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Surgical Management of Moderate Sized Spontaneous Cerebellar Hematomas: Role of Intracranial Pressure Monitoring

Orta Boyutta Spontan Serebellar Hematomlarda Cerrahi Tedavi: İntrakranial Basınç Monitörizasyonun Rolü

Manoj K. TEWARI[1], Manjul TRIPATHI[1], Rewati Raman SHARMA[2], G. P. MISHRA[2], S. D. LAD[2]

[1]Postgraduate Institute of Medical Education & Research, Chandigarh, India
[2]Khoula Hospital, Muscat, Sultanate of Oman

Corresponding Author: Manoj K TEWARI / E-mail: manojktewari@gmail.com

ABSTRACT

AIM: Acute onset spontaneous cerebellar hematoma (SCH) is a neurosurgical emergency with unpredictable natural history and outcome. Specific guidelines are available for management of small (<2.5 cm) and large sized (4.0 cm <) SCH. But, literature is sparse for treatment of moderate sized SCH (2.5-4.0 cm).

MATERIAL and METHODS: In a retrospective analysis of 32 patients, with moderate sized acute SCH, external ventricular drainage (EVD) tube was inserted for evaluation of ICP and evacuation of cerebrospinal fluid. All patients with ICP >25 mmHg underwent emergency SCH evacuation. Postoperatively, EVD was continued for 48-72 hours for ICP monitoring. Patients showing no improvement or persistent ventriculomegaly underwent ventriculoperitoneal shunt (VPS) insertion for the management of hydrocephalus.

RESULTS: 29/32 patients needed operative intervention either in the form of hematoma evacuation or shunt placement. 10 patients improved to GOS 5 and 7 to GOS 4. Overall mortality was 25% (n=8). Despite SCH evacuation, none of the patients with ICP >40 mmHg experienced good outcome (p<0.0001).

CONCLUSION: 47% of patients with moderate sized SCH need surgical evacuation. EVD insertion not only helps in ICP management but also includes the ability to gradually decompress ventricular system by varying the outflow pressure. Apart from radiologic findings, ICP measurement should be a guideline in management decisions.

KEYWORDS: Cerebellar hemorrhage, Hematoma, Intracranial pressure, Outcome, Computed tomography

ÖZ

AMAÇ: Akut başlayan spontan serebellar hematomlar (SSH) doğal seyri ve sonucu tahmin edilemeyen nöroşirürjikal acillerdir. Küçük (<2,5 cm) ve büyük (4,0 cm <) boyutlu SSH'da tedavi için spesifik ilkeler bellidir. Ancak literatürde orta boyutlu (2,5-4,0 cm) SSH'lar için net bir tedavi protokolü yoktur.

YÖNTEM ve GEREÇLER: Orta boyutta akut SSH'u olan, intrakranial basınç monitörizasyonu (İBM) ve beyin-omurilik sıvısı boşaltılması için eksternal ventrikül drenajı (EVD) uygulanan 32 hasta retrospektif olarak incelendi. İntrakranial basıncı 25 mmHg üzerinde olan hastalara acil SSH boşaltılması ameliyatı uygulandı. Postoperatif dönemde EVD, İBM amacıyla 48-72 saat devam ettirildi. Ventrikülomegalisi düzelmeyen veya devam eden hastalarda hidrosefalinin tedavisi amacıyla ventriküloperitoneal şant uygulandı.

BULGULAR: Otuz iki hastanın 29'unda hematomun boşaltılması veya şant takılması amacıyla ameliyat ihtiyacı oldu. 10 hastada Glasgow Sonuç Skoru 5'e, 7 hastada ise Glasgow Sonuç Skoru 4'e yükseldi. Tüm mortalite oranı %25 (n=8) oldu. SSH boşaltılmasına rağmen intrakranial basıncı 40 mm Hg'nin üzerindeki hastaların hiçbirinde iyi sonuç elde edilemedi (p<0,0001).

SONUÇ: Orta boyutta SSH'u olan hastaların %47'sinde cerrahi boşaltma ihtiyacı oldu. EVD yerleştirilmesi sadece İBM'ye yardımcı olmaz aynı zamanda değişken akım basıncı ile ventriküler sistemin tedrici olarak dekompresyonunu sağlar. Tedaviye karar verirken radyolojik verilerden farklı olarak, İBM verileri de göz önünde bulundurulmalıdır.

ANAHTAR SÖZCÜKLER: Serebellar hemoraji, Hematom, İntrakranial basınç, Sonuç, Bilgisayarlı tomografi

ABBREVIATIONS: CSF= Cerebrospinal fluid, **CT=** Computed tomography, **EVD=** External ventricular drain, **GCS=** Glasgow coma scale, **GOS=** Glasgow outcome scale, **ICP=** Intracranial pressure, **NCCT=** Non contrast computerized tomographic scan, **SCH=** Spontaneous cerebellar hematoma, **VPS=** Ventriculo-peritoneal shunt.

INTRODUCTION

Acute onset spontaneous cerebellar hematoma (SCH) constitutes about 5-10% of all cases of non- traumatic intracranial bleeds (4, 8). It usually presents in elderly population with features of raised intracranial pressure (ICP) and acute onset incoordination (giddiness and ataxia) or both. Computed tomography (CT) is an established investigation for the immediate time and cost effective diagnosis that helps in formulating appropriate treatment plan. SCH carries significant mortality and morbidity, if unattended. There is a consensus about non-operative management of small hematomas (<2.5 cm in diameter) and immediate surgical management of large hematomas (4.0 cm <), but the controversy persists regarding optimum management of moderate sized SCH (2.5 to 4.0 cm) (14, 16, 21, 27). There is very limited literature available on the role of ICP monitoring in patients with SCH (11, 23). We have analyzed the ICP findings of 32 cases of moderate sized SCH with discussion of management protocol. Interesting clinico-radiologic findings and the results of the study are presented with discussion over relevant clinical factors directly affecting the management and outcome.

MATERIAL and METHODS

This is a retrospective analysis of 32 patients with moderate sized acute SCH, admitted between May 1996 and December 2003. The clinical data were retrieved from the medical records held at the Khoula Hospital, Muscat, Oman. The cases of SCH measuring less than 2.5 cm and more than 4.0 cm in maximum diameters on CT scan were excluded from evaluation. On admission, all patients underwent standard neurological examination and laboratory investigations. The attending surgeon noted brief history of onset, progression and co-existing illnesses such as hypertension, diabetes mellitus, liver and renal diseases, coagulopathies, and use of medications. Level of consciousness was rated as per Glasgow Coma Scale (GCS) categorizing patients in one of the four groups; 3-8, 9-12, 13-14 and 15. After hemodynamic stabilization, all patients underwent non-contrast computed tomography (NCCT) scan. NCCT was evaluated for fixed parameters i.e. location and maximum diameter of hematoma (cerebellar hemisphere, vermis or both), hydrocephalus (present or absent), intraventricular extension of blood (present or absent), compression of brain stem and fourth ventricle.

As per the protocol, ICP monitoring was performed in all patients with moderate sized SCH, even for patients with good consciousness levels. The rationale was on the presumption that these patients may suffer from sudden deterioration resulting from brain stem compression. ICP was monitored with an external ventricular drainage (EVD) probe, where cerebrospinal fluid (CSF) release was possible with ease, whenever required to lower the raised ICP. The ventricular probe was inserted into frontal horn of lateral ventricle, preferably on the right side. ICP was recorded in four categories; normal (≤15 mm Hg), mildly high (16-25 mm Hg), moderately high (25-40 mm Hg) and severely high (≥40 mm Hg). All patients with ICP ≥25 mm Hg were immediately operated to evacuate SCH as surgical emergency. Bilateral suboccipital craniectomy was performed, followed by opening of dura. A trans-vermian route was chosen for evacuation of midline hematomas, while hemispheric hematomas were approached through relevant hemisphere. Ventricular drain was continued for 48-72 hours, till the patients were weaned off from ventilator and ICP returned to within normal range. EVD was converted into ventriculo-peritoneal shunts (VPS), in patients with persistently raised ICP, despite 72 hours of CSF drainage. Patients in critical neurological condition were managed with mechanical ventilation and received full dose of corticosteroids and mannitol. As a protocol, we did not continue EVD for more than 3 days in order to prevent chances of infection. NCCT head was repeated in cases of fluctuation of consciousness and/or increase in ICP readings. (Figure 1)

The remaining patients with initial ICP in the range of 16-25 mm Hg were continuously monitored for their clinical status and vital signs. All patients with fluctuating level of consciousness and persistently raised ICP underwent surgical evacuation of SCH between 24-48 hours of admission. The Glasgow Outcome Score (GOS) was used as an assessment parameter for patients' outcome at the time of discharge and three months follow up. GOS of 4-5 was defined as good outcome.

Statistical Analysis

The data was analyzed with Spearman ranked sum analysis to evaluate correlation between various factors. The Chi-Square test was used for categorical analysis. In addition, multivariate analysis of variance was used to correlate clinical presentation, ICP readings and clinical outcome.

Literature Review

The literature on SCH was searched on PUBMED by using keywords "cerebellar hemorrhage", "cerebellar hematoma", "spontaneous cerebellar bleed", and "intracranial pressure monitoring". Inclusion criteria were: spontaneous cerebellar hematoma, ICP monitoring and surgical treatment. Excluding criteria was: post traumatic cerebellar hemorrhage.

RESULTS

Demographic Analysis

Total 32 patients (20 males and 12 females) of moderate sized SCH were included in the study. The age ranged between 46 and 80 years. Only 2 patients (both male) were older than 80 years of age. The mean age was 60.4 years and age distribution below and above 60 years was almost equal (Table I, Figure 2).

Co-morbid Illnesses

Twenty-two patients (68.5%) were known hypertensive on medications for 4 to 10 years, 6 patients were diabetic on medications and three patients had ischemic heart disease (on oral anticoagulant) (Table I).

Clinical Profile

Eight (25%) patients presented with acute onset coma

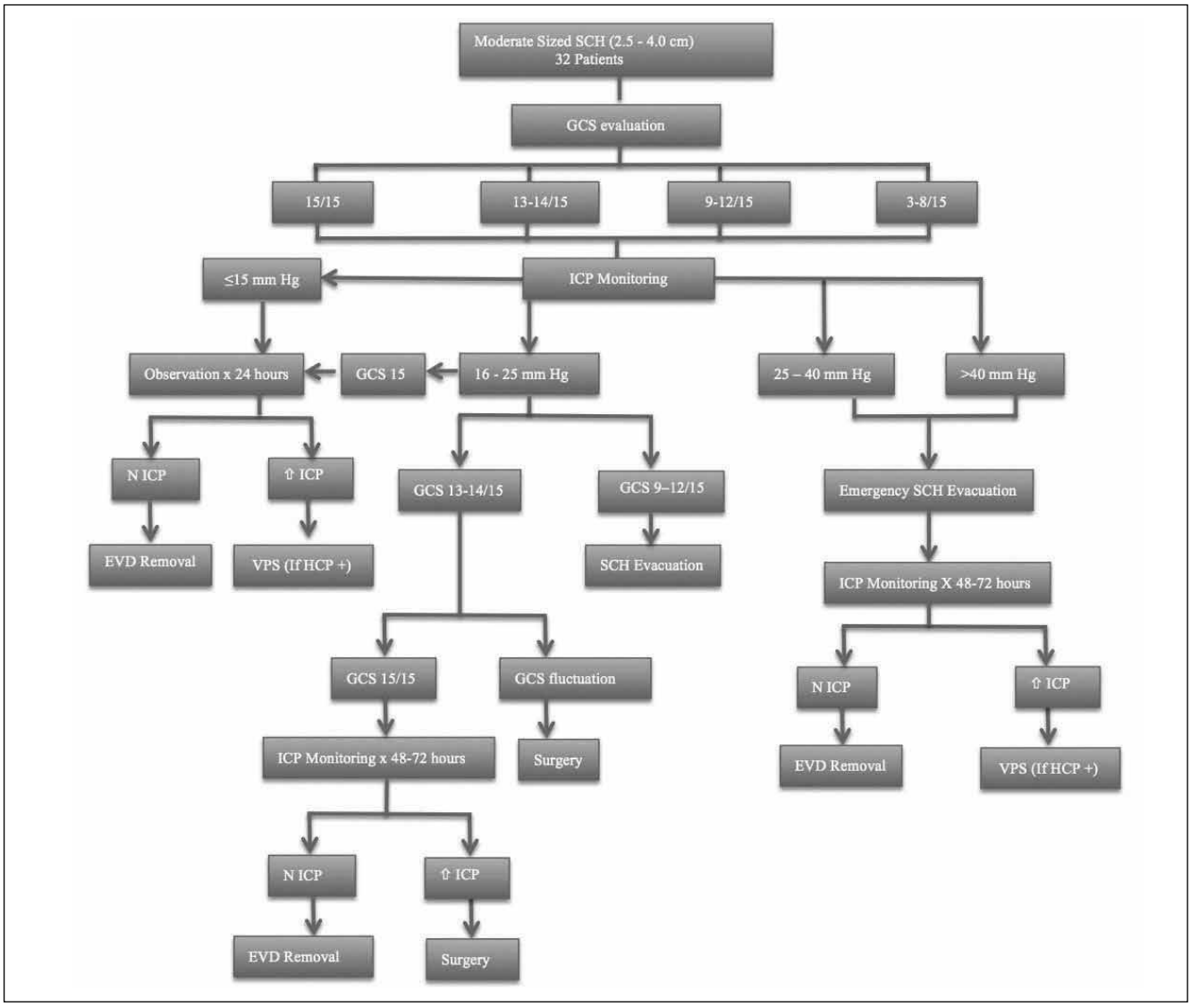

Figure 1: Management protocol for patients of moderate-sized spontaneous cerebellar hematoma (EVD, External Ventricular Drainage; GCS, Glasgow Coma Scale; HCP, Hydrocephalus; ICP, Intracranial pressure; N, Normal; SCH, Spontaneous Cerebellar Hematoma; VPS, Ventriculoperitoneal Shunt).

producing spontaneous SCH. Among the remaining twenty-four (75%) patients, twenty had presented with acute occipital headaches and vomiting while four patients with acute vertigo followed by acute occipital headaches. 2/24 patients, with non-coma producing SCH at the onset, became comatose before reaching the hospital. The analysis revealed significant statistical correlation between opening ICP and GCS at presentation (p=0.002) (Figure 3). In 27 patients, pupils were reacting and normal in size (1-3 mm) but five patients had pupillary dilatation with no response to light. Among 27 patients completely confined to bed, 25 patients needed controlled ventilation. Though remaining 2 patients were ataxic, they had some mobility with assistance. At the time of presentation, vital parameters were stable in majority of the patients. Blood pressure was >150 mm Hg in 18 (56.3%) patients.

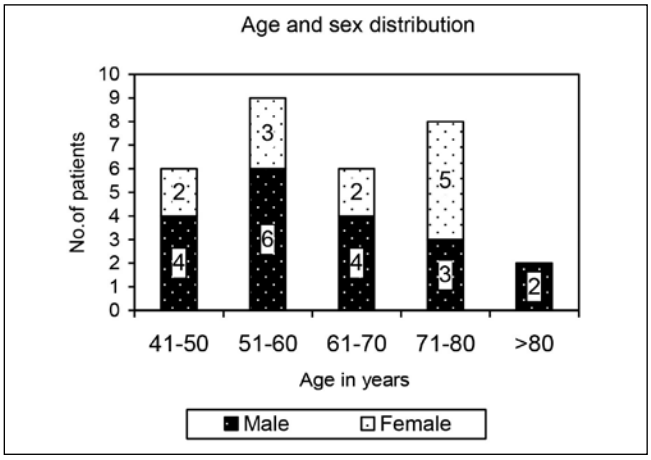

Figure 2: Age and sex distribution of patients with moderate-sized spontaneous cerebellar hematoma.

Radiologic Parameters

On the CT brain scans, SCH was predominantly located in one of the cerebellar hemisphere (lobar) in 24 patients, in vermis in 5 patients and in both locations (cerebellar hemisphere and vermis) in 3 patients. Local mass effect was seen in all patients with variable degree of deformation and compression of the fourth ventricle. Twenty-four (75%) patients had ventricular dilatation and 3 patients had evidence of intraventricular bleed (Table II, Figure 4A-D).

ICP Monitoring and Surgical Management

Interestingly, there was not a single patient with normal ICP findings. ICP readings were mildly high (16-25 mmHg) in 14 patients, moderately high (26-40 mmHg) in 12 patients, and severely high (>40 mmHg) in 6 patients. In two patients, the ICP was in the higher side of the normal range after initial drainage of CSF. All 6 patients with ICP >40 mm Hg and 10 patients with ICP between 25-40 mmHg were immediately operated for SCH evacuation as emergency. EVD was continued for 48-72 hours posts operatively till the patients were weaned off from ventilator and the ICP had returned to

Table I: Clinical Summary of 32 Patients with Moderate Sized Spontaneous Cerebellar Hematoma

Parameters	
Total Patients	32
Male/Female	20/12
Age Range	46-80 years
Mean Age	60.4 years
Mean time between symptom onset and hospitalization	21 hours
Comorbidity • Hypertension • DM • Ischaemic Heart Disease	 • 22 (68.5%) • 6 (18.8%) • 3 (9.4%)
GCS • 15 • 13-14 • 9-12 • 3-8	 • 3 (9.4%) • 4 (12.5%) • 15 (46.8%) • 10 (31.3%)
Site • Vermis • Hemisphere • Vermis + hemisphere	 • 24 (75%) • 5 (15.6%) • 3 (9.4%)
Surgical Management • Only VPS • Only hematoma evacuation • Both VPS and hematoma evacuation	 • 11 (34.4%) • 15 (46.8%) • 3 (9.4%)
Operative mortality	Nil
Overall mortality	8 (25%)
Average duration of hospitalization	19 days

Table II: CT Scan Findings and Intracranial Pressure in 32 Patients of Moderate-Sized Spontaneous Cerebellar Hematoma

CT Findings (Spontaneous Cerebellar Hematoma)						Fourth Ventricle		Ventricular Dilatation	Compression of Quadrigeminal Cistern
Maximum Diameter (cm)	No. of patients	Percentage	Location			Effaced	Compressed		
			Lobar	Vermis	Both				
2.5-3	6	18.75	4 (3^a+1^b)	2 (1^a+1^b)		-	-	2	-
3-3.5	9	28.13	5(2^a+3^b)	2^c	2^c	5	3^c	8	3^c
3.5-4	17	53.13	15(8^a+7^b+1^c)	1^c	1	5	3^c	13	3^c

a*= *mildly high ICP (16-25 mm Hg) [14 patients]*, ***b*= *moderately high ICP (26-40 mm Hg) [9 patients]*, ***c*= *very high ICP (>40 mm Hg) [6 patients].

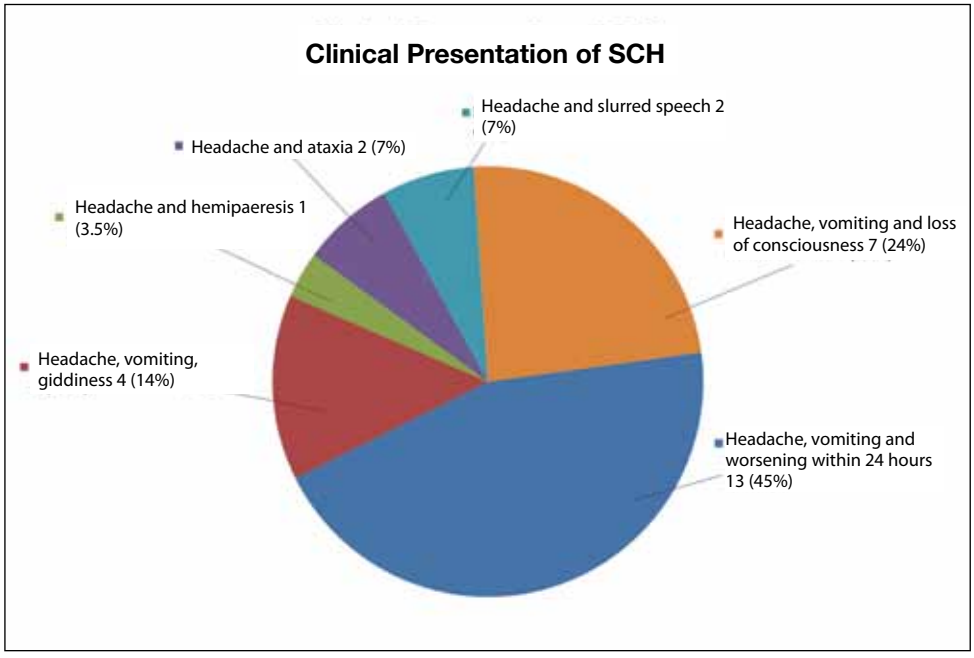

Figure 3: Clinical presentation of patients with moderate-sized SCH (SCH, Spontaneous cerebellar hematoma).

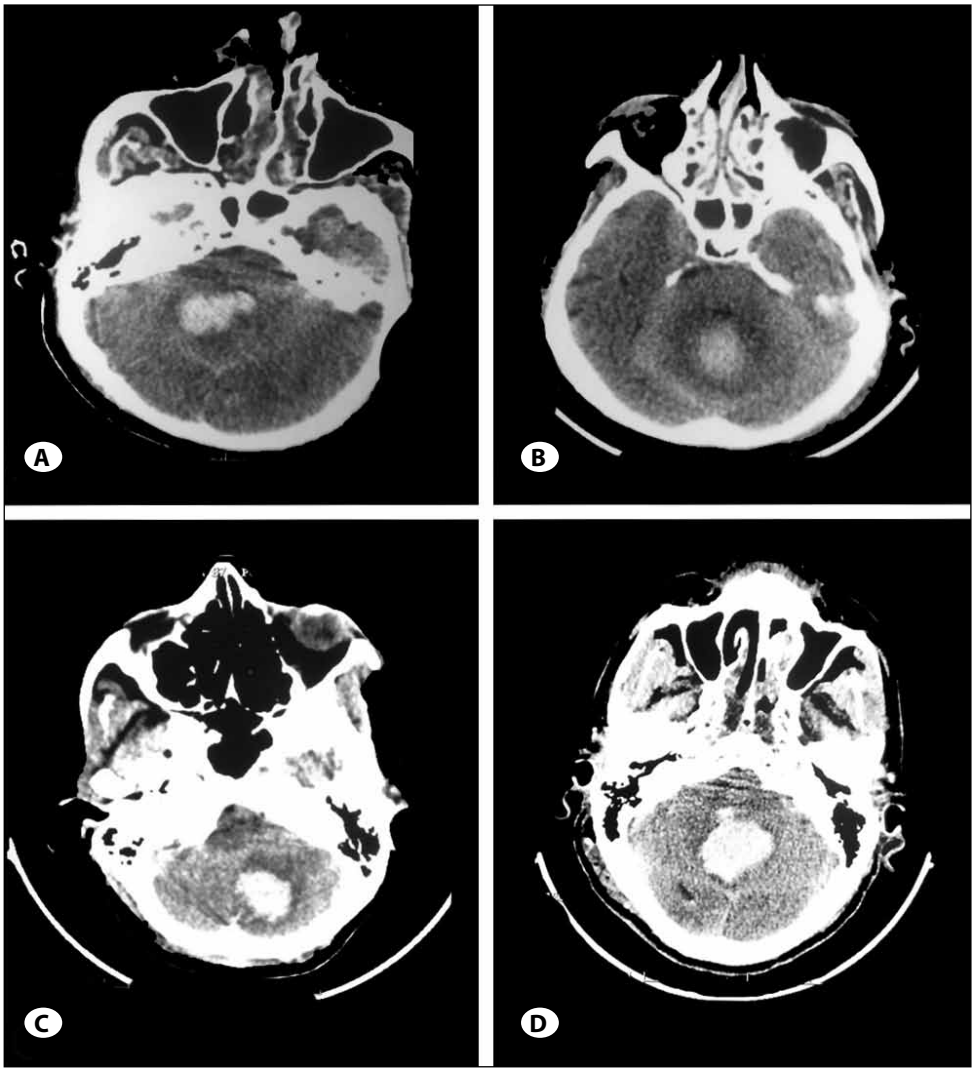

Figure 4: NCCT head showing evidence of lobar **(A, C)** and vermian hematoma **(B,D)** with significant mass effect.

within normal range. In three of these patients, ICP remained high, despite 72 hours of CSF drainage; the EVD was converted into VPS (Table III).

Among the fourteen patients, with initial ICP readings between 16-25 mmHg, GCS was 9-12/15 in seven patients, 13-14 /15 in four and 15/15 in three patients. 11/14 patients underwent surgical evacuation of SCH between 24 to 48 hours following admission in view of fluctuating level of consciousness and/ or clinical symptomatology of raised ICP. In three patients with GCS 13-14, ICP dropped down to normal limits with CSF drainage only; however recurrent vomiting, unremitting severe occipital headaches and persistent ataxia prompted evacuation of SCH after 96 hours of admission. Three patients could be managed non-operatively with excellent outcome. Their CT scans showed gross cerebellar atrophy.

Follow up

At the time of discharge, ten patients improved to GOS- 5, seven patients to GOS- 4, five patients to GOS- 3, two patients GOS-2 and eight patients could not be survived. 6/8 patients with GOS 1 (age group 65-80 years), were comatose (GCS ≤8) from the onset, had very high ICP and emergency evacuation of hematoma did not change their clinical status. Four of these patients had vermian hematoma with brain stem compression and two patients had lobar hematoma with intraventricular extension of blood. Statistical analysis revealed highly significant relation between ICP at presentation and GOS at discharge from the hospital ($p<0.0001$). In these cases, there was obliteration of the fourth ventricle with supraventricular hydrocephalus on the initial CT scans. Four more patients died at three months follow up, two with pulmonary infections and one with large hemispheric infarct. 20% patients were lost to follow up. Only 30% patients could return to normal life (Table IV).

DISCUSSION

Demographic Evaluation

Based on MRI volumetric analysis, the volume of the posterior fossa is approximately 200 cc in men and slightly less in women (3,7). The brain constitutes 80% of this volume and the remaining 20% i.e. 40 ml is equally shared by circulating blood and CSF. So, any SCH of volume 18-20 cc (equivalent to diameter of 32 mm; as volume of a sphere is $4/3\times\pi r^3$ where r is the radius) is likely to cause significant mass effect with any further increase in its size, once this critical volume of CSF space is obliterated (13). Our demographic data is in accordance with the existing literature showing male predominance (3:2). However, we did not encounter any difference in outcome in both sexes.

Etiology

Primary SCH is associated with hypertension, constituting 5-10% of all intracerebral bleeds. It is a localized collection of blood in cerebellar parenchyma in the absence of any radiologically detectable lesion such as aneurysm, AVM, brain tumor, hemorrhagic infarcts and without any history of trauma and vasculopathy. In secondary intracerebellar hematomas, there is usually an underlying pathological

Table III: GCS at Admission of 32 Patients with Moderate-Sized Spontaneous Cerebellar Hematoma and the Correlating Intracranial Pressure Levels

	ICP (mm Hg)			
GCS	≤15	16-25	26-40	≥40
15 (n=3)	0	3	0	0
13-14 (n=4)	0	4	0	0
9-12 (n=15)	0	7	7	1
3-8 (n=10)	0	0	5	5
Total		14	12	6

***GCS,** Glasgow Coma Scale; **ICP,** intracranial pressure.*

Table IV: Management and Outcome of 32 Patients as Per Management Protocol

Initial I CP (mm Hg)	No. Of patients	Initial Treatment		Subsequent Treatment	Mortality	Outcome (GOS) at Discharge				
		VPS	Hematoma evacuation	VPS		5	4	3	2	1
≤15	0	0	0	0	0	0	0	0	0	0
16-25	14	11	0	0	0	9	1	4	0	0
26-40	12	0	12	3	2	1	6	1	2	2
>40	6	0	6	0	6	0	0	0	0	6

***GOS,** Glasgow Outcome Score; **ICP,** intracranial pressure; **VPS,** ventriculoperitoneal Shunt.*

process not directly related to hypertension. SCH is commonly seen in elderly males, who have episodes of cerebrovascular disease in the past (15-72%), hypertension (60-89%) and/or cerebral amyloid angiopathy (8, 12, 15, 16). In our analysis, 68.5% patients were hypertensive. No patient suffered from any hematologic or liver disease. Except for lower incidence of cerebrovascular disease, our findings are in accordance with available literature (8, 15).

Management Protocol and Role of ICP Measurement

Patients with moderate sized SCH, require close neurosurgical observation. We have made an attempt to identify a subgroup of moderate SCH, where an active surgical role may lead to improved outcome. Decision making for this subgroup requires consideration of various prognostic factors, like initial neurological status of patient, disease progression, size and location of hematoma, development of hydrocephalus, and pressure over the fourth ventricle, brain stem and basal cisterns (15). A variety of treatment plans have been suggested including CSF diversion alone (19), CT guided fibrinolysis and aspiration (14), endoscopic third ventriculostomy (17), endoscopic removal of hematoma (26), clot evacuation along with temporary EVD insertion for 3-4 days (16). Though a few authors have expressed their concern about sudden reverse herniation that may occur with EVD placement in SCH (11, 23), other have shown better results with ventricular drainage only. Some clinical series report good outcome with only ventricular drainage in patients with no obliteration of basal cisterns (6, 19, 22). Interestingly, we did not encounter any complication of reverse transtentorial herniation. The presence of tight posterior fossa is a negative prognostic factor. Ventriculostomy alone may be the treatment of choice in patients having hydrocephalus without tentorial herniation or brain stem compression and immediate surgical decompression of posterior fossa may be lifesaving even in deeply comatose patients (25).

Our policy of EVD insertion in all patients of moderate sized SCH aims at continuous ICP monitoring (both pre and post operatively) and controlled drainage of CSF. Though EVD insertion is an emergency surgical procedure, yet it can be safely performed in ICU. It not only prognosticates the course of the disease on the basis of initial ICP readings, but also provides therapeutic benefit by reducing ICP. It also helps in early washout of blood mixed CSF from the ventricles, reducing chances of late onset hydrocephalus and shunt blockage. There was no traumatic complication associated with EVD insertion and in maximum cases (94.75%) and frontal horn could be hit at second attempt. Third attempt was needed only in 2 patients. By clamping of EVD and observing the patient for next 24 hours, we could screen the patients, who needed VPS insertion in addition to SCH evacuation. 3 patients with GCS <12 suffered from ventriculitis resulting in mortality in 2 patients. EVD insertion is a safe surgical procedure with no significant surgical risk and hospitalization time.

Location of hematoma has greater impact on the sensorium decline and elevation of ICP than size of hematoma, as the former is responsible for obliteration of basal cisterns and direct pressure on brain stem (2, 5, 9, 10, 16, 23). In this study, 31% patients (n=10) had large lobar hematoma yet they were preserved (ICP was high to moderately high). In its comparison, patients with vermian hematoma, had rapid worsening and very high ICP, irrespective of their size. In these cases, CT scan revealed compression of basal cisterns with acute dilatation of ventricles. When an alert patient becomes comatose, the mortality rises from 17% to 75-90% (2, 10, 15, 16). Management of comatose patients is controversial and results of surgery are not rewarding, when they present late with decerebration (2, 5, 20). While a few reports have reservations for operating on a patient in deep coma or flaccid paralysis or lost brain stem reflexes for more than two hours (16), others have recommended early decompressive surgery (25). Recent studies indicate that surgical treatment gives better results than conservative management, even in presence of poor prognostic factors. In this study, patients with good neurologic grade had better outcome. All patients with symptomatic worsening after clamping of EVD underwent VP shunt insertion. Overall mortality was 25% and mortality in patients with GCS <8 was 60%, which is in congruity with findings of other authors (1, 6, 24).

Controlled release of CSF helps in transient reduction of ICP preventing chances of sudden neurological deterioration. Initial ICP measurement helps in identification of patients in need of emergent surgical evacuation of hematoma. 8/32 (25%) patients gradually improved with evacuation of hematoma only. This helped in identification of patients who could be managed without a permanent VPS. Avoidance of VPS reduces the chances of long-term shunt related complications such as infection, blockage, under or over drainage etc. 6/10 patients with GCS <12 could not be saved even after EVD insertion and emergency surgical evacuation of SCH. This accounted for 60% mortality in patients with GCS 3-8 ($p<0.01$).

No patient (n=6) with ICP >40 mm Hg could be saved irrespective of EVD insertion and SCH evacuation ($P<0.001$). Statistical analysis revealed a statistically significant correlation among ICP >25 mm Hg and GCS <12. All patients with ICP ≤25 mm Hg were survived irrespective of their GCS at the time of presentation. This highlights the possibility of raised ICP as a primary causative factor for poor GCS and outcome.

Role of Radiological Parameters

CT scan has undoubtedly proven its role in the diagnosis and semiological management of patients with SCH. The value of CT scan in early diagnosis, evaluation of tight posterior fossa, serial management and timely management is proven by the drastically reduced mortality rates from 73.5% to 20% over a course of three decades (10, 11, 18). The concept of tight posterior fossa is of significant value in guiding further management. The fourth ventricular compression and tight

posterior fossa should also be considered with other factors such as GCS and ICP.

Outcome

Life threatening consequences are more frequent in intracerebellar hematomas as compared to the subcortical white matter hematomas. We did not encounter any operative mortality. The overall mortality was 25% (n=8). Literature reveals a 40%-56% mortality rate at 3 months follow up. However, advanced age is not necessarily a negative prognostic factor for outcome as long as intervention is immediately performed. EVD proves quite cost effective as with ICP monitoring, a significant number of patients could be managed without surgical evacuation of hematoma or permanent shunt insertion, decreasing associated surgical morbidity, mortality and cost of hospitalization.

CONCLUSION

A significant number of patients with moderate sized SCH (47%) need surgical evacuation. Outcome is far better in patients with good GCS, near normal or slightly raised ICP and hemispheric hematoma. Vermian hematomas carry a poor clinical outcome probably because of direct brainstem compression and obstructive hydrocephalus. Further studies on larger volume of patients are needed to shed more light on the factors of clinical importance in the management of moderate sized SCH. This study suggests that apart from the size and location of hematoma, fluctuating GCS, persistently raised ICP and unremitting clinical symptomatology are important determinants of operative management. EVD insertion and controlled CSF drainage were sufficient to tide over the acute crisis in some patients, who could then be treated without hematoma evacuation or permanent ventriculoperitoneal shunt placement. EVD insertion and ICP monitoring not only carry therapeutic significance but also help to prognosticate the patients. It is an important tool for implementation of "watchful, armed wait and see" strategy for moderate sized SCH cases.

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