
SAFETY OF OPEN DRAINAGE IN CHRONIC SUBDURAL HEMATOMAS : A PROSPECTIVE STUDY OF 189 CASES

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RÉSUMÉ: L'hématome sous dural chronique est l'une des hémorragies intracrâniennes les plus fréquentes. Il se voit particulièrement chez les sujets âgés. Sa physiopathologie n'est toujours pas entièrement élucidée et il n'existe pas de «gold standard» en matière de traitement. Le drainage fermé a été définitivement adopté dès les années 80 et ce afin de diminuer le risque infectieux qui est relativement élevé lors du drainage ouvert. Cependant, le drainage fermé nécessite un matériel qui n'est pas toujours disponible ou trop cher dans certains pays à faibles revenus, ce qui a justifié notre préférence envers le drainage ouvert, que nous avons réintroduit au milieu des années 90, avec des résultats jugés satisfaisants. Afin d'évaluer l'efficacité et la sûreté de cette méthode du drainage ouvert, nous avons mené une étude prospective, qui a concerné 189 patients adultes présentant un hématome sous dural chronique, durant la période allant de Janvier 2008 à Décembre 2011. Tous les patients ont été traités selon le même protocole et ont été opérés à travers un trou de trépan, avec évacuation spontanée de l'hématome et drainage ouvert dans le pansement. L'étude a été focalisée principalement sur les complications infectieuses, les survenues de convulsions post opératoires, les récidives et le devenir du patient. De cette série de 189 patients, 163 ont été guéris, 15 ont gardé des séquelles et 11 sont décédés. Le taux global des complications était de 15,34% avec un taux d'infection de 1,58% et de convulsions post opératoires de 1,05%. Le taux de récurrence était de 14,8%. Ces résultats sont en concordance avec ceux de la littérature. Cette étude suggère que le drainage ouvert est une méthode efficace et sans danger pour le traitement de l'hématome sous dural chronique de l'adulte. Il s'agit aussi d'une option qui offre un bon rapport cout-efficacité et qui par conséquent peut être très intéressante pour les pays en voie de développement. .

Mots clés : *Hématome sous dural chronique, Drainage ouvert, infection, Technique chirurgicale*

ABSTRACT: Chronic subdural hematoma is one of the most frequent intracranial hemorrhages in adults. It is a common disease in elderly. Its pathophysiology remains unclear and the Gold standard treatment is still not well defined.. Since the 80's, closed drainage has become a standard in techniques using drains because the open type has been incriminated in high rates of postoperative infections. However, closed drainage requires equipment which is sometimes not available or expensive in low income countries, that's why, open drainage was reintroduced in our department in the middle of the 90's. In order to assess safety and efficacy of open drainage in treatment of chronic subdural hematomas, we have conducted a prospective study from January 2008 to December 2011 and collected 189 patients. All these patients were managed by the same protocol. The surgical procedure included one burr-hole craniostomy, spontaneous evacuation and open drainage in each case. The study focused on infectious complications, postoperative seizures, recurrences and outcome. Results of the study are compared with those of literature. The mean age was 69.2 years and 113 patients have associated disease. Among the 189 operated patients, 163 were cured, 15 had disabilities and 11 died. Overall rate of complications was 15.34% with an infection rate of 1.58%, a postoperative seizure rate of 1.05% and a recurrence rate of 14.2%. All results were in concordance with those of large series of literature. The data of the current study suggest that open drainage is a safe and efficient method in treatment of chronic subdural hematoma. Moreover, its low cost makes it a treatment that could be very interesting for medium and low income countries.

Key words : *Chronic subdural hematoma, open drainage, infection, surgical technique*

INTRODUCTION

GENERAL FEATURES

Chronic subdural hematoma (CSH) is one of the most frequent intracranial hemorrhages [8]. It is a common disease in elderly [8, 31]. The incidence increases gradually from 1 to 8.2 cases in 100.000 per year in the sixth and seventh decade of life [2, 26, 34, 67, 74]. The disease will be more frequent in coming years with increase of life expectancy [37, 68]. CSH is consecutive to trauma in a large proportion with a frequency varying from 56 % to 80% [10-12, 16, 23, 27, 66]. The other risk factors include coagulopathies, therapeutic anticoagulation, antiplatelet agents, alcohol abuse, epilepsy, and intracranial hypotension [1, 13, 17, 20, 24, 29, 48, 63, 67, 77]. Chronic subdural hematoma has been described to arise in patients who had presented an acute subdural hematoma or hygroma [39, 47, 49, 53, 78]; but the latter is more related to the disease. However the real mechanisms of pathophysiology are not totally elucidated. Although CSH is frequently observed, there is no gold standard for treatment. There are several techniques. The most used are craniostomy by burr hole or twist drill with or without irrigation, and with or without drainage [19, 22, 25, 26, 28, 31, 35, 36, 43, 50, 55, 64, 65, 69, 77, 81]. Drainage seems to be a must for several authors [33, 38, 41, 44, 45, 56, 69, 71, 75, 80]. Closed system drainage is used since the mid of the 80's because open drainage has been incriminated in high rates of infection [42, 46, 57, 76]. However closed drainage requires material which can be not available or can be expensive in some instances particularly in low and medium income countries. In our department we have reintroduce the open drainage in the mid of the 90's. We have observed good results and no increase of infections rate; that's why we have conducted a prospective study to assess the safety and efficacy of open drainage.

PATIENTS AND METHODS

The prospective study was conducted from January 2008 to December 2011 in the department of neurosurgery at the Academic Hospital Mustapha Pacha Algiers. A total of 189 consecutive patients were managed by the same protocol. Age of patients varies from 18 to 96 years with a mean of 69.4 years. There was a male predominance (144 patients). 113 patients have associated disease including cardio-

vascular disease, diabetes, anticoagulation therapy and neoplastic formations. Trauma was the most common etiology with a frequency of 70.5%. We didn't find any etiology in 32 patients (16%). Patients were clinically assessed by using the Markwalder's score (Table 1) and Glasgow coma scale. Grade 1 and 2 were present in 54% of cases while grade 3 and 4 were present in 46%. All patients were explored by CT scan. The hematoma was bilateral in 20%. A total of 241 cavities were explored. The lesion was homogeneous (hypodense, isodense and hyperdense) in only 30.6%. The remaining cavities were heterogeneous (mixt, layered and compartmentalized).

Markwalder's Grade	Number (%)
1	15 (7.9)
2	83 (43.9)
3	88 (46.5)
4	03 (1.5)

Table 1. Distribution of clinical grades according to Markwalder's grading

MANAGEMENT

All patients were operated after stabilization including resuscitation in some cases and normalization of coagulation parameters. Patients underwent surgery in the operative room. Surgery was performed under local anesthesia associated to sedation in 102 patients. The other patients were operated under general or local anesthesia. During surgery, patients were placed in supine position with head elevated and rotated 30 degrees to opposite side in cases of unilateral lesions. The head was not turned in bilateral hematomas. Bilateral hematomas were all operated simultaneously. Surgery consisted of one burr hole made on the thickest part of the hematoma according to the preoperative CT scan. The dura was incised and coagulated by bipolar coagulation.

The outer membrane was then divided. The hematoma was spontaneously evacuated. The drain which is constituted by a finger of sterile glove was then inserted (Fig. 1). The skin was closed afterward. Drainage was open in the dress. In the postoperative period patients were hyper hydrated intravenously with 2000 ml of glucose solution 5% every 24 hours during 48 hours. Patients were kept at flat bed rest during this period. The dress was not manipulated during the 48 postoperative hours. We didn't use

antiepileptic prophylaxis. The drain was removed after 48 hours, and Patients were then discharged. Postoperative CT scan was not done systematically and was reserved only to patients who did not show improvement or those who presented a neurological worsening.



Fig. 1: Photos showing the drain and its location in the burr hole

All patients underwent a clinical and radiological assessment at 1 month after surgery. Recurrence was considered when the patient presented a reappraisal or a worsening of the symptoms with a consequent radiologic image. All patients were reoperated using the same technique. Follow-up of patients was continued till 6 months after surgery. Results were then collected.

RESULTS

Final results were collected after 6 months. 163 patients were cured (86.2%), 15 patients presented disabilities (7.9%) and 11 patients died (5.8%); mortality was observed in the early postoperative period. No other patients died during follow-up.

A total of 29 patients presented postoperative complications (Tab 2) with an overall rate of 15.34%. Some patients had more than one complication.

Three presented acute subdural hematoma and all were reoperated. In all cases

the bleeding was from the dura. Two of these patients died. Intraparenchymal hematomas were observed in 2 patients who were medically managed. One of these patients died. Compressive pneumocephalus occurred in 4 cases. Two of them were treated surgically and the two others by massive oxygeno-therapy. One of the patients treated surgically died. Infections were observed in 3 patients (1.58%). Two of them, who both had a history of diabetes, had superficial wound infections and the third presented a meningitis. The infection was diagnosed within the first week after surgery in all cases. There was no empyema. All patients with infectious complications were treated by intravenous antibiotherapy. The patient with meningitis developed also pneumonia and died despite an adapted treatment; he was 84 years old with a history of stroke. Postoperative seizures were observed in 2 patients (1.05%). The onset of seizure was within the 72 hours of surgery in the 2 cases. No complications due to traumatic handling of the drain were noticed. Reoperation for recurrence was performed in 27 patients (14.2%). In all cases we used the initial technique. Recurrences were mainly observed in mixt and hyperdens lesions with a rate of recurrence of 2.7% for hypodenses lesions and 25% for hyperdens lesions; the difference was statistically significant ($X^2 = 6.64$, $p \leq 0.005$).

Type of complication	Number (%)
Acute subdural hematoma	03 (1.58)
Intraparenchymal hematoma	02 (1.05)
Controlateral CSH	02 (1.05)
Compressive pneumocephalus	04 (2.11)
Subarachnoid hemorrhage	02 (1.05)
Superficial infection	02 (1.05)
Deep infection (meningitis)	01 (0.52)
Seizures	01 (1.05)
Temporary acute agitated delirium	05 (2.64)
Pneumopathy	06 (3.17)
Unbalanced diabetes	04 (2.11)
Unbalanced arterial hypertension	03 (1.58)
Stroke	01 (0.52)

Table 2. Detail of complications observed in a total of 29 patients

Postoperative mortality rate was 5.8% (11 patients), due to different causes (Tab 3). Ten of the patients who died had presented postoperative complications, such as acute subdural hematoma, intraparenchyma hematoma, compressive pneumocephalus and severe infections.

Age	Associated disease	Grade	Cause of mortality
60	Multiple myeloma and diabetes	3	Intraparenchymal hematoma
60	Valve replacement and hypertension	3	Acute subdural hematoma
63	Coronary stenosis operated	3	Stroke
75	Hepatitis and thrombophlebitis	3	Multi organ failure
78	Hypertension and diabetes	4	Unbalanced diabetes
79	Leukemia and pacemaker	3	Complications of leukemia
84	Manic-depressive	3	Acute subdural hematoma
84	Stroke	3	Meningitis
86	Diabetes	3	Unbalanced diabetes
92	Diabetes	3	Pneumopathy
93	Prostate adenoma	3	Compressive pneumocephalus

Table 3. Causes of mortality in a total of 11 patients

DISCUSSION

Multiple modalities of treatment of chronic subdural hematomas exist. Standard approaches include craniotomy by either burr hole or twist drill, evacuation of the hematoma with or without irrigation and in most instances drainage. Defenders of drainage argued that this latter will allow brain expansion by progressive evacuation of residual fluid after spontaneous evacuation or irrigation of the cavity ; it seems also diminish early complications [33, 41, 44, 45, 69, 71, 75, 80]. Since the mid of the 80's, all series reporting treatment with drainage used a system of closed-drainage.

This attitude was adopted because open drainage has been incriminated in high rates of postoperative infections [42, 46, 57, 76]. In our series the rates of superficial and deep infections were respectively 1.05% and 0.5%. In literature, the rate of superficial infections ranged from 0.2% to 1.5% [21, 25, 36, 47, 76] while the rate of deep infections varied from 0.7% to 5.5% [12, 18, 26, 35, 60-62, 65, 73, 76]. Deep infections can be life-threatening as it was the case in our series. In the present series, rates of infections were consistent with those of literature in spite the use of open drainage. We think that it is due to the fact that the dress is made under aseptic conditions in the operative room and is not manipulated till the ablation of the drain. But large studies are needed to confirm our explanation. Postoperative seizures are reported to occur in 0.5% to 8% of cases [8, 9, 14, 62, 65, 73].

In our study the rate was 1.05%. Some studies have incriminated drains in occurrence of post operative seizures [4, 52, 55, 71]. We think that the rate observed in the present series is in relation with the nature of the drain which is very

soft. Indeed, other complications can occur with classical drains such as bleeding from capsules or cortex, occlusion, and exceptionally rupture [7, 25, 32, 55, 58]. It is of note that we didn't observe complications in relation with the drain. Regarding recurrence rates, a review of the literature reveals that this latter occur in 0% to 37% [1, 5, 6, 15, 21, 24, 30, 34, 35, 55, 56, 62, 65, 67, 72, 79, 81]. We have observed 14.2% of recurrences ; they were mainly observed in mixt and hyperdense lesions. Recurrences seem to be in relation with the preoperative density of the lesion and consequently with the inflammatory status of the hematoma as observed by some authors [3, 26, 34, 51, 54].

Overall results of the present series are in total concordance with those of large series of the literature [7, 10, 12, 27, 35, 36, 40, 47, 59, 60-62, 66, 67, 70, 81].

CONCLUSION

CSH is one of the most frequent affections encountered in daily practical of neurosurgery. In spite of this there is little consensus about treatment. Several approaches are described with equivalent results. One burr hole trepanation combined with open drainage is an effective, safe and easy technique. The overall rates of complications and outcome of this procedure are well within other forms of treatment. It is also a cost-efficient modality of treatment; so it could be a very interesting method for treatment of CSH regarding health care expenditure. However, large studies are needed to confirm our results, that's why we should initiate a multicentre study to confirm our results.

DISCLOSURES

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RÉFÉRENCE

- 01] ADHYAMAN V, ASGHAR M, GANESHARAM KN, BOHWMICK K. Chronic subdural haematoma in the elderly. *Postgraduate Medical Journal* (2002) 78: 71-75
- 02] AMIRJAMSHIDI A, EFTEKAR B, ABOUZARI M, RASHIDI A (2007). The relationship between Glasgow coma / outcome scores and abnormal CT scan findings in chronic subdural hematomas. *Clin Neurol Neurosurg* 109: 152-157
- 03] AMIRJAMSHIDI A, ABOUZARI M, EFTEKHAR B, RASHIDI A, REZAI ESFANDIARI K, SHIRANI A, ASADOLLAHI M, ALEALI H (2007). Outcomes and recurrence rates in chronic subdural hematoma. *Br J Neurosurg* 21: 272-275
- 04] ASFORA W, SCHWEBACH L (2003). A modified technique to treat chronic and subacute subdural hematoma : technical note. *Surg Neurol* 59: 329-332
- 05] BEATTY RA (1999). Subdural hematomas in the elderly: experience with treatment by trephine craniotomy and not closing the dura or replacing the bone plate. *Br J Neurosurg* 13: 60-64
- 06] BENES L, EGGERS F, ALBERTI O, BERTALANFY H (2002): A new screw catheter kit for the bedside treatment of chronic subdural hematomas. *J Trauma* 52: 591-594
- 07] BENZEL EC, BRIDGES RM JR, HADDEN TA, ORRISSON WW (1994). The single burr-hole technique for the evacuation of non-acute subdural hematomas. *J Trauma* 36: 190-194
- 08] BORGER V, VATTER H, OSZVALD A, MURQUARDT G, SEIFERT V, GÜRESIR E (2012). Chronic subdural hematomas in elderly: a retrospective analysis of 322 cases patients between ages of 65 - 94 years. *Acta Neurochir* 154: 1549-1554
- 09] BOURGEOIS PH, SLEIMAN M, LOUIS E, HADDAD G, TOUZET A, FICHTEN A, LEJEUNE JP (1999). L'hématome sous dural chez les patients de plus de 80 ans. *Neurochirurgie* 45 : 124-128
- 10] CAMEL M, GRUBB RL JR (1986). Treatment of chronic subdural hematoma by twist drill craniostomy with continuous catheter drainage. *J. Neurosurg* 65: 183-187
- 11] CAMEL M (2000). Twist drill for treatment of chronic subdural hematoma. *Neurosurg Clin N Am* 11: 515-518
- 12] CAMERON MM (1978). Chronic subdural haematoma: a review of 114 cases. *J Neurol Neurosurg Psychiatry* 41: 834-839
- 13] CHEN JC, LEVY ML (2000). Causes, epidemiology and risk factors of chronic subdural hematoma. *Neurosurg Clin N Am* 11: 399-406
- 14] CHEN CW, KUO JR, LIN HJ, YEH CH, WONG BS, KAO CH, CHIO CC (2004). Early post operative seizures after burr-hole drainage for chronic subdural hematoma: correlations with brain CT findings. *J Clin Neurosci* 11: 706-709
- 15] CHON KH, LEE JM, KOH EJ, CHOI HY (2012). Independent predictors for recurrence of chronic subdural hematoma. *Acta Neurochir (Wienn)* 154 : 1541-1548
- 16] DAKURAH TK, IDRISU M, WEPEDA G, NUAMAH I (2005). Chronic subdural hematoma: review of 96 cases attending the Korle Bi teaching hospital, Accra. *West Afr J Med* 24: 283-286
- 17] DE NORONHA RJ, SHARRACK B, HADJIVASSILOU M : Subdural hematoma : a potentially serious consequence of spontaneous intra cranial hypotension. *J Neurol Neurosurg Psychiatry* 74: 752-755
- 18] DRAN G, BERTHIER F, FONTAINE D, RASENRARIJAE D, PASQUIS P (2007). Efficacité de la corticothérapie dans le traitement adjuvant des hématomes sous duraux chroniques. Etude rétrospective de 198 cas. *Neurochirurgie* 53 : 477-482
- 19] Drapkin AJ (1991). Chronic subdural hematoma : patho physiological basis for treatment. *Br J Neurosurg* 5: 467-473
- 20] EL KADI H, MIELE VJ, KAUFMAN HH (2000). Prognosis of chronic subdural hematomas. *Neurosurg Clin N Am* 11: 553-567
- 21] EDMONDS N, HASSIER WE (1999). New device to treat chronic subdural hematoma – hollow screw. *Neurol Res* 21: 77-78

- 22] ERNESTUS RJ, BELDZINSKI P, LANGERMANN H, KLUG N (1997). Chronic subdural hematoma: surgical treatment and outcome in 104 patients. *SurgNeurol* 48 : 220-225
- 23] FOGELHOLM R, WALTIMO O (1975). Epidemiology of chronic subdural haematoma. *ActaNeurochir (Wien)* 32 : 247-250
- 24] FRATI A, SALVATI M, MAINIRO F, IPPOLITI F, ROCCHI G, RACOCAROLI E, CANTORE G, DELFINI R (2004). Inflammation markers and risk factors for recurrence in 35 patients with post traumatic chronic subdural hematoma. *J. Neurosurg* 100: 24-32
- 25] GAZZERI R, GALERZA M, NERONI M, CANOVA A, REFICE GM, ESPOSITO S (2007). Continuous subgaleal suction drainage for the treatment of chronic subdural haematoma. *ActaNeurochir (Wienn)* 149 : 487-493
- 26] GELABERT-GONZALEZ M, GALERZA M, NERONI M, CANOVA A, REFICE GM, ESPOSITO S (2005). Chronic subdural haematoma: surgical treatment and outcome in 1000 cases. *Clin Neurol Neurosurg* 107 : 223-229
- 27] GRISOLI F, GRAZIANI N, PERAGUT JC, FABRIZI AP, CARUZO G, BELLARD S (1988). Perioperative lumbar injection of Ringer's lactate solution in chronic subdural hematoma : a series of 100 cases. *Neurosurgery* 23: 616-621
- 28] GURELIK M, ASLAN A, GURELIK B, OZUM U, KARADAG O, KARS HZ (2007). A safe and effective method for treatment of chronic subdural hematoma. *Can. J. Neurol. Sci* 34: 84-87
- 29] HAMILTON MG, BEVAN FRIZZEL J, BRUCE I (1993). Chronic subdural hematoma : the role of craniotomy reevaluated. *Neurosurgery* 33: 67-72
- 30] HENNING R, KLOSTER R (1999). Burr hole evacuation of chronic subdural hematomas followed by continuous inflow and outflow irrigation. *ActaNeurochir (Wienn)* 141: 171-176
- 31] HORNS EM, FREIZ-ERFEN I, BRISTOL RE, SPETZLER RF, HARRINGTON TR (2006). Bedside twist drill craniostomy for chronic subdural hematoma : a comparative study. *Surg Neurol* 65: 150-154
- 32] KITAKAMI A, OGAWA A, HAKOZAKI S, KIDOGUSHI J, OBONAL C, KUBO N (1995). Carbon dioxide gas replacement of chronic subdural hematoma using single burr-hole irrigation. *Surg Neurol* 43: 574-577
- 33] KIYMAZ N, YILMAZ N, MUMCU C (2007). Controversies in chronic subdural hematoma: continuous drainage versus one-time drainage. *Med Sci Monit* 13: 240-243
- 34] KO BS, LEE JK, SEO BR, MOON SJ, KIM JH, KIM SH (2008). Clinical analysis of risk factors related to recurrent chronic subdural hematoma. *J Korean Neurosurg Soc* 42: 11-15
- 35] KOTWICA Z, BRZEZINSKI J (1991). Chronic subdural hematoma treated by burr holes and closed system drainage : personal experience with 131 patients. *Br JNS* 5: 461-465
- 36] KRUPP WF, JANS PJ (1995). Treatment of chronic subdural hematoma with burr hole craniostomy and closed drainage. *Br J Neurosurg* 9: 619-627
- 37] KUDO H, KUWAMURA K, IZAWA I, SAWA H, TAMAKI N (1992). Chronic subdural hematoma in elderly people. Present status on Awaji islands and epidemiological prospect. *Neurol Med Chir (Tokyo)* 32 : 207-209
- 38] KUROKI T, KATSUME M, HARADA N, YAMAZAKI T, AOKI K, TAKASU N (2001). Strict closed- system drainage for treating chronic subdural haematoma. *Acta Neurochir (Wienn)* 143: 1041-1044
- 39] LEE K, BAE WK, DOH JW, BAE HG, YUN IG (1998). Review: origin of chronic subdural haematoma and relation to traumatic subdural lesions. *Brain Inj* 12: 901-910
- 40] LEE JY, EBEL H, ERNESTUS RI, KUG N (2004). Various surgical treatments of chronic subdural hematoma and outcome in 172 patients : is membranectomy necessary ? *Surg Neurol* 61 : 523-528
- 41] LIND CRP, LIND CJ, MEE EW (2003). Reduction of the number of repeated operations for the treatment of

- subacute and chronic subdural hematomas by placement of subdural drains. *JNS* 99: 44-46
- 42] LOEW R, KIVELETZ R (1976). Chronic subdural hematomas. In *Hand Book of Clinical Neurology* edited by Vinken PJ and Bruyn GW – North Holland Publishing Company Amsterdam Oxford – Vol 24 Part III : 297-328
- 43] MARKWALDER TM, STEINSEPE, ROHNER M, REINCHENBACH W, MARKWALDER H (1981). The course of chronic subdural hematomas after burr hole craniostomy and closed drainage. *J Neurosurg* 55 : 390-396
- 44] MARKWALDER TM, SEILER RW (1985). Chronic subdural hematomas : to drain or not drain? *Neurosurgery* 16: 185-188
- 45] MARKWALDER TM (2000). The course of chronic subdural hematomas after burr hole craniostomy with and without closed system drainage. *Neurosurg Clin N Am* 11: 541-546
- 46] MELLEGARD P, WISTEN O (1996). Operations and reoperations for chronic subdural hematomas during 25 years period in a well-defined population. *Acta Neurochir (Wienn)* 138 : 708-713
- 47] MORI K, MAEDA M (2001). Surgical treatment of chronic subdural hematoma in 500 consecutive cases: clinical characteristics, surgical outcome, complications and recurrence rate. *Neurol Med Chir (Tokyo)* 41: 371-381, 2001
- 48] MURAKAMI M, MORIKAWA K, MATSUNO A, KANEDA K, NAGASHIMA T (2000). Spontaneous intracranial hypotension associated with bilateral chronic subdural hematomas. *Neurol Med Chir (Tokyo)* 40: 484-488
- 49] MURATA K (1993). Chronic subdural hematoma may be preceded by persistent traumatic subdural effusion. *Neurol Med Chir (Tokyo)* 33: 691-696
- 50] MUZII, BISTAZZONI S, ZALAGI A, CARANGELO B, MARIOTINI L, PALMA L (2005). Chronic subdural hematoma: comparison of two surgical techniques. Preliminary results of a prospective randomized study. *J. Neurosurg Sci* 49: 41-46
- 51] NAGANAMI K, TAKEUCHI S, SAKAKIBARA F, OTANI N, NAWASHIRO H (2011). Radiological factors related to recurrence of chronic subdural hematoma. *Acta Neurochir (Wienn)* 153: 1713
- 52] NAKAJIMA H, YASUI T, NISHIKAWA M, KISHI H, KAN M (2002). The role of postoperative patient posture in the recurrence of chronic subdural hematoma: a prospective randomized trial. *Surg Neurol* 58: 385-387
- 53] OHNO K, SUZUKI R, MASSAOKA H, INABA Y, MONMA S (1987). Chronic subdural haematoma preceded by persistent traumatic subdural collection. *J Neurol Neurosurg Psychiatry* 50: 1694-1699
- 54] OISHI M, TOYAMA M, TAMATANI S, KITAZAWA T, SAITO M (2001). Clinical factors of recurrent chronic subdural hematoma. *Neurol Med Chir (Tokyo)* 41: 382-386
- 55] OKADA Y, AKAI T, OKAMOTO K, IIDA T, TAKATA H, IIZUKA H (2002). A comparative study of the treatment of chronic subdural hematoma – burr hole drainage versus burr hole irrigation. *Surg Neurol* 57: 405-410
- 56] PAHATOURIDIS D, ALEXIOU GA, FTAKOPOULOS G, MIHOS E, ZIGOURIS A, DROSOS D, VOULGARIS S (2013). Chronic subdural hematomas: a comparative study of an enlarged burr hole vs double burr hole drainage. *Neurosurg Rev* 36: 151-155
- 57] PROBST C (1988). Peritoneal drainage of chronic subdural hematomas in older patients. *J. Neurosurg* 68: 908-911
- 58] RAM Z, HADONI M, SAHAR A, SPIEGELMANN R (1993). Continuous irrigation drainage of the subdural space for the treatment of chronic subdural haematoma. A prospective trial. *Acta Neurochir (Wienn)* 120: 40-43
- 59] RAMACHANDRAN R, HEGDE T (2007). Chronic subdural hematomas – Causes of morbidity and mortality. *Surg Neurol* 67: 367-373
- 60] REINGES MHT, HASSELBERG I, ROHDE V, KUKER W, (2000). Prospective analysis of bedside

- percutaneous subdural tapping for the treatment of chronic subdural haematoma in adults. *JN. Neurosurg Psychiatry* 69 : 40-47
- 61] ROBINSON RG (1984). Chronic subdural hematoma: surgical management in 133 patients. *J. Neurosurg* 61: 263-268
- 62] ROHDE V, GRAF G, HASSLER W (2002). Complications of burr-hole craniostomy and closed-system drainage for chronic subdural hematomas : a retrospective analysis of 376 patients. *Neurosurg Rev* 25 : 89-94
- 63] RUST T, KIEMER N, ERASMUS A (2006). Chronic subdural haematomas and anticoagulation or antithrombic therapy. *J Clin Neurosci* 13: 823-827
- 64] RYCHLICKI F, RECCHIONI A, BURCHIANTI M, MARCOLINI P, (1991). Percutaneous twist drill craniostomy for the treatment of chronic subdural haematoma. *Acta Neurochir (Wienn)* 113: 38-41
- 65] SABATIER P (2001). Traitement per cutané des hématomes sous duraux chroniques par twist drill et drainage continu. *Etude rétrospective de 65 cas. Neurochirurgie* 47: 488-490
- 66] SABO RA, HANIGAN WC, ALDAG JC (1995). Chronic subdural hematomas and seizures: the role of prophylactic anticonvulsive medication. *Surg Neurol* 43: 579-582
- 67] SAMBASIVAN M (1997). An overview of chronic subdural hematoma : experience with 2300 cases. *Surg Neurol* 41: 418-422
- 68] SANTARIUS T, HUTCHINSON PJ (2004). Chronic subdural haematoma time to rationalize treatment? *Br J Neurosurg* 18: 328-332
- 69] SMELY C, MADLINGER A, SCHEREMET R (1997). Chronic subdural hematoma – A comparison of two different modalities. *Acta Neurochir (Wien)* 139: 818-826
- 70] STROOTBANDT G, FRANSEN P, THAUVOY C, MENARD E (1995). Pathogenic factors in chronic subdural hematoma and causes of recurrence after drainage. *Acta Neurochir (Wienn)* 137: 6-14
- 71] SUZUKI K, SUJITA K, AKAI T, TAKAHATA T, SANUBE M (1998). Treatment of chronic subdural hematoma by closed-system drainage without irrigation. *Surg Neurol* 50: 231-234
- 72] TORIHASHI K, SADAMASA N, YOSHIDA K, NARUMI O, CHIN M, YAGAMATA S (2008). Independent predictors factors for recurrence of chronic subdural hematoma. *Neurosurgery* 63: 1125-1129
- 73] VAN HAVENBERGH T, VAN CALENBERGH F, GOFFIN J, PLETS C (1996). Outcome of chronic subdural haematoma: analysis of prognostic. *Br J Neurosurg* 1: 35-39
- 74] VOELKER JL (2000). Non operative treatment of chronic subdural hematoma. *Neurosurg Clin N Am* 11: 507-513
- 75] WAKAI S, HASHIMOTO K, WATANABE N, INOH S, OCHIARI C, (1990). Efficacy of closed-system drainage in treating chronic subdural hematoma. A prospective study. *Neurosurgery* 26 : 771-773
- 76] WEISSE A, BERNEY J (1994). Chronic subdural haematomas. Results of a closed drainage method in adults. *Acta Neurochir (Wienn)* 127: 37-40
- 77] WILLIAMS GR, BASKAYA MK, MENEDEZ J, POLIN R, WILLIS B, (2001). Burr-hole versus twist drill drainage for the evacuation of chronic subdural hematoma: a comparison of clinical results. *J Clin Neurosci* 8: 551-554
- 78] YAMADA H, WATANABE T, MURATA S, SHIBUI S, NIKEI H (1988). Developmental process of chronic subdural collections of fluid based on CT-Scan findings. *Surg Neurol* 13: 444-448
- 79] YAMAMOTO H, HIRASHIMA Y, HAMADA H, HAYASHI N, ENDO S (2003). Independent predictors of recurrence of chronic subdural hematoma : results of multivariate analysis performed using a logistic regression model. *J Neurosurg* 98: 1217-1221
- 80] ZAKARIA AM, ADNAN JS, HASPANI MS, NAING NN, ABDULLAH JM (2008). Outcome of 2 different types of operative techniques practiced for chronic subdural hematoma in Malaysia: an analysis. *Surg Neurol* 69 : 608-615.