrence rate was variously announced at 3.1% to 33.3%[23].

Various surgical methods have been introduced so far, but burr-hole trephination is now considered the most effective surgical methods[18,36]. In addition, it is known that maintaining drainage after surgery has the effect of decreasing the recurrence rate by about half[26,36]. However, there are some controversy over the effect of whether or not to perform intraoperative saline irrigation on the recurrence rate.

Based on our surgical experience, we started the study by determining the performance of intraoperative irrigation could lower the recurrence rate of CSDH. Through this study, we try to prove that the procedure with intraoperative saline irrigation can lower the recurrence rate and reoperation rate of CSDH. Furthermore, the effects of the comorbidity and radiologic feature of hematoma on the recurrence rates and the patient’s prognosis were researched.

Materials and Methods

We retrospectively analyzed the electronic medical records (EMR) and radiologic findings of 205 patients with CSDH who underwent burr-hole trephination in our hospital from January 2019 to December 2021. In all cases, surgery was performed through a single burr-hole trephination. Preoperative computed tomography (CT) or magnetic resonance image (MRI) were performed for diagnostic purposes in all patients. So as to minimize errors, the interpretation of the imaging findings was randomly interpreted by two neurosurgeons. Among them, patients with a follow-up period of less than 3 months, patients with vascular malformation such as arteriovenous fistula and intracerebral hemorrhage were excluded.

A total 126 patients were selected as the population, and a total 145 cases were collected considering the case of bilateral CSDH. There were 98 (67.5%) male and 47 (32.4%) female. The median age was 70.46 years old and there were patients ranging from 26 to 92 years old. We divided all cases into two groups depending on the intraoperative saline irrigation. Fortunately, the surgical technique of two neurosurgeons who performed surgery in this institution could be classified into whether to perform intraoperative saline irrigation as in this study. The group that did not perform the intraoperative saline irrigation was classified as group A (n=91), and the group that was performed the intraoperative saline irrigation was classified as group B(n=54). In group A, we inserted the drain catheter right away and terminated the operation without further treatment. In group B, we performed the saline irrigation through burr-hole using a large amount of saline, and the irrigation through a catheter was also performed using a syringe. Irrigation was continued until the drainage fluid came out in a somewhat clean form. The drainage catheter was connected to the drain bag, and the drainage bag was placed on lower dependent position than the head for smooth drainage. It was maintained for 1 or 2 days and withdrawed in consideration of drain volume and CT findings.

Data collection

Demographic, clinical and radiographic data were collected by electronic medical records. The demographic and clinical data were included: gender, age, direct head trauma, smoking history, medical history(; hypertension, hyperlipidemia, diabetes, cardiovascular diseases, liver diseases, renal diseases, stroke), history of anticoagulant or antiplatelet medication, pre or postoperative Glasgow Coma Scale (GCS), pre or postoperative modified Rankin Score (mRS), hospitalization days. A GCS and mRS were immediately before and 30 days after surgery through medical records in all patients, and the effect of surgical treatment was evaluated through this.

The radiographic data included: operation side, hematoma thickness (thickness on the axil view that identified the maximal length on CT or MRI), midline shifting (more than or less than 10mm), hematoma density characteristics on preoperative CT(Figure 1). All hematomas were classified into four types according to hematoma density: homogeneous, laminar, separated, and trabecular types[20]. And more broadly, it was classified into the homogenous group and non-homogenous group including the rest group.

Recurrence was defined as a case in which existing neurological symptoms deteriorate or new neurological deficit occurs within one month after surgery. Even if there was no additional change in neurologic symptoms, if an increase in the amount of fluid collection was confirmed on the CT scan after one month, it was considered a recurrence.

Statistical analyses

We used the SPSS version 24.0 (IBM Corp., Armonk, NY, USA) software for statistical analysis. Datas were collected on demographic features, clinical history, radiologic factors, clinical outcomes, recurrence and re-operation rate. We performed an univariate analysis to study the relationships between each variable and the recurrence rate of CSDH by applying the Mann–Whitney U test and the Chi-square test. Logistic regression analysis was used to identify the degree for correlation the surgical procedure and the recurrence, and significance was prescribed at a *p* value of less than 0.05.

Results

A total 126 patients; a total 145 cases were successfully treated by burr-hole trephination with closed drainage. Demographic and clinical datas of patients are shown in Table 1. The mean age was 70.5 years. Sexual ratio showed a high incidence in men overall. Group A (n=91) consisted of 61 men and 30 women, and Group B (n=54) consisted of 37 men and 17 women. The initial mean GCS of each group was 13.63±2.7 and 13.85±2.2 in Group A and B. On pre-operative CT, the mean hematoma thickness of Group A was 18.1±6.3 mm and hematomas showed homogenous type in 33 patients, laminar type in 21 patients, separated type in 27 patients and trabecular type in 10 patients. In Group B, the mean hematoma thickness was 18.8±5.2 mm and hematomas showed homogenous type in 15 patients, laminar type in 23 patients, separated type in 4 patients and trabecular type in 12 patients.

The overall recurrence rate was 22.8% and among them, 4.1% of patients needed additional reoperation due to worsening of severe neurological symptoms. Our study showed the differences in the recurrence rate and clinical outcomes depending on whether or not the intraoperative saline irrigation is performed(Table 2). In comparison of the preoperative and postoperative GCS in the two groups, the preoperative GCS showed 13.6±2.7 in Group A and 13.8±2.3 in Group B, but postoperative GCS showed 13.7±3.4 in Group A and 14.8±0.8 in Group B. There were no significant differences of the preoperative GCS, but significant differences were identified in postoperative GCS between two groups, and relatively good outcomes were confirmed in Group B (p=0.032). Ironically, it was confirmed that the recurrence rate was low in the group that performed intraoperative saline irrigation, but the hospital stay period was short.

This is presumed to be an error made from the difference in the characteristics of the two operators. Neurosurgeon who did not perform intraoperative saline irrigation generally transferred to other local hospitals within 5 days for postoperative management.

Recurrence was reported in 33 patients (22.76%), comprised of 25 patients (27.47%) in Group A and 8 patients (14.81%) in Group B. Most recurrences were confirmed in Group A, and statistically significant difference were confirmed (p= 0.048). Moreover, though there are no significant differences in the re-operation rate, but the re-operation rate was confirmed to be high in Group A with 5 patients (5.49%) and 1 patient (1.85%) in Group B.

As a result of analyzing other risk factors through comparison between the recurrence and non-recurrence groups of CSDH, statistical significance was identified in the medication history of anticoagulants and hematoma characteristics(Table 3). In the recurrent group, the history of anticoagulants was identified in 5 patients (15.15%), and in the non-recurrent group, the history of anticoagulants was identified in 2 patients (1.79%). The history of anticoagulants was strongly correlated with the recurrence of CSDH (p=0.027). However, no statistical significance in recurrence rates was found in patients taking antiplatelet drugs such as aspirin and clopidogrel.

There are no significant differences in each hematoma characteristics, but a significant increase in recurrent rate was identified in the non-homogenous hematoma type when largely divided into the homogenous hematoma group and the non-homogenous hematoma group including laminar, separated and trabecular type. In the non-homogenous group, recurrence of 27 patients (81.82%) was confirmed, whereas in the homogenous group, recurrence was confirmed in only 6 patients(18.18%) and there is statistical significance (p=0.039). Although it was a natural result, it was confirmed that the postoperative hematoma thickness, hospital day and re-operate rate were significantly higher in the recurrent group.

Discussion

Surgical treatment of CSDH is probably one of the first surgical technique for neurosurgeon. Commonly, it is usually treated with burr-hole trephination and has a good prognosis. However, it shows a relatively high recurrence rate after surgery, and there are various controversies over detailed surgical methods and risk factors to reduce this. Many risk factors of the recurrence of CSDH have been reported. There were age, gender, antiplatelet or anticoagulant medication, brain atrophy, direct trauma history, bilateral hematoma, hematoma type, diabetes, postoperative posture, time of surgery, surgical procedure, postoperative pneumocephalus, cytokines, alcohol abuse, smoking history and midline shifting[1,3,8,19,20,21,22,26,27,33,35].

Our study attempted to confirm the difference of detailed surgical methods on the recurrence rate of CSDH and the existing risk factors. In principle, it is required to understand the pathophysiology of CSDH. CSDH is a fluid collection consist of various stages of bleeding depending on the production time between the dura mater and arachnoid mater in the subdural space[7]. Conventionally, the cause of CSD was a traumatic head injury inducing tearing of the bridging veins on the brain surface[17,24]. However, this theory is controversial considering that imaging scans performed immediately after head trauma often do not find acute bleeding, that it takes more than four weeks on average to develop neurologic symptoms[9,31], and that the blood pattern is conflicting with a substance of bridging vein[5]. Considering these points, we can assume that acute hemorrhage is not the only source of CSDH formation.

Recently many studies propose there are complex pathway involved in CSDH development. Ellie et. al. reported the main causes of CSDH formation are inflammation, angiogenesis and membrane development[7]. The unnatural membrane surrounding the CSDH has been identified as a source of fluid collection and hemorrhage. Angiogenesis promote the formation of fragile blood vessels within membrane walls and companied with fibrinolysis prevent clot formation. This series of processes causes bleeding tendency, which leads to repeated hemorrhage. An abundance of inflammation markers have been found within the membranes and CSDH[12,32]. It contributes the inflammatory response and promotes membrane growth and fluid collection[7]. Saito et al. [25] reported that the risk of CSDH recurrence increased when high concentrations of these inflammation markers remained after surgery. This can be the physiologic rationale for reducing the recurrence rate of CSDH by burr-hole trephination with saline irrigation, and the same results can be confirmed in our study. In our study, most recurrences were confirmed in intraoperative non-irrigation group, and statistically significant difference were identified. Moreover, the recurrence rate was significantly high in the non-homogenous hematoma group(including, laminar, separated, trabecular type) compared to the homogenous hematoma group. Considering other study showing that the concentration of inflammation markers in the hematoma is higher in the non-homogenous group, it is thought that reducing the concentration of inflammation markers by intraoperative saline irrigation can have a full effect on reducing the recurrence of CSDH.

Contrariwise, Kim et al. [13] reported a higher recurrence rate in saline irrigation group than in non-irrigation group. The author mentioned that the massive irrigation procedure leaves a large amount of air in the subdural space after surgery, and that the air generated in this way suppresses the expansion of the brain parenchyma. In addition, brain cortex damage that occurs during saline irrigation can cause not only recurrence of CSDH, but also acute cerebral hemorrhage, so it is recommended not to perform the irrigation during burr-hole trephination with closed drainage[28,30].

However, if intraoperative saline irrigation is performed, we think that the proper amount of saline injection through drain catheter at the end of surgery can minimize the pneumocephalus and that careful irrigation can prevent brain damage. On the authority of our study, it is thought that we need a more effective and safe procedure that can reduce the postoperative pneumocephalus and brain cortex injury.

Our research has the limitations of retrospective research, research in a single institution, and a relatively small group, and it is thought that it needs to be supplemented. Later, it is judged that a study targeting a larger number of patients, including those from other institutions, is needed. In addition, it seems necessary to study whether there is a clinical improvement in comparing the difference between GCS and mRS before and after surgery.

Conclusion

CSDH is a common disease in elderly patients and the incidence is increasing with aging. In our study, overall recurrence rate after burr-hole drainage was 22.8%. We confirmed a significant increase in recurrence rates in patients with anticoagulation medical history and patients with non-homogenous hematoma type in preoperative CT scan, and a low recurrence rate in the group with intraoperative saline irrigation. Through this, a certain correlation between intraoperative irrigation procedure, hematoma characteristics, and recurrence rate was confirmed. Therefore, we recommend the implement of saline irrigation carefully during burr-hole trephination surgery in CSDH patients.

References

1. Abouzari M, Rashidi A, Rezaii J, Esfandiari K, Asadollahi M, Aleali H, Abdollahzadeh M. The role of postoperative patient posture in the recurrence of traumatic chronic subdural hematoma after burr-hole surgery. Neurosurgery. 2007;61:794–797, discussion 797

2. Almenawer SA, Farrokhyar F,Hong C, AlhazzaniW,Manoranjan B, Yarascavitch B, Arjmand P, Baronia B, Reddy K, Murty N, Singh S. Chronic subdural hematoma management: a systematic review and meta-analysis of 34,829 patients. Ann Surg. 2014;259:449–457

3. Amirjamshidi A, Abouzari M, Eftekhar B, Rashidi A, Rezaii J, Esfandiari K, Shirani A, Asadollahi M, Aleali H. Outcomes and recurrence rates in chronic subdural haematoma. Br J Neurosurg. 2007;21:272–275

4. Bosche B, MolcanyiM, Noll T, Kochanek M, Kraus B, Rieger B, el Majdoub F, Dohmen C, LöhrM, Goldbrunner R, Brinker G. Occurrence and recurrence of spontaneous chronic subdural haematoma is associated with factor XIII deficiency. Clin Neurol Neurosurg. 2013;115:13–18

5. D'abbondanza JA, Loch MR. Experimental models of chronic subdural hematoma. Neurol Res. 2014;36(2):176–88.

6. Drapkin AJ. Chronic subdural hematoma: pathophysiological basis for treatment. Br J Neurosurg. 1991;5:467–473

7. Ellie Edlmann, Susan Giorgi-Coll, Peter C. Whitfield, Keri L. H. Carpenter and Peter J. Hutchinson. Pathophysiology of chronic subdural haematoma: inflammation, angiogenesis and implications for pharmacotherapy. Journal of Neuroinflammation. 2017;14:108

8. Fukuhara T, Gotoh M, Asari S, Ohmoto T, Akioka T. The relationship between brain surface elastance and brain reexpansion after evacuation of chronic subdural hematoma. Surg Neurol. 1996;45:570–574

9. Gelabert-Gonzalez M, Iglesias-Pais M, Garcia-Allut A, et al. Chronic subdural haematoma: surgical treatment and outcome in 1000 cases. Clin Neurol Neurosurg. 2005;107(3):223–9.

10. Gernsback J, Kolcun JPG, Jagid J. To drain or two drains: recurrences in chronic subdural hematomas. World Neurosurg. 2016;95:447-50

11. Ito H, Komai T, Yamamoto S. Fibrinolytic enzyme in the lining walls of chronic subdural hematoma. J Neurosurg. 1978;48:197–200

12. Jang KM, Kwon JT, Hwang SN, Park YS, Nam TK. Comparison of the outcomes and recurrence with three surgical techniques for chronic subdural hematoma: single, double burr hole, and double burr hole drainage with irrigation. Korean J Neurotrauma. 2015;11:75-80.

13. Kim DH, Kim HS, Choi HJ, Han IH, Cho WH, Nam KH. Recurrence of the chronic subdural hematoma after burr-hole drainage with or without intraoperative saline irrigation Korean J Neurotrauma. 2014;10:101-5.

14. Kudo H, Kuwamura K, Izawa I, Sawa H, Tamaki N. Chronic subdural hematoma in elderly people: present status on Awaji Island and epidemiological prospect. NeurolMed Chir. 1992;32:207–209

15. Labadie EL, Glover D. Local alterations of hemostaticfibrinolytic mechanisms in reforming subdural hematomas. Neurology. 1975;25:669–675

16. Lee JK, Choi JH, Kim CH, Lee HK, Moon JG. Chronic subdural hematomas: a comparative study of three types of operative procedures. J Korean Neurosurg Soc. 2009;46:210-214

17. Markwalder TM. Chronic subdural haematoma: a review. J Neurosurg. 1981;54(5):637–45.

18. Muzii VF, Bistazzoni S, Zalaffi A, Carangelo B, Mariottini A, Pal-ma L. Chronic subdural hematoma: comparison of two surgical techniques. Preliminary results of a prospective randomized study. J Neurosurg Sci. 2005;49:41-46; discussion 46-47

19. Nagatani K, Takeuchi S, Sakakibara F, Otani N, Nawashiro H. Radiological factors related to recurrence of chronic subdural hematoma. Acta Neurochir (Wien). 2001;153:1713

20. Nakaguchi H, Tanishima T, Yoshimasu N. Factors in the natural history of chronic subdural hematomas that influence their postoperative recurrence. J Neurosurg. 2001;95:256–262

21. Nakaguchi H, Tanishima T, Yoshimasu N. Factors in the natural history of chronic subdural hematomas that influence their postoperative recurrence. J Neurosurg. 2001;95:256–262

22. Oishi M, Toyama M, Tamatani S, Kitazawa T, Saito M. Clinical factors of recurrent chronic subdural hematoma. Neurol Med Chir (Tokyo). 2001;41:382–386

23. Okada Y, Akai T, Okamoto K, Iida T, Takata H, Iizuka H. A comparative study of the treatment of chronic subdural hematoma--burr hole drainage versus burr hole irrigation. Surg Neurol. 2002;57:405-409; discussion 410

24. Ommaya AK, Yarnell P. Subdural haematoma after whiplash injury. Lancet. 1969;2(7614):237–9.

25. Saito K, Ito H, Hasegawa T, Yamamoto S. Plasmin-alpha 2-plasmin inhibitor complex and alpha 2-plasmin inhibitor in chronic subdural hematoma. J Neurosurg. 1989;70:68-72.

26. Santarius T, Kirkpatrick PJ, Ganesan D, Chia HL, Jalloh I, Smielewski P, Richards HK, Marcus H, Parker RA, Price SJ, Kirollos RW, Pickard JD, Hutchinson PJ. Use of drains versus no drains after burr-hole evacuation of chronic subdural haematoma: a randomised controlled trial. Lancet. 2009;374:1067–1073

27. Scotti G, Terbrugge K, Melancon D, Belanger G. Evaluation of the age of subdural hematomas by computerized tomography. J Neurosurg. 1977;47:311–315

28. Seong HY, Park JB, Kwon SC, Sim HB, Kim Y, Lyo IU. Effect of saline irrigation in the surgical treatment of chronic subdural hematoma. J Korean

Neurotraumatol Soc. 2008;4:19-23

29. Shim YS, Park CO, Hyun DK, Park HC, Yoon SH. What are the causative factors for a slow, progressive enlargement of a chronic subdural hematoma. Yonsei Med J. 2007;48:210–217

30. 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). 2003;155:323-333; discussion 333,

31. Stroobandt G, Fransen P, Thauvoy C, et al. Pathogenetic factors in chronic subdural haematoma and causes of recurrence. Acta Neurochir (Wien). 1995;137(1-2):6–14.

32. Taussky P, Fandino J, Landolt H. Number of burr holes as independent predictor of postoperative recurrence in chronic subdural haematoma. Br J Neurosurg. 2008;22:279-82.

33. Torihashi K, Sadamasa N, Yoshida K, Narumi O, Chin M, Yamagata S. Independent predictors for recurrence of chronic subdural hematoma: a review of 343 consecutive surgical cases. Neurosurgery. 2008;63:1125–1129, discussion 1129

34. TrotterW. Chronic subdural hemorrhage of traumatic origin and its relation to pachymeningitis haemorhhagica interna. Br J Surg. 1914;2:271–291

35. Yamamoto H, Hirashima Y, Hamada H, Hayashi N, Origasa H, Endo S. Independent predictors of recurrence of chronic subdural hematoma: results of multivariate analysis performed using a logistic regression model. J Neurosurg. 2003;98:1217–1221

36. Zakaraia AM, Adnan JS, Haspani MS, Naing NN, Abdullah JM. Outcome of 2 different types of operative techniques practiced for chronic subdural hematoma in Malaysia: an analysis. Surg Neurol. 2008;69:608-615; discussion 616

Table 1. Demographic and clinical characteristics of patients

	Overall (N=145)	Non-irrigation group (N=91)	Irrigation group (N=54)
Age, mean ± SD	70.46 ± 12.49	69.26 ± 13.37	72.48 ± 10.53
Sex, N (%)			
Male	98 (67.59)	61 (67.03)	37 (68.52)
Female	47 (32.41)	30 (32.97)	17 (31.48)
Trauma Hx, N (%).	100 (68.97)	69 (75.82)	31 (57.41)
Hypertension, N (%)	72 (49.66)	48 (52.75)	24 (44.44)
Diabets, N (%)	36 (24.83)	24 (26.37)	12 (22.22)
Cardiovascular disease, N (%)	6 (4.14)	2 (2.20)	4 (7.41)
Stroke, N (%)	13 (8.97)	11 (12.09)	2 (3.70)
Liver disease, N (%)	2 (1.38)	2 (2.20)	0 (0)
Renal disease, N (%)	6 (4.14)	5 (5.49)	1 (1.85)
Antiplatelet agents, N (%)	25 (17.24)	15 (16.48)	10 (18.52)
Atrial fibrillation, N (%)	7 (4.83)	4 (4.40)	3 (5.56)
Anticoagulation, N (%)	7 (4.83)	4 (4.40)	3 (5.56)
Smoking, N (%)	16 (11.03)	11 12.09)	5 (9.26)
Location, N (%)			
Right	68 (46.59)	41 (45.05)	27 (50.0)
Left	77 (53.10)	50 (54.95)	27 (50.0)
Bilateral	19 (13.10)	12 (13.18)	7 (12.28)
Hematoma, N (%)			
Homogenous	48 (33.10)	33 (36.26)	15 (27.78)
Laminar	44 (30.34)	21 (23.08)	23 (45.59)
Separated	31 (21.38)	27 (29.67)	4 (7.41)
Trabecular	22 (15.17)	10 (10.99)	10 (10.98)
Hematoma thickness, mean ± SD (mm)			
Pre-operative	18.36 ± 5.90	18.10 ± 6.25	18.80 ± 5.24
Post-operative	11.68 ± 6.02	11.54 ± 6.59	11.93 ± 4.92
1 month f/u	6.05 ± 4.98	6.54 ± 5.58	5.41 ± 3.96

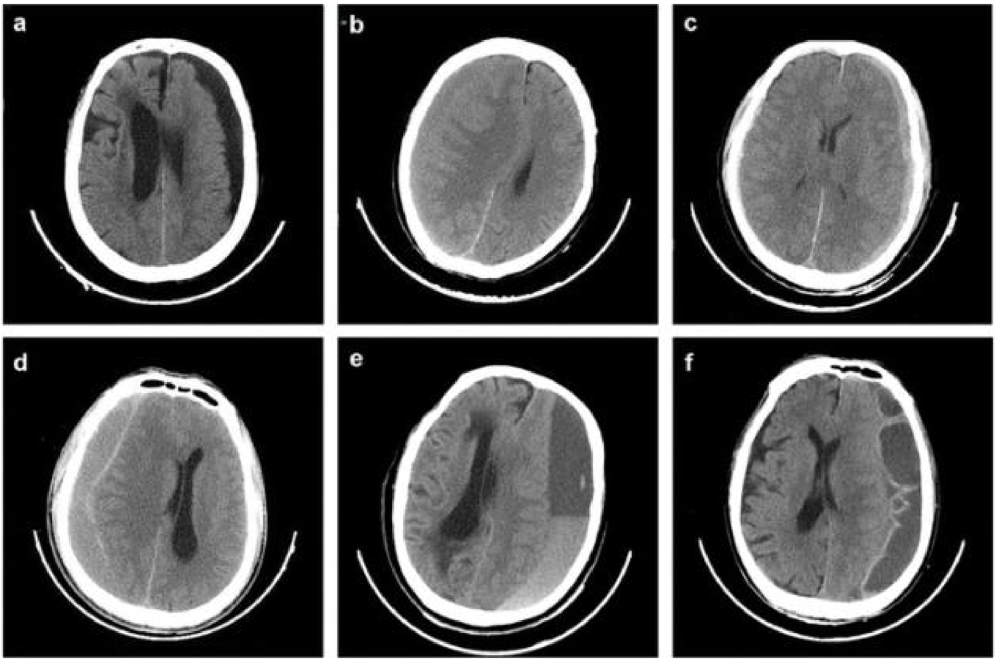
Table 2. Postoperative clinical outcomes and radiologic results according to intraoperative irrigation

	Overall (N=145)	Non-irrigation group (N=91)	Irrigation group (N=54)	*p* -value
Hospital day, mean ± SD	10.46 ± 6.61	9.31 ± 6.95	12.41 ± 5.47	0.000
Pre deviation, N (%)	55 (37.93)	36 (39.56)	19 (35.19)	0.570
Post deviation, N (%)	16 (11.03)	9 (9.89)	7 (12.96)	0.569
Pre GCS, mean ± SD	13.71 ± 2.56	13.63 ± 2.72	13.85 ± 2.25	0.394
Post GCS, mean ± SD	14.10 ± 2.75	13.71 ± 3.36	14.76 ± 0.82	0.032*
Pre mRS, mean ± SD	2.17 ± 1.27	2.21 ± 1.31	2.11 ± 1.20	0.783
Post mRS, mean ± SD	0.97 ± 1.55	1.18 ± 1.73	0.63 ± 1.11	0.129
Recurrence, N (%)	33 (22.76)	25 (27.47)	8 (14.81)	0.048*
Re-operation, N (%)	6 (4.14)	5 (5.49)	1 (1.85)	0.289

Table 3. Patients' characteristics according the recurrence

	Overall (N=145)	Recurred group (N=33)	Non-recurred group (N=112)	*p*-value
Age, mean ± SD	70.46±12.49	71.09±13.36	70.28±12.21	0.481
Sex, N (%)				
Male	98 (67.59)	29 (87.88)	69 (61.61)	0.005*
Female	47 (32.41)	4 (12.12)	43 (38.39)	
Trauma Hx, N (%)	100 (68.97)	22 (66.67)	78 (69.64)	0.746
HTN, N (%)	72 (49.66)	14 (42.42)	58 (51.79)	0.346
DM, N (%)	36 (24.83)	8 (24.24)	28 (25.00)	0.930
Cardiovascular disease, N (%)	6 (4.14)	3 (9.09)	3 (2.68)	0.105
Stroke, N (%)	13 (8.97)	5 (15.15)	8 (7.14)	0.158
Liver disease, N (%)	2 (1.38)	0 (0)	2 (1.79)	0.441
Renal disease, N (%)	6 (4.14)	3 (9.09)	3 (21.43)	0.105
Antiplatelet agents, N (%)	25 (17.24)	3 (9.09)	22 (19.64)	0.273
Atrial fibrillation, N (%)	7 (4.83)	5 (12.12)	3 (21.43)	0.027*
Anticoagulation, N (%)	7 (4.83)	5 (15.15)	3 (21.43)	0.027*
Smoking, N (%)	16 (11.03)	2 (6.06)	14 (12.5)	0.301
Location, N (%)				0.344
Right	68 (46.59)	18 (54.55)	50 (44.64)	
Left	77 (53.10)	15 (45.45)	62 (55.36)	
Bilateral	19 (13.10)	6 (18.18)	13 (11.60)	
Hematoma, N (%)				0.075
Homogenous	48 (33.10)	6 (18.18)	42 (37.5)	
Laminar	44 (30.34)	12 (36.36)	32 (28.57)	
Separated	31 (21.38)	9 (27.27)	22 (19.64)	
Trabecular	22 (15.17)	6 (18.18)	16 (14.29)	
Hematoma, N (%)				0.039*
Homogenous	48 (33.10)	6 (18.18)	42 (37.5)	
Non-homogenous	97 (66.90)	27 (81.82)	70 (62.5)	
Hematoma thickness, mean ± SD (mm)				
Pre-operative	18.36±5.90	18.21±5.33	18.40±6.06	0.904
Post-operative	11.68 ±6.02	12.12±5.80	11.55±6.08	0.664
1 month f/u	6.05±4.98	10.13±5.02	4.51±4.05	<0.001*
Hospital day, mean ± SD	10.46±6.61	13.45±8.66	9.58±5.57	0.002*
Pre deviation, N (%)	55 (37.93)	11 (33.33)	44 (39.29)	0.537
Post deviation, N (%)	16 (11.03)	4 (12.12)	12 (10.71)	0.821
Pre GCS, mean ± SD	13.71±2.56	13.73±2.60	13.71±2.54	0.636
Post GCS, mean ± SD	14.10±2.75	14.06±2.57	14.12±2.81	0.474
Pre mRS, mean ± SD	2.17±1.27	2.09±1.24	2.20±1.28	0.646
Post mRS, mean ± SD	0.97±1.55	0.97±1.49	0.97±1.57	0.850
Re-operation, N (%)	6 (4.14)	6 (18.18)	0 (0)	<0.001*

Figure 1. Classification of chronic subdural hematoma on brain CT scans



Brain CT scans showing classification of chronic subdural hematoma. a Homogenous hypo-dense. b Homogenous iso-dense. c Homogenous hyper-dense. d Laminar hematoma. e Separated hematoma. f Trabecular hematoma.