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Surgical management of spontaneous posterior fossa hematoma: predictors of the neurological outcome

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Abstract

Objective To detect demographic, clinical, and radiological predictors of patient outcomes and prognosis in spontaneous cerebellar hematoma patients that may guide accurate decision making.

Methods This retrospective study was conducted on 45 patients with spontaneous cerebellar hematoma who underwent surgical treatment. The patient data including demographics (age, gender), preoperative consciousness at the time of admission, medical comorbidities (HTN, DM), radiological findings (location, volume, and diameter of the cerebellar hematoma, hydrocephalus, compression of the fourth ventricle, effacement of the quadrigeminal cistern, intraventricular hematoma, tight posterior fossa, and brain stem compression), and treatment methods were collected and correlated with prognosis. Outcome assessment was done using the Glasgow Outcome Scale (GOS), classified into good outcome (favorable result; GOS > 4) and poor outcome (unfavorable result; GOS < 4).

Results There was a statistically significant correlation ($p = 0.030$) between the time to surgery and GOS, with more favorable outcomes in patients who underwent early surgery compared to late surgery. Unfavorable outcomes were detected in patients with higher Taneda grade and Kirollos grade, and both were statistically significant ($p = 0.001$). The presence of hydrocephalus and/or brainstem compression had a statistically significant ($p < 0.001$) negative impact on outcomes. Patients with extensive IVH had an unfavorable outcome compared to other patients ($p = 0.016$). The mortality rate in our study was 28.9%.

Conclusions Surgical management of spontaneous cerebellar hematoma is challenging. Many factors influence the appropriate decision making and surgical outcome. Predictors of an unfavorable outcome include the level of consciousness at admission, delayed time to surgery, a higher grade of 4th ventricular effacement (Kirollos) and quadrigeminal cistern effacement (Taneda), extensive IVH, hydrocephalus, and brainstem compression (statistically significant). There was no statistical significance regarding gender, age, hematoma volume, or hematoma diameter in relation to an unfavorable outcome.

Keywords Cerebellar, Spontaneous, Quadrigeminal, 4th Ventricular, Hematoma

Introduction

Spontaneous posterior fossa hematoma (sPFH) is a critical condition characterized by bleeding inside the posterior fossa or cerebellum, accounting for approximately 6.3% to 16.4% of all intracranial hemorrhages. It is more prevalent in middle-aged and elderly individuals. Hypertension and minor vascular disease are risk factors for

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developing a posterior fossa hematoma. Regardless of different treatment modalities, sPFH has mortality rates ranging from 20 to 75%, with total surgical mortality rates ranging from 20 to 50% [1–4].

Appropriate diagnosis with the onset of clinical presentation is crucial for outcome prediction of these cases. Due to the limited space within the posterior fossa, even small hematomas can cause both significant compression "leading to a disturbed conscious level" and mass effect that compresses the basal cisterns and 4th ventricle, resulting in hydrocephalus. These characteristics contribute to the potential morbidity and mortality associated with sPFH [5–7].

Decision of the appropriate treatment whatever conservative or surgical in relation to time is critical to reduce mortality and morbidity rates. Surgical decision making is based on hematoma size, volume, and location, the degree of 4th ventricular compression, intraventricular extension, effacement of basal brainstem cisterns, and the development of hydrocephalus [8–12].

Surgical management is directed to evacuation of hematoma and/or management of associating hydrocephalus. Several prognostic models have been developed to aid in predicting outcomes for patients with posterior fossa cerebellar hematoma. The prognosis of such challenging cases is not only dependent on appropriate management plan; but also, other factors may determine the global outcome including demographic, clinical and radiological features [13–16].

This study investigates the impact of demographic, clinical, and radiological prognosticator findings of spontaneous posterior fossa hematoma on appropriate decision making, patient outcomes, and prognosis.

Materials and methods

A retrospective single-center study was conducted on 45 patients with spontaneous posterior fossa hematoma treated at Mansoura University Emergency Hospital between January 2016 and May 2022. The medical records of the patients were extracted, examined, and analyzed.

The inclusion criteria of the patients included in this study were those who underwent surgical intervention for sPFH. Our protocol for surgical intervention is based on the criteria of Kobayashi et al. [9] and the guidelines proposed by the American Heart Association/American Stroke Association (AHA/ASA) [22].

Inclusion criteria included all cases of spontaneous cerebellar hematoma while patients with secondary posterior fossa hematomas resulting from Moyamoya disease, tumoral bleeding, arteriovenous malformations-related ICH, cerebral aneurysm rupture, hemorrhagic transformation of a cerebellar infarct, or traumatic cerebellar hemorrhage were excluded based on post contrast CT brain to rule out tumoral hemorrhage and CT angiography to rule out vascular malformation.

Patients' data included demographics (age, gender), preoperative neurological status including "conscious level" measured by the Glasgow Coma Scale (GCS) at the time of admission, associated chronic medical comorbidities (HTN, DM), radiological findings, treatment methods, and prognosis.

All patients were diagnosed using a pre-operative CT scan. The following radiological parameters were extracted and collected:

1. The location, volume, and maximal diameter of the cerebellar hematoma.
2. The absence or presence of hydrocephalus.
3. Any compression of the fourth ventricle.
4. The quadrigeminal cistern effacement.
5. The absence or presence of an intraventricular hematoma.
6. The absence or presence of a tight posterior fossa.
7. Any radiographic signs of brain stem compression.

The location of the posterior fossa hematoma can be hemispheric or vermian. The largest diameter of the hematoma on the brain CT scan was used to determine its maximum diameter.

The hematoma volume (cc or cm^3) was calculated using the equation $V = A \times B \times C/2$, where A represents the longest diameter of the hemorrhage on the CT section with the largest area of the hemorrhage, B is the diameter perpendicular to A, and C is the number of sections with hemorrhage multiplied by the section thickness (typically 5 mm or 0.5 cm). The final volume is obtained by multiplying the A, B, and C values together and dividing by 2 [17].

The diagnosis of hydrocephalus through initial CT scan is defined as a dilated temporal horn of the ventricle and/or an Evan's ratio greater than 0.3 (the ratio of the bilateral frontal horn's ventricular width to its maximum biparietal diameter).

According to Kirollos et al. the degree of compression on the fourth ventricle was divided into three groups: normal, partial compression, and complete obstruction [18]. Quadrigeminal cistern effacement is classified according to Taneda et al. into three grades: grade I (normal), grade II (compressed), and grade III (absent) [19].

Interventricular hemorrhage was carefully evaluated, and different types were reported (no IVH, IVH in the fourth ventricle, IVH up to the third ventricle, and panventricular hemorrhage).

The term "tight posterior fossa" was used to describe an effacement of the posterior fossa's basal cisterns, an expansion of the third and lateral ventricles, including the temporal horns, and, infrequently, an effacement of the fourth ventricle [20].

Using the criteria of Wada et al., hematoma expansion within 48 h was defined as an increase in volume of greater than 30% or greater than 6 mL from the baseline brain CT scan. Rebleeding was defined as a fresh or increased amount of bleeding detected by the brain CT scan together with a sudden clinical deterioration [21].

Surgical management

The surgical treatment of SCH at our center follows the guidelines proposed by the American Heart Association/American Stroke Association (AHA/ASA) [22]. Surgery is indicated in cases with a disturbed conscious level (GCS < 13) or hematoma diameter greater than 3 cm, and/or hydrocephalus caused by IVH or 4th ventricle obliteration. While patients with initial GCS 13–15 subjected to delayed surgical intervention if hematoma was progressed in size on follow-up or conscious level was deteriorated or hydrocephalus or IVH were increased. Surgical intervention was delayed in some cases on anti-platelets and anti-coagulants.

Surgical options were tailored for each patient according to clinical and radiological features, taking into consideration patient comorbidities. For patients whose neurological condition deteriorated and whose cerebellar hematoma volume or maximum hematoma diameter was larger than 10 mL or greater than 3 cm, respectively, surgical hematoma evacuation with a typical suboccipital craniotomy was considered. This may be done with or without the implantation of an external ventricular drain (EVD), depending on the degree of ventricular dilatation. An EVD alone was implanted in cases of hematoma diameter less than 3 cm but with IVH or 4th ventricle obliteration leading to a decline in conscious level and/or radiological evidence of hydrocephalus. Ventriculoperitoneal shunt was implanted alone for cases with hydrocephalus associated with small hematoma in absence of IVH.

Clinical and surgical outcome

The Glasgow Outcome Scale (GOS) was used to evaluate outcomes at discharge and 6 months postoperatively. The GOS scores were as follows: Grade 1: Death, Grade 2: Vegetative state, Grade 3: Severe disability, Grade 4: Moderate disability, and Grade 5: Good recovery.

Patients with GOS 4, 5 were considered good outcomes (favorable result) while those with GOS 1, 2, 3 were considered poor outcomes (unfavorable result). These results were then compared with various demographic, clinical, and radiographic factors.

Statistical analysis

The collected data were coded, processed, and analyzed using SPSS (Statistical Package for Social Sciences) version 22 for Windows® (SPSS Inc, Chicago, IL, USA). The Mann–Whitney *U* test was used to compare continuous variables (hematoma size, age) and ordinal variables (GCS score, GOS score) between groups and subgroups. The Chi-square test was used to compare categorical data (mortality, radiographic characteristics) between groups and subgroups. P-values lower than 0.05 were considered statistically significant.

Results

Among 45 patients included in our study, 20 patients were males (44.4%) and 25 were females (55.6%), with a median age of 61.2 ± 13.5 years (range 22–73 years). Thirty-two patients were between 50 and 70 years of age, accounting for 71.1% of the total population. 40 patients (88.9%) had a preexisting diagnosis of arterial hypertension, 14 patients (31.1%) were diabetic. Atrial fibrillation was present in 35.5% (16 out of 45) of the patients, and liver disease was present in 13.3%. 18 patients on anti-platelets (40%) and 15 patients on anti-coagulants (33.3%).

There were a wide range of clinical presentation of our cases included disturbed level of consciousness, according to admission GCS; 17 patients (37.7%) had scores of 14–15, 24 patients (53.3%) had scores of 9–13, and 4 patients (8.8%) had scores of ≤ 8 in 28 patients (62.2%). Other clinical manifestation include dizziness in 15 patients (33.3%), and nausea and vomiting in 10 patients (22.2%) (Table 1).

Analysis of radiological findings is summarized in Table 2. Twenty nine patients (64.5%) had unilateral cerebellar hemispheric hematoma, 10 patients (22.2%) had vermian midline hematoma, and 6 patients (13.3%) had diffuse hematomas. The size of the hematoma was determined by its diameter, with a mean largest diameter of 3.9 ± 1.7 cm. Among the patients, 33 (73.3%) had hematoma size greater than 3 cm, while 12 (26.7%) had hematomas smaller than 3 cm.

Hematoma volume was greater than 10 mm in 28 cases (62.2%) and less than 10 mm in 17 patients (37.8%). The mean volume of the hematomas was 12.8 ± 10.5 mL. In this study, there was a statistically significant association between hematoma volume and largest diameter and GOS ($p < 0.001$).

Hydrocephalus was diagnosed using the admission CT scan in 23 patients (51.1%), while 22 patients (48.9%) showed no hydrocephalic changes. Brain stem compression was found in 13 individuals (28.9%), while 32 patients (71.1%) did not exhibit this compression.

Table 1 Demographic and clinical presentation data of the studied group

Patient data	No. (%)
Gender	
Male/Female	20 (44.4%) / 25 (55.6%)
Age	61.2 + 13.5 years (range 22–73 years)
Clinical symptoms	
Conscious level (GCS) at admission	
GCS (14–15)	17 (37.8%)
GCS (13–9)	24 (53.3%)
GCS (8–5)	4 (8.9%)
Dizziness	15 (33.3%)
Nausea, vomiting	10 (22.2%)
Headache	6 (13.3%)
Seizure	4 (8.9%)
Dysarthria	3 (6.6%)
Ataxia	2 (4.5%)
Medical Co morbidities	
Hypertension	40 (88.9%)
Cardiac	16 (35.6%)
Diabetes mellitus	14 (31.1%)
Liver disease	6 (13.3%)
Anti-platelets	18 (40%)
Anti-coagulants	15 (33.3%)

Values are presented as number (%)

There were a statistical significant correlation between Hydrocephalus and brainstem compression and GOS ($p < 0.001$).

Among the patients, 31 individuals (68.9%) had no expansion of the hematoma, while 14 patients (31.1%) experienced hematoma expansion within 48 h in the unfavorable group. However, there was a significant association with a poor outcome ($p = 0.005$). Additionally, six patients (13.3%) had postoperative rebleeding, and 19 patients (42.2%) had a tight posterior fossa.

The compression of the fourth ventricle was graded according to Kirollos, with grade I observed in 25 patients (55.6%), grade II in 8 patients (17.8%), and grade III in 12 patients (26.7%). Higher Kirollos grades were associated with an unfavorable outcome, and this association was statistically significant ($p = 0.001$) (Fig. 1).

Quadrigeminal cistern effacement was stratified according to Taneda classification; grade I present in 13 patients (28.9%), grade II in 19 patients (42.2%), and grade III in 13 patients (28.9%). Unfavorable outcome was detected in higher Taneda grades, and the association had statistical significance ($p = 0.001$) (Fig. 2).

Regarding assessment of intraventricular hemorrhage (IVH), no IVH in 19 patients (42.2%), IVH in the fourth ventricle in 10 patients (2.2%), IVH up to the third ventricle in 5 patients (11.1%), and pan ventricular hemorrhage in 11 patients (24.4%). Patients with extensive IVH on brain CT had an unfavorable outcome compared to other patients ($p = 0.016$) (Fig. 3).

Surgical procedures and its relation to outcome

- Suboccipital craniectomy and hematoma evacuation in 25 patients (55.6%), out of them, 16 patients had favorable outcome (10 patients had GOS 5, 6 patients had GOS 4) and 9 patients had unfavorable outcome (6 patients died, while 3 patients had GOS 3).
- Hematoma evacuation combined with EVD in 11 patients (24.4%), out of them, 3 patients had favorable outcome (2 patients had GOS 5, 1 patient had GOS 4) and 8 patients had unfavorable outcome (4 patients died, while 4 patients had GOS 3).
- External ventricular drainage alone implanted in 5 patients (11.1%), out of them, 3 patient had favorable outcome (GOS 5) and 2 patients had unfavorable outcome (2 patients died).
- Ventriculo-peritoneal shunt alone implanted in 4 patients (8.9%), out of them, 3 patients had favorable outcome and unfortunately 1 patient died (Table 3).

Timing for surgery

Surgery was performed within the first twenty-four hours for 31 patients (68.8%), later longer than that for 14 patients (31.1%); there was a statistically significant association between time to surgery and GOS ($p = 0.030$); surgery within the first 24 h had a favorable results (Table 3).

Four patients underwent VP shunt; 1 patient operated upon early due to hydrocephalus reported on initial CT, 3 patients operated upon late due to progression of the hydrocephalus with no significant increase in the size of hematoma.

Five patients underwent implantation of EVD; 3 patients operated upon early (1 patient with small cerebellar hematoma associated with IVH, the other 2 patients had a big size hematoma but the patients were unfit for surgery). 2 patients operated upon late due to expansion of the hematoma and extension into the ventricles.

Thirty-six patients underwent hematoma evacuation; 27 patients operated upon early (in 5 patients hematoma evacuation was coupled with EVD, 22 patients hematoma evacuated alone); 9 patients operated upon lately (EVD was associated with hematoma evacuation in 6 patients, hematoma evacuation alone in 3 patients) (Table 4; Fig. 4).

Table 2 Radiologic criteria of patients with spontaneous cerebellar hematoma

Radiological finding	All patients	6 months outcome (GOS)		*P*-value
		Favorable GOS 4,5 (*n* = 25, 55.6%)	**Unfavorable GOS 1,2,3 (*n* = 20, 44.4%)**	
Location				
Unilateral (hemispheric)	29 (64.5%)	15 (33.4%)	14 31.1%)	
Midline (vermian)	10 (22.2%)	6 (13.3%)	4 (8.9%)	.725
Diffuse	6 (13.3%)	4 (8.9%)	2 (4.4%)	
Hematoma size (diameter)				
> 3 cm	33 (73.3%)	22 (48.8%)	11 (24.4%)	> 0.05
< 3 cm	12 (26.7%)	3 (6.7%)	9 (20%)	
Hematoma volume				
> 10 mm	18 (40%)	5 (11.1%)	13 (28.9%)	> 0.05
< 10 mm	27 (60%)	20 (44.4%)	7 (15.5%)	
Brainstem compression				
Yes	13 (28.9%)	4 (8.9%)	9 (20%)	.431
No	32 (71.1%)	21 (46.7%)	11 (24.4%)	
Hematoma expansion				
Yes	14 (31.1%)	3 (6.7%)	11 (24.4%)	0.065
No	31 (68.9%)	18 (40%)	13 (28.9%)	
Tight posterior fossa				
Yes	19 (42.2%)	5 (11.1%)	14 (31.1%)	.202
No	26 (57.8%)	20 (44.4%)	6 (13.3%)	
4th ventricle (Kirollos grade)				
Grade I	25 (55.6%)	17 (37.8%)	8 (17.8%)	
Grade II	8 (17.8%)	5 (11.1%)	3 (6.7%)	< 0.001
Grade III	12 (26.7%)	3 (6.7%)	9 (20%)	
Quadrigeminal cistern (Taneda)				
Grade I	13 (28.9%)	10 (22.2%)	3 (6.7%)	
Grade II	19 (42.2%)	12 (26.7%)	7 (15.5%)	< 0.001
Grade III	13 (28.9%)	3 (6.7%)	10 (22.2%)	
Hydrocephalus on admission CT scan				
Yes	23 (51.1%)	11 (24.4%)	12 (26.7%)	
No	22 (48.9%)	14 (31.1%)	8 (17.8%)	< 0.001
Intraventricular hemorrhage				
No IVH	19 (42.2%)	15 (33.4%)	4 (8.9%)	
4th ventricular IVH	10 (22.2%)	7 (15.5%)	3 (6.7%)	0.016
3rd ventricular IVH	5 (11.1%)	3 (6.7%)	2 (4.4%)	
Panventricular IVH	11 (24.4%)	0	11 (24.4%)	

Values are presented as number (%)

Outcome evaluation

The Glasgow Outcome Scale was utilized to assess the surgical and neurological outcome, 2 had a score of 2 (8.9%), 5 had a score of 3 (11.1%), 9 had a score of 4 (20.1%), and 16 had a score of 5 (35.5%) and unfortunately 13 patients died (28.9%). Among the patients, 25 (55.6%) had favorable results, while 20 (44.4%) had unfavorable outcomes. The mortality rate was 28.9%, and 32 patients (72.1%) were discharged. The morbidity rate was 44.4% (Table 3). Different surgical approaches were correlated to neurological outcome and are summarized in Table 5.

Correlation of timing of surgery to admission conscious level

Regarding the admission conscious level and its correlation with the timing of surgery, the 4 patients with conscious level 8 or less underwent early surgery. Out of

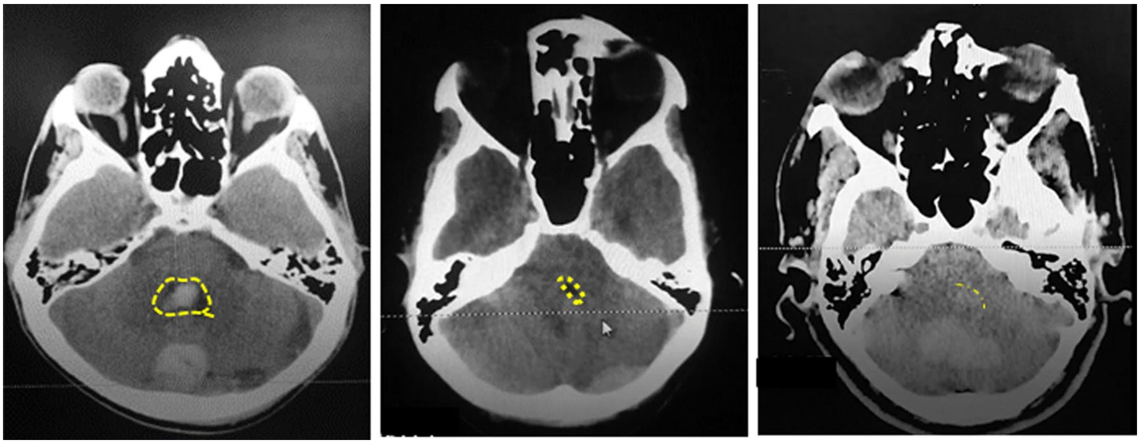

Fig. 1 Kirollos grading of fourth ventricular compression "dotted yellow ring": (Grade I) patent normal "left", (Grade II) partial compression "middle" and (Grade III) complete obstruction "right"

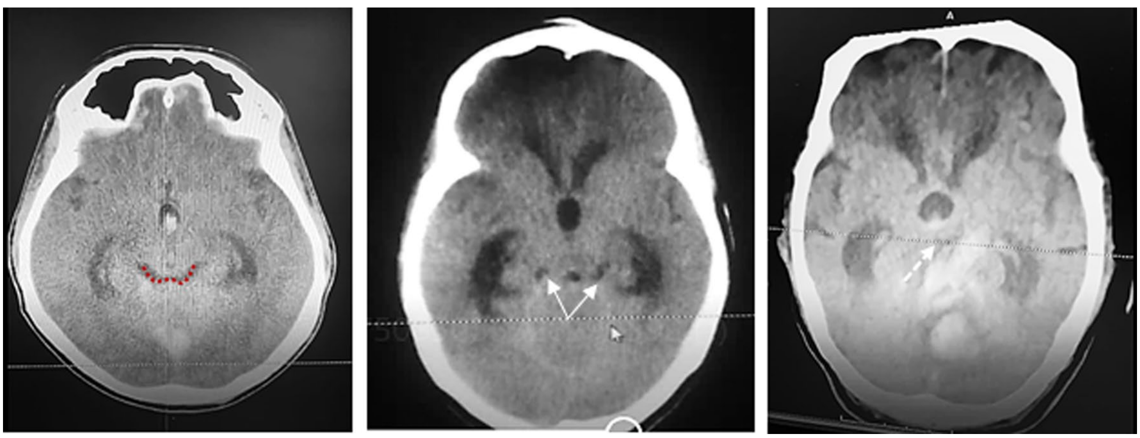

Fig. 2 Taneda grading of quadrigeminal cistern effacement: is classified according to Taneda et al. into three grades: grade I (normal) "left", grade II (compressed) "middle", and grade III (absent) "right"

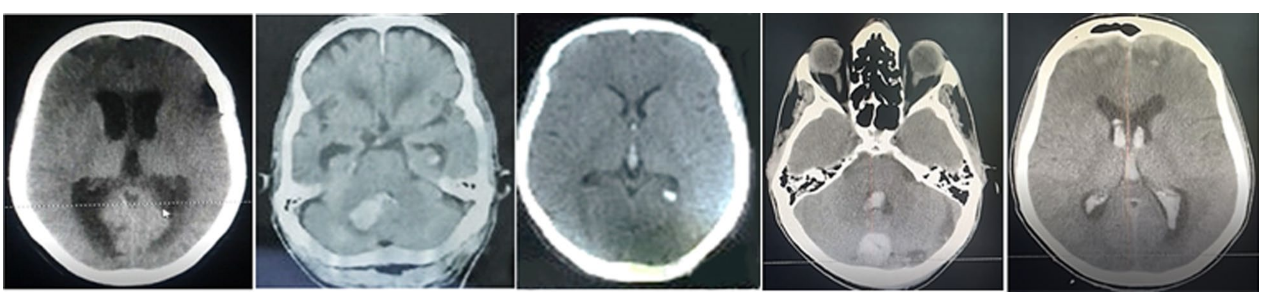

Fig. 3 Intraventricular hemorrhage: no IVH, 4th ventricular IVH, 3rd ventricular IVH, PAN ventricular IVH

the 24 patients in the group of conscious level 9–13, 20 patients underwent hematoma evacuation including 4 patients associated with EVD insertion. Eleven cases of the group of conscious level 14–15 had been operated upon early, but 6 patients operated upon lately (Table 6).

Correlation of timing of surgery to neurological outcome

Analysis of different surgical options in relation to timing of surgery and outcome revealed 22 patients had early evacuation (13 favorable outcomes, 9 unfavorable outcomes) and the 3 hematomas evacuated lately had

Table 3 Details of surgical management modalities and outcome

Surgical parameter	No. (%)	Favorable GOS 4,5 (*n* = 25, 55.6%)	Unfavorable GOS 1,2,3 (*n* = 20, 44.4%)	*P*-value
Surgical technique				
Surgical evacuation	25 (55.6%)	16 (35.6%)	9 (20%)	
Evacuation + EVD	11 (24.4%)	3 (6.7%)	8 (17.6%)	< 0.001
EVD	5 (11.1%)	3 (6.7%)	2 (4.4%)	
VP Shunt	4 (8.9%)	3 (6.7%)	1 (2.2%)	
Survival				
Discharged	32 (71.1%)	25 (55.6%)	7 (15.5%)	0.015
Mortality	13 (28.9%)	0	13 (28.9%)	
Time to surgery				
< 6–24 h	31 (68.8%)	20 (44.4%)	11 (24.4%)	0.030
> 6–24 h	14 (31.1%)	5 (11.1%)	9 (20%)	

Values are presented as number (%)

Table 4 Timing of surgery in relation to different surgical options

	Early surgery	Late surgery	Total
Surgical evacuation	22	3	25
Evacuation + EVD	5	6	11
EVD	3	2	5
VP shunt	1	3	4

favorable outcomes. Hematoma evacuations associated with EVD were done in 11 cases; out of 5 patients underwent early intervention; 3 patients had favorable outcome, while 4 out of 6 patients underwent late hematoma evacuation associated with EVD had unfavorable outcome. Two out of 3 patients underwent early EVD implantation had favorable outcome, while late EVD implantation in 2 patients had 1 favorable and 1 unfavorable. Late VP shunt insertion has a favorable result in 2 out of 3 patients, while the only shunt implanted early had favorable outcome (Table 7).

Discussion

Spontaneous posterior fossa hemorrhage (sPFH) is a life-threatening condition that represents 10–15% of all types of posterior circulation neurovascular events. It is associated with higher rates of mortality and morbidity. Despite tremendous improvements in diagnostic and surgical techniques, debates still exist regarding the appropriate candidates for surgical intervention [2, 12, 23]. In our study, the highest prevalence of spontaneous cerebellar hemorrhage was observed in patients between the 5th and 7th decade, accounting for 71.1% of the patients (32 patients). This corresponds to the literature common age range for such pathological situation.

Many case series have reported female predominance among cases with spontaneous cerebellar hemorrhage, which is consistent with our study [1, 24, 25]. However, there is no statistically significant correlation between age, and clinical outcome which is the same observation in many case series [26, 27].

In the literature, different reports discussed the risk factors for cerebellar hematoma and concluded that Hypertension is the most common risk factor attributed to sPFH [28, 29]. In our study, 68.8% of the total patients (31 out of 45) had a preexisting diagnosis of arterial hypertension.

A surgical approach for the management of posterior fossa hematoma was originally described by Balance et al. in 1906 [15]. Since then, it has been accepted as a valuable option for the treatment of cerebellar hemorrhages. However, the surgical indication remains a matter of debate, and many articles have confirmed the consensus on major surgical indications, including effacement of the quadrigeminal cistern, 4th ventricular compression, and a hematoma diameter larger than 3 cm [9].

Different management algorithms gained wide acceptance in the literature. Kobayashi et al. [9] used two determent factors: initial conscious level "GCS-score at admission" and the hematoma diameter on CT-scan. Other prospective algorithm by Kirollos et al. [18] depends on two determent factors: 4th ventricle effacement on CT and graded as either normal (grade I), compressed (grade II), or absent (grade III) and second parameter was the GCS score (< 13 or > 13) [18]. Other algorithm by Mathew et al. [27] considered the level of consciousness and the presence or absence of acute hydrocephalus as determents.

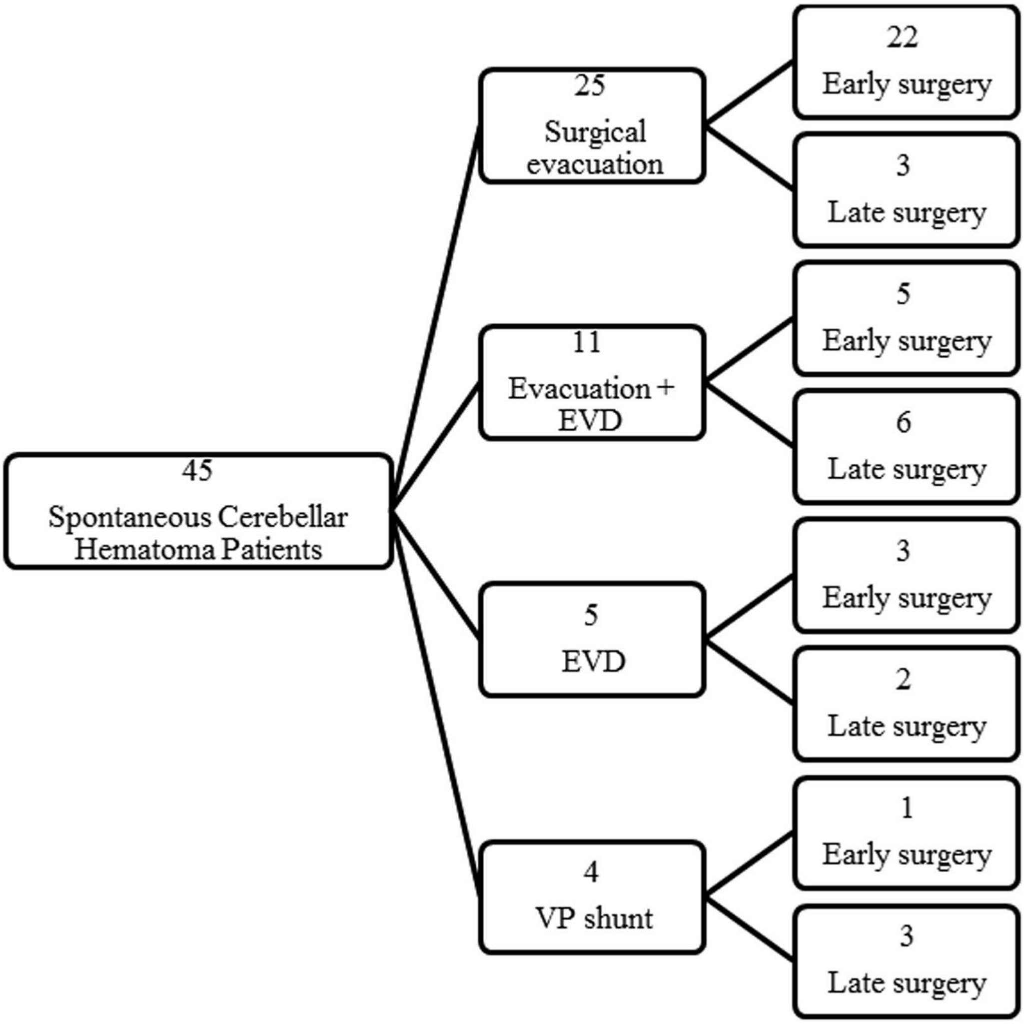

Fig. 4 Flow chart showing summary of the treatment of our case series

Table 5 Neurological outcome in relation to different surgical options

Outcome	GOS	Patients	Evac	Evac + EVD	EVD	Shunt
Unfavorable (*N* = 20, 44.4%)	1	13 (28.9%)	6	4	2	1
	2	2 (4.4%)	0	0	2	0
	3	5 (11.1%)	3	2	0	0
Favorable (*N* = 25, 55.6%)	4	9 (20%)	6	1	0	2
	5	16 (25.5%)	10	4	1	1
			25	11	5	4

Values are presented as number (%)

Evac evacuation

In a study conducted by Cohen et al., the surgical indications were based on a hematoma diameter larger than 3 cm and a hematoma volume larger than 15 mL. However, some cases with a hematoma diameter greater than 3 cm and a hematoma volume larger than 15 mL were managed conservatively and still had favorable outcomes. Therefore, the diameter and volume of the hematoma should not be considered the sole surgical indications. The degree of 4th ventricular compression, the presence of hydrocephalus, intraventricular hemorrhage (IVH),

Table 6 Correlation of timing of surgery to initial GCS:

	GCS ≤ 8		GCS 9–13		GCS 14–15	
	Early surgery	Late surgery	Early surgery	Late surgery	Early surgery	Late surgery
Evacuation	0	0	16	2	6	1
Evacuation + EVD	1	0	4	2	0	4
EVD	3	0	0	0	0	2
VP shunt	0	0	0	0	1	3

Table 7 Correlation of timing of surgery to outcome GOS

Surgical option	Surgery time	Favorable	Unfavorable
Evacuation	Early	13	9
	Late	3	0
Evacuation + EVD	Early	3	2
	Late	2	4
EVD	Early	2	1
	Late	1	1
VP shunt	Early	1	0
	Late	2	1

effacement of the quadrigeminal cistern, and other factors should also be considered indicative of surgical treatment [24].

In our study, early surgery was indicated in cases of hematoma larger than 3 cm, associated hydrocephalus and 4th ventricular effacement and brain-stem compression (22 patients underwent surgical evacuation in case of hematoma larger than 3 cm without hydrocephalus, 5 patients underwent hematoma evacuation associated with EVD in case of hematoma larger than 3 cm with intraventricular hemorrhage and 3 patients underwent EVD alone and only 1 patient underwent shunt were the hematoma was smaller than 3 cm and associated hydrocephalus).

Surgical evacuation of posterior fossa hematoma theoretically offers several benefits, such as reducing mass effect, relieving brainstem compression, and preventing secondary brain insult, including ischemia and subsequent edema that can result in significant mass effect. Surgical hematoma evacuation has been shown to be a significant predictor of favorable outcomes. Patients with cerebellar hemorrhage and neurological function impairment, as well as those with brainstem compression and hydrocephalus due to ventricular obstruction, should undergo surgical removal of the hemorrhage as soon as possible. Surgical hematoma evacuation may minimize mortality and enhance treatment outcomes by releasing brainstem compression and relieving ventricular compression [4, 26]. In our study, 25 patients (55.6%) had a favorable outcome (16 had hematoma evacuation, 5 had evacuation with EVD, 1 EVD alone, and 3 shunted).

According to Luparello and Canavero [31], patients with hematomas larger than 3 cm and a GCS score less than 9 had an unfavorable outcome despite surgery, while patients with hematomas smaller than 3 cm and a GCS score greater than 9 had a favorable outcome. The location of the hematoma, as well as the presence of hydrocephalus, quadrigeminal cistern involvement, and IVH, were all factors influencing the outcome of patients with hematomas larger than 3 cm and a GCS score greater than 9. In our study, hemorrhage in the cerebellar vermis was associated with a poor prognosis. This can be explained by the 4th ventricular compression caused by the vermian hematoma, resulting in hydrocephalus and brainstem compression.

The initial conscious level upon admission is a determinant factor for prognosis. Several studies have reported its significant relation to outcome [26]. Early mortality has been correlated with a Glasgow Coma Scale (GCS) score below 8 and the presence of hydrocephalus and IVH [28].

Taneda et al. studied the outcome of spontaneous PFH and correlated it with the degree of quadrigeminal cistern effacement, concluding that worse outcomes were associated with higher grades of quadrigeminal cistern compression [19]. In our study, favorable outcome was detected in 10 patients of grade I Taneda out of total 13, 12 patients grade II Taneda out of 19, 3 patients grade II Taneda out of 13. These results support our correlation.

Higher grades of 4th ventricular and quadrigeminal cistern compression were associated with worse outcomes regardless of the intervention. Kirollos et al. discussed the management of spontaneous PFH and concluded that patients with good neurological status presenting with grade III 4th ventricular compression should undergo evacuation. In fact, in this large study, most of the patient population subjected to either conservative or surgical treatment with higher grades of 4th ventricular compression (grade III) had similarly worse outcomes. This raises questions about the surgical option when compared with the best medical management [18]. In our study, unfavorable outcome in grade III Kirollos grading, 9 patients out of 12 patients, while favorable outcome detect in 17 patients had grade I Kirollos grading out of 25 patients.

Another retrospective analysis of 72 patients with spontaneous cerebellar hematoma divided the patients into two groups: a 6-month mortality group ($N=21$) and a survival group ($N=51$). Multivariate Cox proportional hazards regression analysis was performed to investigate the independent predictors for the mortality group, revealing that radiological brainstem compression is a strong predictor of mortality [4]. In our series, mortality was 13 cases (28.9%); 6 patients died after evacuation of hematoma (due to their initial low GCS), 4 patients died after evacuation of hematoma coupled with EVD (due to their initial bad general condition), 2 patients died after EVD, 1 patients died after shunt (as a consequence of pulmonary embolism).

Limitations

Limitations of this study include its retrospective design and small sample size. Therefore, in order to establish definitive treatments based on prognosis, a randomized controlled trial must be conducted.

Conclusion

The surgical management of spontaneous cerebellar hematoma is challenging. Many factors influence the appropriate decision making and surgical outcome. Predictors of an unfavorable outcome include the level of consciousness at the time of admission, delayed time to surgery, a higher grade of 4th ventricular effacement (Kirollos) and quadrigeminal cistern effacement (Taneda), extensive IVH, hydrocephalus, and brainstem compression (statistically significant). There was no statistical significance regarding gender, age, hematoma volume, or hematoma diameter in relation to an unfavorable outcome. The mortality rate in our study was 28.9%, and we recommend further randomized controlled trials to strengthen our correlation.

Abbreviations

sPFH	Spontaneous posterior fossa hematoma
VP	Ventriculo peritoneal
EVD	External ventricular drainage
GCS	Glasgow consciousness score
GOS	Glasgow Outcome Scale
IVH	Intraventricular hemorrhage
AHA/ASA	American Heart Association/American Stroke Association

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Author contributions

All authors contributed to the study conception and design, read and approved the final manuscript for submission and publication. Contribution to the study was organized according to: conceptualization: Ahmed Naguib Taha, Mohamed Mohsen Amen, Mahmoud Saad; methodology: Ali A. Mowafy, Mahmoud Saad; formal analysis and investigation: Ahmed Naguib Taha, Mahmoud Saad, Mohamed Badran; writing—original draft preparation: Hanee Ali, Mahmoud Saad; writing—review and editing: Hanee Ali, Mahmoud Saad, Mohamed Badran; resources: Hanee Ali, Mohamed Badran, Ali A. Mowafy; supervision: Ahmed Naguib Taha, Mohamed Mohsen Amen, Mahmoud Saad. All authors read and approved the final manuscript.

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Availability of data and materials

All data related for this study are available for sharing upon request.

Declarations

Ethics approval and consent to participate

This study was approved by the IRB of Mansoura University Faculty of Medicine (R.23.02.2076.R1). This article does not contain any studies with human participants performed by any of the authors.

Consent for publication

All data and records of patients were approved for publications by authors and involved patients.

Competing interests

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest; and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

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