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Original research evaluation of risk factors in patients with cerebral Haemorrhage requiring ventriculoperitoneal shunt after initial external ventricular drain implantation in Golestan hospital of ahvaz in 2019-2020

Running title: cerebral haemorrhage requiring ventriculoperitoneal shunt

Saleh Rasras
Department of Neurosurgery, School of Medicine, Golestan Hospital, Ahvaz Jundishapur University of Medical Sciences ORCID: 0000-0001-7605-7626
Email: dr.rasras@gmail.com

Hosein Safari
Department of Neurosurgery, School of Medicine, Golestan Hospital, Ahvaz Jundishapur University of Medical Sciences ORCID: 0000-0003-3477-6344
Email: hoseinsafari1382@gmail.com

Armin Jahangiri Babadi
Department of Neurosurgery, School of Medicine, Golestan Hospital, Ahvaz Jundishapur University of Medical Sciences ORCID: 0000-0003-0718-399X
Email: armin57.jb@gmail.com

Mostafa Ahmadi Milasi*
Clinical Research Development Unit, Golestan Hospital, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran ORCID: 0000-0003-0616-1801 and Department of Neurosurgery, School of Medicine, Golestan Hospital, Ahvaz Jundishapur University of Medical Sciences, Tell: +98 61 33204574, Mobile: +98 9139881305
* Corresponding author email: drahmadi67@gmail.com

Arash Kiani
Department of Neurosurgery, School of Medicine, Golestan Hospital, Ahvaz Jundishapur University of Medical Sciences ORCID: 0000-0003-1423-5452
Email: kiani-a@ajums.ac.ir

Elham Farhadi
Clinical Research Development Unit, Golestan Hospital, Ahvaz Jundishapur University of Medical Sciences, Ahvaz, Iran ORCID: 0000-0002-6272-1861
Email: e.farhadi67@gmail.com

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***Abstract*---**Background: A significant number of studies have explored the risk factors in patients requiring a cerebrospinal fluid (CSF) shunt following presentation with hydrocephalus, secondary to various types of cerebral haemorrhage, other brain disorders and complications. In this study, we intend to explore the risk factors in patients with Spontaneous cerebral haemorrhage that require ventriculoperitoneal shunt following initial implantation of an external ventricular drain. Methods: This study was based at the neurosurgery ward of Golestan Hospital in Ahvaz. We looked at all patients between the ages of 17 and 80 years who were admitted between 2019 and 2020 with spontaneous cerebral haemorrhage and were treated with an external ventricular drain (EVD). After the group was filtered for inclusion & exclusion criteria discussed later, their risk factors for dependence on long-term CSF drainage by ventriculoperitoneal shunt were evaluated. Data analysis, both descriptive and statistical were performed by SPSS software version 25. Results: It was observed that old age, brain surgery (except for EVD implantation), presence of underlying comorbidities including hypertension and Diabetes mellitus, duration of intubation categorised into three classes, <7 days, 7-14 days and >14 days, daily EVD quantity, EVD duration, distance from burr hole entry to the EVD exit site, CSF infection, Fisher grade, Number of ventricular hemorrhages, level of consciosness associated with dependence on ventriculoperitoneal shunt following initial implantation of an external ventricular drain. Conclusion:There are a number of risk factors that are associated with long term dependence of ventriculoperitoneal shunt following initial implantation of an external ventricular drain. The contribution of each of these risk factors requires further investigation.

Keywords*---Ventricular shunt, external ventricular drainage, hydrocephalus, spontaneous cerebral haemorrhage.***

Introduction

Hydrocephalus is a condition in which cerebrospinal fluid (CSF) accumulates abnormally inside the cavities of the brain. The prevalence of this disease in developing countries is approximately 0.7 per 1000 births, other studies have shown the prevalence to be even higher than this (1). CSF shunts have been used to treat hydrocephalus for over 50 years (2). Congenital and non-congenital factors play a role in the development of hydrocephaly.

Non-congenital hydrocephalus can present at birth or later in life due to various causes including cerebral haemorrhage, tumors, and brain trauma (3). Symptoms include loss of consciousness, nausea, vomiting, headache, dizziness, postural instability, difficulty walking, mild dementia and urinary incontinence. These symptoms may occur simultaneously or individually.

Hydrocephalus can be treated with CSF shunting unless it is complicated by cerebral haemorrhage in which case external ventricular drainage and permanent shunt implantation may be necessary. These invasive devices are associated with complications including recurrent infections, meningitis and intraoperative haemorrhage and may require further surgery to correct these. The devices as well as correction of subsequent complications are also associated with a high financial burden for patients (4). Some papers have reported a greater than 59% incidence of shunt failure within 6 months of placement (5). Additionally, other shunt related complications have been reported in 40% of patients including infection, malfunction, excessive discharge and shunt malformation (6,7).

The clinical status of patients with implanted EVD devices is assessed to review their dependence on long-term drainage and the possibility of EVD removal. Issues such as loss of consciousness, failure to return to baseline status and risks such as EVD displacement associated with transferring patients for CT scans have been noted as significant problems (8). In some third world countries, patients' dependence on the shunt and its further dysfunction results in major economic, social and healthcare costs.

Therefore, in order to reduce and eliminate these risks and adverse effects, a protocol considering the risk factors of a patient's dependence on long-term drainage of CSF is necessary. Where possible, implantation of a ventriculoperitoneal shunt should be considered as the initial surgery or if this is not possible then patients should have a ventriculoperitoneal shunt at the earliest possible opportunity without CT evaluation or catheter clamping to reduce the complications associated with long duration of EVD placement. Examining and identifying these risk factors helps to reduce patients' dependence on shunts. (10)

A significant number of studies have explored the risk factors in patients requiring a cerebrospinal fluid (CSF) shunt following presentation with hydrocephalus, secondary to various types of cerebral haemorrhage, other brain disorders and complications. In this study, we intend to explore the risk factors in patients with cerebral haemorrhage that require ventriculoperitoneal shunt following initial implantation of an external ventricular drain.

Materials and methods

The study is analytical and based on data from the hospital and clinics. Written consent was obtained from the patients. This study was approved by the Ethics Committee of Ahvaz Jundishapur University with the code "IR.AJUMS.HGOLESTAN.REC.1399.115" as a prospective study in 2019 and 2020 in Golestan Teaching Medical Centre of Ahvaz. The aim of this study was to evaluate the risk factors in patients who presented to Golestan Hospital in Ahvaz with spontaneous cerebral haemorrhage requiring ventriculoperitoneal shunting after initial implantation of external ventricular drainage. In this study, we included adults aged between 17 and 80 years who were hospitalised due to cerebral haemorrhage including SAH, ICH, IVH and ICH + IVH and had subsequently had an external ventricular drain inserted. Furthermore, patients were excluded if they died after EVD placement for any reason, if they were transferred to other centers or if they expressed dissatisfaction.

In this study, patients underwent clinical and radiological evaluations upon admission based on approved and applicable treatment parameters. Consciousness levels were assessed and recorded based on the Glasgow Coma Score (GCS) at the time of admission and at later stages. Using radiographic images (CT-Scan) that were available in the hospital's imaging system, the type, location and the number of bleeding ventricles in each patient were assessed and recorded. Fisher grade was also evaluated and recorded based on CT-Scan findings . CSF analysis was performed weekly for all patients and in those with features of meningitis such as fever, analysis was performed earlier on during their admission and the day before their shunt surgery. Other variables such as the type of EVD, the type of commercial set used, the sterile Nelaton Catheter, EVD location, catheter outlet distance from the skin to the burr hole, average daily drainage, other surgery at time of admission including craniotomy and bleeding discharge were also examined. Past history of all the patients were thoroughly investigated and noted. A pre-designed checklist was completed for all subjects, including demographics such as age and gender. Characteristics of clinical relevance like as any underlying disease, history of previous cerebral haemorrhage and history of coagulation issues were looked at. An informed consent was obtained from all patients to use their information for the purpose of participating in this study. Patient information with a significacce level of 0/05 was then analysed with SPSS software version 25 with descriptive and analytical statistics.

Data availability

He data associated with the paper are not publicly available but are available from the corresponding author on reasonable request.

Results

The study included 43 (51.8%) males and 40 females (48.2%). The Chi-square test was used to establish that there was no significant relationship between gender and whether patients did or did not receive a CSF shunt. When assessing age, the patients in the study were grouped as either under age 50 or over age 50 and it was found that the degree of dependence on a CSF shunt increased significantly with age (Table 1).

Table 2 shows the relationship between the 4 groups of intracerebral haemorrhage which are ICH, IVH, SAH, ICH + IVH and whether patients did or did not receive a CSF shunt. It can be seen that no significant relationship is observed between these variables, which shows thate aftaer initial hydrocephalus and implantation in each of the bleedins,other factors have a great effect on the pation,s dependence on the shunt. Patients were categorised into two groups based on whether they had surgery on the day of their admission or is surgery was delayed and no significant difference was observed between the groups. Patients were placed into 7 different groups based on the volume of their bleeding and again the table shows no significant difference was identified between these groups. Whether patients had undergone other brain surgery (except EVD) concurrently did show significant difference (Table 2).

Table 3 shows a significant relationship between the presence of underlying disease(hypertention and diabetesmellitys) and whether or not patients were shunted. There was a significant association between the duration of intubation, in the three categories <7, 7-14, and >14 days and whether or not patients were shunted. A significant relationship was found between the EVD type and EVD shelf life whether or not patients were shunted. However, the findings were not significant regarding the relationship between EVD location and whether or not patients were shunted (Table 3).

The results show a significant relationship between the distance from the empty site to the EVD burr hole and whether or not patients were shunted. A significant relationship was observed between CSF infection and the Fisher grade and whether or not patients were shunted.

According to the findings of Table 5, there was a significant relationship between consciousness level at the time of admission and before and after EVD implantation with whether or not patients were shunted. Also, a significant relationship was observed between preoperative shunt consciousness and ventricular haemorrhage in shunted and unshunted patients (Table 5).

Discussion

This study aimed to investigate the causes of dependence on CSF shunt after spontaneous cerebral haemorrhage in hydrocephalus patients and has demonstrated various variables that fit these criteria. In this study patients were divided into two groups, namely those requiring shunt implantation and those who did not. Different variables in these two groups were then compared and analysed.

In the present study, old age and shunt dependence were associated with an increased risk of shunt dependence, consistent with the results of a 2007 paper by Oliveira et al. Numerous other studies have reported that in-hospital events also contribute to the development of shunt-related hydrocephalus after aneurysmal subarachnoid haemorrhage (SAH), and the duration of external drainage is often cited as an important factor. Furthermore, in patients who require long-term external ventricular drainage, the risk of chronic hydrocephalus after SAH is significantly increased (11, 12).

O'Kelly et al. (2009) stated that employing multiple EVDs indicates an increased duration of drainage, as the prolonged need for drainage is a good indicator for shunt replacement. Similar to the results of this study, they suggested that the need for shunt replacement in these patients may indicate an infection due to extended EVD usage, which is a potential factor in shunt dependence. They further stated that no significant differences in shunt-dependent hydrocephalus were found between those patients with aneurysms treated with clips versus those treated with coils (13). Other similar studies, consistent with the results of this study, have shown that a number of factors are associated with hydrocephalus and postoperative ventricular shunt dependence, including low GCS, severity of SAH and IVH, and patients with cerebral haemorrhage except IVH were seen to require more shunts (14,15).

Contrary to the results of our study, Low et al. found that younger age was associated with post-traumatic hydrocephalus, while in our study, patients over the age of 50 years required more shunt implants (16). While other research, similar to the results of this study have shown an association between older age and persistent hydrocephalus and dependence on post-traumatic shunt (17). Kan et al. reported a high prevalence (40%) of traumatic hydrocephalus requiring ventricular shunting in children without craniotomy (18). High-energy traumatic injuries, more severe brain tissue damage, and lack of brain atrophy in younger people may increase the risk of persistent hydrocephalus symptoms and shunt dependence in young patients after craniotomy (19).

Another study in 2020 found that age of over 65, higher Hunt-Hess grade, modified Fischer scale, the need for EVD, the need for ICU admission, the presence of fever for 5 days or more, infection, and meningitis are some of the factors influencing shunt dependence. The results of this study are very similar to the conclusions of machine learning models. (20).

Postoperative infection is a serious complication, especially in hospitalised patients. Proper management of fever and infectious diseases in the postoperative period may be valuable in preventing shunt surgery and thus improving clinical outcomes (21-23). As observed, the patients in our study who had normal CSF were not significantly shunted.
Another similar study found that predictors of shunt-dependent hydrocephalus in patients with SAH are an increased Graeb's score, lower CSF glucose levels and lower glomerular filtration rates (24).

In 2020, Sanusi et al. stated that the higher Hunt Hess and Fisher grades, the lower grade of Glasgow consciousness, EVD infection, posterior circulatory aneurysm, and older age are shunt-dependent risk factors for subarachnoid aneurysm (25).

Conclusions

In this study, it was observed that overall, older age, lower level of consciousness, meningitis, shorter catheter exit distance from the skin to the burr hole, higher Fisher grade in SAH patients, presence of intraventricular haemorrhage (IVH) and bleeding present in the greater number of ventricles, prolonged endotracheal intubation, use of Nelaton cathater for EVD, longer shelf life of EVD, concomitant surgery, and underlying disease(diabetes mellitus and hypertention) require long-term drainage of cerebrospinal fluid by ventriculoperitoneal shunt.

Table's: 5 **Figure**: 0

Ethic code: Written consent was obtained from the patients. This study ethically approved by the Medical Ethics Committee of Ahvaz Jundishapur University of Medical Sciences (IR.AJUMS.HGOLESTAN.REC.1399.115).

Conflicts of interest:

The authors declare that they have no conflict of interest

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Ethic code:

Written consent was obtained from the patients. This study ethically approved by the Medical Ethics Committee of Ahvaz Jundishapur University of Medical Sciences (IR.AJUMS.HGOLESTAN.REC.1399.115).

Highlights:

- that the degree of dependence on a CSF shunt increased significantly with age

- a significant relationship between the presence of underlying disease and whether or not patients were shunted

- results show a significant the relationship between distance from the empty site to the EVD burr hole and whether or not patients were shunted.

References

1. Zakaria R, Kandasamy J, Khan Y, Jenkinson MD, Hall SR, Brodbelt A, Pigott T, Mallucci CL. Raised intracranial pressure and hydrocephalus following hindbrain decompression for Chiari I malformation: a case series and review of the literature. British journal of neurosurgery. 2012;26(4):476-48. PMID: 22280544
2. Zhou Y, McClelland CM, Lee MS. Increased Intracranial Pressure Without Hydrocephalus Associated With Spinal Cord Tumor: Literature Review. Journal of Neuro-Ophthalmology. 2021;41(1):8-13. PMID: 32826715
3. Kahle KT, Kulkarni AV, Limbrick Jr DD, Warf BC. Hydrocephalus in children. The lancet. 2016;387(10020):788-799. PMID: 26256071
4. Wang Q, Cheng J, Zhang S, Li Q, Hui X, Ju Y. Prediction of endoscopic third ventriculostomy (ETV) success with preoperative third ventricle floor bowing (TVFB): a supplement to ETV success score. Neurosurgical review. 2020 ;43(6):1575-81. PMID: 31691874

5. Reddy GK, Bollam P, Shi R, Guthikonda B, Nanda A. Management of adult hydrocephalus with ventriculoperitoneal shunts: long-term single-institution experience. Neurosurgery 2011; 69(4): 774-780. PMID: 21508873
6. Sampaio GB, Da Silva SC, Romeiro TH, Beggiora PD, Machado HR, Lopes LD. Evaluation of the effects of quercetin on brain lesions secondary to experimental hydrocephalus in rats. Child's Nervous System. 2019;35(12):2299-306. PMID: 31134338
7. Gholampour S, Bahmani M. Hydrodynamic comparison of shunt and endoscopic third ventriculostomy in adult hydrocephalus using in vitro models and fluid-structure interaction simulation. Computer Methods and Programs in Biomedicine. 2021;204(1):106049. PMID: 33780891
8. Madsen PJ, Mallela AN, Hudgins ED, Storm PB, Heuer GG, Stein SC. The effect and evolution of patient selection on outcomes in endoscopic third ventriculostomy for hydrocephalus: a large-scale review of the literature. Journal of the neurological sciences. 2018;385(2):185-91. PMID: 29406903
9. Larsson J, Israelsson H, Eklund A, Lundin-Olsson L, Malm J. Falls and fear of falling in shunted idiopathic normal pressure hydrocephalus—the idiopathic normal pressure hydrocephalus comorbidity and risk factors associated with hydrocephalus study. Neurosurgery. 2021;89(1):122-8. PMID: 33830219
10. Gasslander J, Sundström N, Eklund A, Koskinen LO, Malm J. Risk factors for developing subdural hematoma: a registry-based study in 1457 patients with shunted idiopathic normal pressure hydrocephalus. Journal of neurosurgery. 2020;1(12):0-1. PMID: 31923893
11. Hirashima Y, Kurimoto M, Hayashi N, Umemura K, Hori E, Origasa H, et al. Duration of cerebrospinal fluid drainage in patients with aneurysmal subarachnoid hemorrhage for prevention of symptomatic vasospasm and late hydrocephalus. Neurol Med Chir (Tokyo). 2005;45(4):177-83. PMID: 15849454
12. Ohwaki K, Yano E, Nakagomi T, Tamura A. Relationship between shunt-dependent hydrocephalus after subarachnoid haemorrhage and duration of cerebrospinal fluid drainage. British journal of neurosurgery. 2004;18(2):130-4. PMID: 15176553
13. O'Kelly CJ, Kulkarni AV, Austin PC, Urbach D, Wallace MC. Shunt-dependent hydrocephalus after aneurysmal subarachnoid hemorrhage: incidence, predictors, and revision rates. Journal of neurosurgery. 2009;111(5):1029-35. PMID: 19361256
14. Honeybul S, Ho KM. Incidence and risk factors for post-traumatic hydrocephalus following decompressive craniectomy for intractable intracranial hypertension and evacuation of mass lesions. Journal of neurotrauma. 2012;29(10):1872-8. PMID: 22583391
15. Tian H-L, Xu T, Hu J, Cui Y-h, Chen H, Zhou L-F. Risk factors related to hydrocephalus after traumatic subarachnoid hemorrhage. Surgical neurology. 2008;69(3):241-6. PMID: 17707493
16. Low CYD, Low YYS, Lee KK, Chan SP, Ang BT. Post-traumatic hydrocephalus after ventricular shunt placement in a Singaporean neurosurgical unit. Journal of Clinical Neuroscience. 2013;20(6):72-76. PMID: 23415060

17. Jiao Q, Liu Z, Li S, Zhou L, Li S, Tian W, et al. Influencing factors for posttraumatic hydrocephalus in patients suffering from severe traumatic brain injuries. Chinese Journal of Traumatology. 2007;10(3):159-62. PMID: 17535639
18. Kan P, Amini A, Hansen K, White GL, Brockmeyer DL, Walker ML, et al. Outcomes after decompressive craniectomy for severe traumatic brain injury in children. Journal of Neurosurgery: Pediatrics. 2006;105(5):337-42. PMID: 17328254
19. Kiening K, Schoening W, Unterberg A, Stover J, Citerio G, Enblad P, et al. Assessment of the relationship between age and continuous intracranial compliance. Intracranial Pressure and Brain Monitoring XII: Springer; 2005(3): 293-7. PMID: 16463868
20. Karimy JK, Zhang J, Kurland DB, Theriault BC, Duran D, Stokum JA, et al. Inflammation-dependent cerebrospinal fluid hypersecretion by the choroid plexus epithelium in posthemorrhagic hydrocephalus. Nature medicine. 2017;23(8):997. PMID: 28692063
21. Takizawa T, Tada T, Kitazawa K, Tanaka Y, Hongo K, Kameko M, et al. Inflammatory cytokine cascade released by leukocytes in cerebrospinal fluid after subarachnoid hemorrhage. Neurological research. 2001;23(7):724-30. PMID: 11680512
22. Wostrack M, Reeb T, Martin J, Kehl V, Shiban E, Preuss A, et al. Shunt-dependent hydrocephalus after aneurysmal subarachnoid hemorrhage: the role of intrathecal interleukin-6. Neurocritical care. 2014;21(1):78-84. PMID: 24840896
23. Park YK, Yi H-J, Choi K-S, Lee Y-J, Chun H-J, Kwon SM, et al. Predicting factors for shunt-dependent hydrocephalus in patients with aneurysmal subarachnoid hemorrhage. Acta Neurochirurgica. 2018;160(7):1407-13. PMID: 29766339
24. Yang Y-C, Yin C-H, Chen K-T, Lin P-C, Lee C-C, Liao W-C, et al. Prognostic Nomogram of Predictors for Shunt-Dependent Hydrocephalus in Patients with Aneurysmal Subarachnoid Hemorrhage Receiving External Ventricular Drain Insertion: A Single-Center Experience and Narrative Review. World neurosurgery. 2021. PMID: 33556600
25. Sanusi TD, McLarnon M, Abouharb A. Risk factors of chronic shunt dependent hydrocephalus following aneurysmal subarachnoid haemorrhage. Clinical Neurology and Neurosurgery. 2020;198:106095. PMID: 32763663

Table 1. Evaluation of frequencies of gender and age in the shunted and unshunted patients

Variable	Shunted	Unshunted	P-value
Gender	Frequency (percentage frequency)	Frequency (percentage frequency)	
Male	)49.1(27	(57.1)16	0.48
Female	(50.9)28	(42.9)12	
Age group (years)			
<50	)16.3(9	(53.6)15	0.001
>50	(83.7)46	(46.4)13	

Table 2. Evaluation of frequencies of diagnosis, duration of surgery, volume of bleeding

Variable	**Shunted**	**Unshunted**	**P-value**
Diagnosis	Frequency (percentage frequency)	Frequency (percentage frequency)	
POST ICH	%)10.9(6	%)3.6(1	0.36
IVH	%)25.5(14	%)14.3(4	
SAH	%)29.1(16	%)35.7(10	
ICH+IVH	%)34.5(19	%)46.4(13	
Surgery			
Time of surgery			0.36
First day of admission	(78.12%)50	(20%)1	
Delays in surgery	(21.87%)14	(80%)4	
Surgery on the same admission			
Yes	%)56.4(31	%)28.6(8	0.01
No	%)43.6(24	%)71.4(20	

Table 3. Evaluation of frequencies of presence of underlying disease(hypertention and diabetes mellitus), duration of intubation, duration of EVD placement and location of EVD

Variable	**Shunted**	**Unshunted**	**P-value**
Presence of underlying disease	Frequency (percentage frequency)	Frequency (percentage frequency)	
Yes	(90.9%)50	(42.9%)12	<0.001
No	(9.1%)5	(57.1%)16	
Duration of intubation			
N/A	3(5.5%)	2(7.1%)	<0.001
<7	8(14.5%)	18(64.3%)	
14-7	32(58.2%)	8(28.6%)	
14<	12(21.8%)	0(0%)	
Type of EVD			
Netalon	13(23.6%)	14(50%)	0.015
Set	42(76.4%)	14(50%)	
Duration of EVD placement			
N/A	0(0%)	2(7.1%)	<0.001
<7	2(3.6%)	11(39.3%)	
14-7	33(60%)	14(50%)	
14<	20(36.4%)	1(3.6%)	
EVD placement location			
Left frontal	15(27.3%)	12(42.9%)	0.35
Right frontal	32(59%)	13(46.4%)	
Occipital	8(13.7%)	3(10.7%)	

Table 4. Evaluation of frequencies of location of EVD placement, distance between burr hole and EVD exit site, CSF analysis, Fisher Grade

Variable	**Shunted**	**Unshunted**	**P-value**
EVD placement location	Frequency (percentage frequency)	Frequency (percentage frequency)	
Left frontal	15 (27.3%)	12 (42.9%)	0.35
Right frontal	32 (58.2%)	13 (46.4%)	
Occipital	8 (14.5%)	3 (10.7%)	
The distance between burr hole and EVD exit site			
5>	40 (72.7%)	8(28.6%)	<0.001
>5	15(27.3%)	20(71.4%)	
CSF analysis			
normal	33(60%)	27(96.4%)	<0.001
abnormal	22(40%)	1 (3.6%)	
Fisher grade			
2	2(11.8%)	5(62.5%)	0.3
3	11(64.7%)	2(25%)	
4	4(23.5%)	1(12.5%)	

Table 5. Evaluation of frequencies of consciousness level upon arrival, consciousness level before EVD and shunt implantation, and the number of ventricles containing blood

Variable	**Shunted**	**Unshunted**	**P-value**
Consciousness level upon arrival (GCS)	**Frequency (percentage frequency)**	**Frequency (percentage frequency)**	
=>8	24 (45.5 %)	11 (35.7 %)	0.03
8-13	24 (45.5 %)	11 (37.5 %)	
=<13	5 (9 %)	8 (26.8%)	
Consciousness level before EVD implantation (GCS)			
<=8	33(60%)	8(28.6%)	0.02
8-13	22(40%)	19(67.9%)	
>=13	0(0%)	1(3.5%)	
Consciousness level after EVD implantation (GCS)			
<=8	35(63.6%)	6(21.4%)	0.04
8-13	18(32.7%)	17(60.7%)	
>=13	2(3.6%)	5(17.9%)	
Consciousness level before shunt surgery(GCS)			
<=8	32(58.2%)	1(3.6%)	0.001
8-13	20(36.4%)	1(3.6%)	
>=13	3(5.4%)	26(92.8%)	
Number of ventricular hemorrhages			
0	(25.5%)14	(35.7%)10	0.001
1	(7.3%)4	(0%)0	
2	(16.4%)9	(50%)14	
3	(34.4%)19	(3.6%)1	
4	(16.4%)9	(10.7%)	