SURGICAL MANAGEMENT OF POSTERIOR FOSSA MASS LESIONS

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RECOMMENDATIONS

(see *Methodology*)

Indications

- Patients with mass effect on computed tomographic (CT) scan *or* with neurological dysfunction *or* deterioration referable to the lesion should undergo operative intervention. Mass effect on CT scan is defined as distortion, dislocation, or obliteration of the fourth ventricle; compression or loss of visualization of the basal cisterns, or the presence of obstructive hydrocephalus.
- Patients with lesions and no significant mass effect on CT scan and without signs of neurological dysfunction may be managed by close observation and serial imaging.

Timing

- In patients with indications for surgical intervention, evacuation should be performed as soon as possible because these patients can deteriorate rapidly, thus, worsening their prognosis.

Methods

- Suboccipital craniectomy is the predominant method reported for evacuation of posterior fossa mass lesions, and is therefore recommended.

KEY WORDS: Cerebellum, Coma, Computed tomographic parameters, Contusion, Head injury, Occipital, Posterior fossa, Surgical technique, Timing of surgery, Traumatic brain injury

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OVERVIEW

Posterior fossa injury is rare, occurring in less than 3% of head injuries in most published series (8, 12, 22). The vast majority of these series deal exclusively with posterior fossa epidural hematomas (EDH), representing 1.2 to 12.9% of all EDH (7, 20, 21, 30). A small number of observational studies address subdural and intraparenchymal hematomas of the posterior fossa (5, 8, 17, 22, 24), representing 0.5 to 2.5% and 1.7% of all subdural hematomas and intraparenchymal hematomas, respectively (22, 24). Additionally, there is a separate literature that focuses on parturitional hemorrhages, up to 48% of which primarily involve the posterior fossa (27). Because of the physiology and anatomy of the neonate, and the unique mechanism of these injuries, this subgroup of patients warrants independent analysis, and will not be addressed in these *Guidelines*.

Despite the rarity of these lesions, the importance of timely recognition and surgical evacuation, when indicated, cannot be overstated. Many patients can undergo rapid clinical deterioration because of the limited size of the posterior fossa and the propensity for these lesions to produce brainstem compression.

PROCESS

A MEDLINE computer search using the following key words: "posterior fossa" or "cerebellum" or "cerebellar" or "occipital" and "subdural" or "epidural" or "extradural" or "intradural" or "parenchymal" or "intraparenchymal" or "intracerebellar" or "fracture" between 1975 and 2001 was performed. A total of 1828 documents were found. The search was narrowed to include the key words: "surgery" or "operative" or "craniotomy" or "craniectomy" or "decompressive craniectomy" or "repair" and "trauma" or "traumatic" or "TBI" or "CHI." A total of 430 articles were found. A tertiary search adding the key words "contu-

sion," "hemorrhagic contusion," "surgical decompression," "craniostomy," "TICH," and "DTICH" was performed, yielding 421 articles. The secondary and tertiary searches were combined, yielding a total of 433 articles. In addition, the reference lists of selected articles were reviewed, and 24 articles were selected for critical analysis. The results of this analysis were incorporated into the review presented here. Papers primarily addressing the following topics were not included: nontraumatic lesions, patients with associated posterior fossa anomalies (e.g., Chiari malformation), posttraumatic aneurysms, chronic subdural hematomas, vertebral artery dissection, patients undergoing anticoagulation therapy, patients with associated illnesses (e.g., acquired immunodeficiency syndrome, idiopathic thrombocytopenia purpura, hemophilia, arteriovenous malformation, after craniotomy, or von Willebrand's disease), pre-CT era reports, and book chapters. In general, papers with the following characteristics were also excluded: case series with less than 10 patients evaluated by CT scan and with incomplete outcome data (mortality or Glasgow outcome score [GOS]), case reports, and operative series with operations occurring longer than 14 days from injury. Several articles with case series of less than 10 patients were examined and reviewed because of the limited number of patient series evaluating primary traumatic posterior fossa mass lesions that exist in the literature. Selected articles were evaluated for design, prognostic significance, therapeutic efficacy, and overall outcome. In addition, several articles were reviewed for the purposes of historical perspective.

SCIENTIFIC FOUNDATION

Because of the rapid and life-threatening nature of neurological deterioration secondary to expanding mass lesions in the limited compartment of the posterior fossa, surgery is generally viewed as required therapy in symptomatic patients with progressive dysfunction. Because of the potential adverse consequences of withholding or delaying surgery for such patients, studies depend on retrospective analyses. As a result, there is no Class I or Class II evidence to support recommendations for the surgical management of these injuries. However, the predominantly observational studies that were reviewed yield an important and relatively clear picture of the prognosis for the patient with a posterior fossa mass lesion as patients are currently managed. Admission Glasgow Coma Scale (GCS) score (5, 7, 8, 12, 24, 26) and GCS score at surgery (6, 14, 19, 20, 22) correlate with outcome (GOS and mortality). D'Avella et al. (5) retrospectively reviewed the clinical and radiographic characteristics of 81 patients with traumatic intracerebellar hemorrhages. Subjecting their data to multivariate analysis, they found that only GCS and the presence of concomitant supratentorial lesions independently predicted outcome at 6 months. Outcome was favorable (GOS, 4 or 5) in 95% of patients with admission GCS score of at least 8, whereas outcome was poor (GOS, 1–3) in 81% of patients with a GCS score less than 8. Class III data suggests that a neurologically deteriorating patient should undergo emergent evacuation of the mass lesion.

Neurologically intact patients with a posterior fossa lesion and no CT evidence for mass effect (compression of cisterns, distortion of 4th ventricle, hydrocephalus) have been successfully managed nonoperatively with close observation and serial imaging (1, 5, 15, 25, 28).

Wong (28) conducted a retrospective study of 25 patients with posterior fossa EDH and compared clinical and radiological characteristics and outcomes between 17 patients undergoing early surgery and 8 patients managed nonoperatively. Patients with a posterior fossa EDH of at most 10 cm^3 in volume, at most 15 mm in thickness, and responsible for at most a 5-mm midline shift had excellent survival rates with either surgical or nonsurgical treatment. Patients managed nonsurgically with a posterior fossa EDH greater than 10 cm^3 in volume, greater than 15 mm in thickness, and responsible for greater than 5 mm of midline shift had a significantly greater mortality than those with similar CT characteristics undergoing early surgery. The disparity in mortality, however, is confounded by the strong correlation between the presence of an associated frontal lesion (which was found more commonly in the latter group) and death. This report raises the concept of conservative management for patients with posterior fossa lesions on the basis of objective CT characteristics. This concept is also supported by a two-center study performed by Bozbuga et al. (1). The authors divided patients into management groups on the basis of CT characteristics. All patients (n = 14) without evidence of mass effect on CT scan, defined by obliteration of the perimesencephalic cisterns, compression and/or displacement of the fourth ventricle, or the presence of hydrocephalus, were managed nonoperatively and had a good outcome (GOS, 5). According to the authors, these objective criteria were "earlier, more predictive, and more reliable" than the clinical findings, although no statistics regarding this statement were performed. Several other case series add additional support (9, 16, 25).

There are several prognostic factors that adversely affect outcome regardless of management. These include the presence of associated intracranial lesions (4, 5, 12, 14, 18–22, 24, 28), extension of an infratentorial lesion into the supratentorial compartment (19), the location of the lesion (e.g., intraparenchymal versus extra-axial, and midline versus hemispheric) (17, 22), the presence or absence of associated hydrocephalus (7, 8, 14), and the acuity of presentation, with subacute presentation portending a better outcome than acute presentation (4, 14, 19, 23–25). There are no controlled studies measuring the impact of these variables on surgical versus nonsurgical management of posterior fossa mass lesions.

SUMMARY

There are no controlled, prospective clinical trials of treatment using surgical versus nonsurgical management of posterior fossa mass lesions. The available data support rapid evacuation of posterior fossa mass lesions that 1) show CT evidence of mass effect, or 2) result in progressive neurological dysfunction. Moreover, data support expectant management

with serial imaging for select cases in which there is neurological stability and no radiological evidence for mass effect.

KEY ISSUES FOR FUTURE INVESTIGATION

There are several patient groups in which the distinction between surgical and conservative management is blurred. One such group includes patients who present with neurological deficit and a traumatic posterior fossa mass lesion without clinical evidence for neurological deterioration or radiological evidence for mass effect. Conversely, another group includes the neurologically intact patient with radiological evidence for mass effect from an offending hematoma. These groups have not been adequately addressed in the current literature, and, when reported, are managed at the discretion of the individual neurosurgeon, thus, precluding an accurate assessment of efficacy of treatment. The literature contains methodological problems outlined in this supplement that preclude the establishment of management standards, and even of treatment guidelines, for posterior fossa injury. Most series present prognostic data regarding outcome after either conservative or surgical treatment of posterior fossa mass lesions. In those few studies that attempt to compare outcomes, important prognostic factors known to be relevant to TBI outcome, such as cardiorespiratory instability, other systemic injuries, comorbidities, etc. (2), are not controlled between the surgical and nonsurgical cohorts. As a result, we have important prognostic information regarding operatively and nonoperatively managed posterior fossa injury, but no means for valid, direct comparison between the two. This comparison is essential if we are attempting to establish a standard of care. Thus, attention needs to be directed to controlled studies of patients with similar CT and clinical characteristics who are managed with operative versus nonoperative intervention.

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TABLE 1. Surgical management of posterior fossa mass lesions[a]

Authors (ref. no.)	No. of patients	Class	Inclusion GCS	Treatment	Outcome	Description	Conclusion
Bozbuga et al. (1)	73	III	Unknown	Surgery and nonsurgical	GOS, not specified	Prospective study of 73 patients with PFEDH managed by CT criteria either surgically or nonsurgically based on presence of signs of mass effect on CT.	• Patients with PFEDH and no associated CT evidence for mass effect may be managed effectively without surgery. • No patient with mass effect on CT was managed nonsurgically, thus, precluding direct comparison between groups. • No morbidity or mortality in subacute cases (presentation 24 h–7 d).
Brambilla et al. (3)	8	III	GCS 4–15	Surgery	Death versus complete recovery, not specified	Retrospective series of 8 patients surgically treated for PFEDH to evaluate clinical characteristics and outcome.	• Authors emphasize high mortality rate thought secondary to concomitant brainstem and basal ganglia injury seen at autopsy. *Note: paper included with n = 8 because of limited number of case series with ≥10 patients.
Ciurea et al. (4)	9	III	GCS 13–14	Surgery	GOS, not specified	Retrospective series of 9 patients aged 2–12 y surgically treated for PFEDH to evaluate clinical characteristics and outcome.	• Subacute presentation predominated (88.8%) and, thus, may have biased outcome data. • Associated intracranial injuries seemed associated with worse outcome (no statistics). Note: paper included with n = 9 because of limited number of case series with ≥10 patients.
d'Avella et al. (5)	81	III	GCS 3–5 to 14–15	Surgery and nonsurgical	GOS 6 mo	Retrospective series of 81 patients with traumatic intracerebellar hemorrhage/contusion to evaluate prognostic factors and examine clinicoradiological presentation.	• 44.4% poor result (GOS 1–3); 55.6% favorable result (GOS 4–5). • GCS, presence of supratentorial lesion, status of basal cisterns and fourth ventricle, mechanism of injury, and clot size correlated with outcome. • GCS and presence of concomitant supratentorial lesion were independent prognostic factors. • 9.4 times relative risk of poor outcome with GCS < 8. • 2.3 times relative risk of poor outcome with associated supratentorial lesion. • Traumatic intracerebellar clots observed to increase in size up to 4 d after injury—authors advocate repeat CT scans until lesion stabilizes. • Authors recommend surgery for patients with larger clots causing posterior fossa mass effect.
Holzschuh and Schuknecht (7)	20	III	GCS 3–15	Surgery	GOS 6 mo	Retrospective series of 20 patients surgically treated for PFEDH to evaluate clinical and radiologic characteristics and outcome.	• GCS correlated with GOS (no statistics) • Mortality of acute (<24 h) and subacute (24 h–7 d) cases was 50% and 20%, respectively. • Authors emphasize importance of CT for patients with signs of occipital trauma to diagnose PFEDH before clinical deterioration. Note: CT in 18/20 cases.

	No. of patients	GR (%)	MD (%)	D (%)
Nonsurgical	14	100	0	0
Surgical	59	86	7	7
Acute (<24 h)	54	85	7	7
Subacute (24 h–7 d)	19	100	0	0

	No. of patients	GR (%)	D (%)
PFEDH	8	62.5	37.5

	No. of patients	GR (%)	MD (%)
PFEDH	9	89	11
PFEDH + associated lesion	4	75	25

	No. of patients	GR/MD (%)	SD/VS/D (%)
Intracerebellar hemorrhage/contusion, total	81	55.6	44.4
GCS ≥ 8	39	94	6
GCS < 8[b]	42	19	81
OR[c]	27	48	52

[b] $P = 0.000$, [c] P = n.s.

	No. of patients	GR (%)	MD (%)	D (%)
PFEDH, total	20	45	20	35
GCS 15–14	2	100	0	0
GCS 13–8	8	62.5	12.5	25
GCS 7–3	10	20	30	50
Acute (<24 h)	14	28.6	21.4	50
Subacute (24 h–7 d)	5	60	20	20
Chronic (>7 d)	1	100	0	0

TABLE 1. Continued

Authors (ref. no.)	No. of patients	Class	Inclusion GCS	Treatment	Outcome	Description	Conclusion
Karasawa et al. (8)	53	III	GCS 3–8 to 13–15	Surgery and nonsurgical	GOS at discharge	Retrospective series of 53 patients with posterior fossa injury comparing those with and without associated HCP to evaluate CT factors associated with the development of HCP and the differences in outcome between subgroups with and without HCP.	• Supratentorial extension, hematoma thickness >15 mm, and abnormal mesencephalic cisterns were significantly associated with HCP ($P < 0.05$). • Bilateral lesions and inability to visualize the fourth ventricle were significantly associated with HCP in intracerebellar hematoma/contusion. • No significant difference in mortality between patients with PFEDH with or without HCP. • HCP increased mortality in patients with ICH/contusion (100% versus 15.4%; $P < 0.05$). • Surgery did not alter mortality in patients with associated HCP, though number of patients was too small for comparison. • Admission GCS was inversely related to mortality (P = n.s.). • Authors advocate external ventricular drainage in patients with ICH/contusion and HCP, not with PFEDH.

	No. of patients	GR (%)	MD (%)	SD (%)	VS (%)	D (%)
Posterior fossa injury, total	53	74	7	2	2	15
EDH	25	88	8	0	0	4
ICH/contusion	13	46.2	0	7.7	7.7	38.5
SAH	7	100	0	0	0	0
SDH	5	80	0	0	0	20
Brainstem hemorrhage	3	0	66.7	0	0	33.3
EDH + surgery + HCP	7	86	14	0	0	0
EDH + surgery, no HCP	7	71	14	0	0	14
ICH + surgery + HCP	2	0	0	0	0	100
ICH + surgery, no HCP	1	100	0	0	0	0
HCP + surgery	9	66.7	11.1	0	0	22.2
HCP, no surgery	3	66.7	0	0	0	33.3

Koc et al. (10)	11	III	GCS 7–15	Surgery	GCS at discharge	Retrospective series of 14 patients (11 with CT scans) treated surgically for PFEDH to examine clinical and radiologic features and to assess outcome.	• Authors report that lesion size, presence of coexisting intracranial lesions, and increasing age are *not* associated with prognosis, however, all morbidity and mortality occurred in patients without CT scans.

	No. of patients	GR (%)	D (%)
PFEDH with CT	11	100	0

Lui et al. (11)	89	III	All GCS	Surgery	GOS, 1 yr; mortality, 1 wk	Retrospective review of 89 patients treated surgically for PFEDH to evaluate outcome related to CT characteristics, age, GCS.	• Mortality 17.9%. • Mortality inversely related to GCS before surgery. • Age <16 yr associated with decreased mortality. • Presence of mixed lesion (i.e., extension into occipital region) and concomitant, noncontiguous supratentorial lesion associated with increased mortality.

	No. of patients	GR (%)	MD (%)	SD (%)	VS (%)	D (%)
PFEDH, total	89	74.2	5.6	1.1	1.1	17.9
GCS (surgery) 3–5	17					64.7
GCS 6–8	19					5.2
GCS 9–12	29					13.8
GCS 13–15	24					0
Age <16 yr	29					10.3
Age ≥16 yr	60					21.7

TABLE 1. Continued

Authors (ref. no.)	No. of patients	Class	Inclusion GCS	Treatment	Outcome	Description	Conclusion
Mahajan et al. (12)	19	III	GCS < 7 to 13–15	Surgery	GOS, not specified	Retrospective series of 19 patients treated surgically for PFEDH to examine clinical characteristics and outcome.	• Mortality 15.8%. • Admission GCS correlated with outcome (no statistics). • Both patients with concomitant supratentorial intracranial lesions died.

	No. of patients	GR (%)	MD (%)	SD (%)	VS (%)	D (%)
PFEDH, total	19	57.9	26.3	0	0	15.8
GCS (admission) 15–13	7	100	0	0	0	0
GCS 12–8	7	57.1	28.6	0	0	14.3
GCS 7–3	5	0	60	0	0	40

Authors (ref. no.)	No. of patients	Class	Inclusion GCS	Treatment	Outcome	Description	Conclusion
Mohanty et al. (13)	24	III	GCS 3–5 to 13–15	Surgery	GOS at discharge	Retrospective series of 489 patients with surgically evacuated EDH comparing prognosis between children and adults and evaluating difference in associated clinical parameters between children and adults. A subgroup of 24 patients with surgically treated PFEDH is included.	• Incidence of PFEDH/EDH higher in children versus adults (11% versus 3%). • PFEDH had better outcome versus supratentorial EDH in both age groups (no statistics).

	No. of patients	GR/MD (%)	SD/VS/D (%)
PFEDH, total	24	87.5	12.5
age ≤ 15 yr	11	91	9
age ≥ 16 yr	13	85	15

Authors (ref. no.)	No. of patients	Class	Inclusion GCS	Treatment	Outcome	Description	Conclusion
Neubauer (14)	18	III	GCS 3–14	Surgery	GOS not specified	Retrospective series of 18 patients surgically treated for PFEDH to evaluate outcome relative to acuity of presentation, presence of hydrocephalus, and presence of associated lesions.	• Mortality 22%—all presented with acute course. • GCS immediately before surgery, acute presentation, and presence of hydrocephalus seemed to correlate with mortality (no statistics). • Concomitant lesions did not alter mortality but correlated with increased disability (no statistics).

	No. of patients	GR (%)	MD (%)	SD (%)	VS (%)	D (%)
PFEDH, total	18	55	11	5.5	5.5	22
With associated lesion	8	25	25	12.5	12.5	25
No associated lesion	10	80	0	0	0	20
Acute (<24 h)	10					40
Subacute (2–7 d)	8					0
With HCP	6					33
No HCP	12					16

Authors (ref. no.)	No. of patients	Class	Inclusion GCS	Treatment	Outcome	Description	Conclusion
Otsuka et al. (15)	11	III	All GCS	Surgery and nonsurgical	GOS at discharge	Retrospective series of 11 patients with PFEDH to evaluate clinical and radiologic features, and to compare outcome between operated and nonoperated groups.	• Mortality 18.2%. • Outcome was similar between groups when surgical indications were deterioration/nonimprovement of neurological signs and symptoms of headache, nausea, and vomiting in presence of CT parameters of maximal hematoma thickness >15 mm, poor visualization of posterior fossa cisterns, marked deformity/displacement of IV ventricle, and extension of PFEDH into supratentorial region (no statistics).

	No. of patients	GR (%)	MD (%)	SD (%)	VS (%)	D (%)
Surgery	6	66.7	16.7	0	0	16.7
Nonsurgical	5	80	0	0	0	20

Authors (ref. no.)	No. of patients	Class	Inclusion GCS	Treatment	Outcome	Description	Conclusion
Pozzati et al. (17)	32	III	GCS < 7 to 14 (14 point scale)	Surgery (n = 30) and nonsurgical (n = 2)	Modified GOS, not specified	Retrospective series of 32 patients with PFEDH, 30 of whom underwent surgery, to evaluate clinical characteristics and outcome.	• Mortality, 15.6%. • Presence of associated intracranial lesion correlates with poor outcome (i.e., disability, mortality) compared with "pure" PFEDH (no statistics). • All patients with GOS < 5 had associated lesions. • Nonsurgical management was successful in 2 patients with small clots.

	No. of patients	GR (%)	Disabled (%)	D (%)
Pure PFEDH, operated	14	100	0	0
Associated lesion, operated	16	50	18.8	31.3
Small, nonsurgical	2	100	0	0

TABLE 1. Continued

Authors (ref. no.)	No. of patients	Class	Inclusion GCS	Treatment	Outcome	Description	Conclusion
Pozzati et al. (18)	7	III	GCS 5–11	Surgery and nonsurgical	GOS at discharge	Retrospective series of 7 patients to examine the role of CT in conservative versus surgical treatment of isolated intracerebellar hematoma.	• Poorer outcome was associated with midline versus hemispheric clots (no statistics). • CT allowed successful conservative management of selected patients. • No good outcome was achieved with clot >3 cm. Note: paper included with n = 7 because of limited number of case series with ≥ 10 patients.
Prusty and Mohanty (19)	17	III	GCS 4–15	Surgery (n = 16) and nonsurgical (n = 1)	GOS at discharge and 6 mo	Retrospective series of 17 patients with PFEDH, 16 of whom underwent surgery, to examine clinical characteristics and outcome.	• Mortality 17.6%—all patients who died presented acutely (<24 h from injury) and had concomitant intracranial lesions. • GOS 5 at 6 mo for all patients presenting with subacute or chronic course. Note: CT performed in 14/17 patients.
Rivano et al. (20)	22	III	GCS 4–15	Surgery	GOS at discharge	Retrospective series of 22 patients undergoing surgery for PFEDH to evaluate clinical and radiologic features with respect to outcome.	• Mortality 13.6%—all patients who died presented with acute clinical course. • GCS at surgery related to outcome (no statistics). • Presence of associated intracranial lesions decreased good outcome, increased morbidity, and increased mortality compared with patients with isolated PFEDH (no statistics). Note: 2/22 patients evaluated by angiography.
Sripairojkul et al. (22)	22	III	GCS 3T–15	Surgery	GOS 6 mo	Retrospective series of 22 patients with surgically treated posterior fossa hematomas evaluating outcome by age, type of hematoma, and interval between injury and surgery.	• Mortality 38%. • GCS < 9 at time of surgery correlated with poor outcome. • Interval between injury and surgery >1 d correlated with *better* outcome than surgery <6 h—this may be caused by a selection of patients with subacute presentation. • Concomitant supratentorial and infratentorial lesions increased morbidity and mortality (mortality 20% versus 0%).

	No. of patients	GR (%)	MD (%)	SD (%)	VS (%)	D (%)
Midline clot	3	0	0	0	0	100
Hemispheric clot	4	50	50	0	0	0
Surgery	3	0	33	0	0	67
Nonsurgical	4	50	25	0	0	25
>3 cm	3	0	67	0	0	33
<3 cm	4	50	0	0	0	50
GCS ≤ 7	4	50	25	0	0	25
GCS > 7	3	0	33	0	0	67

	No. of patients	GR (%)	MD (%)	SD (%)	VS (%)	D (%)
PFEDH, total	17	59	23	0	0	18

	No. of patients	GR (%)	MD (%)	SD (%)	VS (%)	D (%)
Acute (OR <24 h)	14	64	7	7	0	22
Subacute (OR 24 h–10 d)	6	83	17	0	0	0
GCS (surgery) 15–14	5	100	0	0	0	0
GCS 13–8	13	85	15	0	0	0
GCS 7–3	4	0	0	25	0	75
Associated lesion	7	43	14	14	0	29
No associated lesion	13	84.6	7.7	0	0	7.7

TABLE 1. Continued

Authors (ref. no.)	No. of patients	Class	Inclusion GCS	Treatment	Outcome	Description	Conclusion

	No. of patients	GR (%)	MD (%)	SD (%)	VS (%)	D (%)
Age <40 yr	16	75	6.2	6.2	0	12.5
Age ≥40 yr	6	16.7	16.7	16.7	0	50
GCS (surgery) 3–8 [d]	9	33.3	11.1	11.1	0	44.4
GCS 9–12	6	66.7	0	16.7	0	16.7
GCS 13–15	7	85.7	14.3	0	0	0
EDH	7	100	0	0	0	0
EDH + associated lesion	9	55.6	22.2	0	0	22.2
SDH	1	100	0	0	0	0
SDH + ICH	1	0	0	100	0	0
ICH	2	0	0	50	0	50
ICH + supratentorial lesion	2	0	0	0	0	100
Injury to OR <6 h	9	55.6	0	11.1	0	33.3
Injury to OR 6 h–1 d	7	42.9	14.3	14.3	0	28.6
Injury to OR >1 d	6	83.3	16.7	0	0	0

[d] Odds ratio, 0.057 (statistically significant).

St. John and French (23) — 8 — III — GCS 6–14 — Surgery — GOS, not specified — Retrospective series of 8 patients surgically treated for traumatic posterior fossa hematoma to evaluate clinical characteristics and outcome.

- Mortality 25%.
- Subacute presentation seemed to correlate with better outcome, but number of patients too small to evaluate. Note: paper included with n = 8 because of limited number of case series with ≥ 10 patients.

	No. of patients	GR (%)	MD (%)	SD (%)	VS (%)	D (%)
All patients	8	50	12.5	12.5	0	25
Acute (<24 h)	6	33.3	16.7	16.7	0	33.3
Subacute (24 h–7 d)	2	100	0	0	0	0

Tsai et al. (24) — 57 — III — All GCS — Surgery and nonsurgical — GOS variable — Retrospective series of 57 patients with primary posterior fossa injury to evaluate CT characteristics and correlate type of injury with prognosis.

- PFEDH patients who were comatose on admission died with or without surgery.
- 2/2 PFSDH patients with associated injury were comatose on admission, did not undergo surgery, and died.
- Evidence for brainstem injury, posterior fossa swelling/cistern obliteration correlated with increased mortality (no statistics).

	No. of patients	GR (%)	MD (%)	SD (%)	VS (%)	D (%)
PFEDH	14	50	0	0	0	50
PFSDH	8	62.5	12.5	0	0	25
Cerebellar injury	14	0	0	28.6	14.3	57.1
Brainstem injury	21	0	0	0	23.8	76.2

Vrankovic et al. (25) — 11 — III — Unknown — Surgery and nonsurgical — GOS at discharge — Retrospective series of 11 patients with ATPFH treated either surgically (n = 8) or nonoperatively (n = 3) to evaluate clinical and radiologic characteristics and outcome.

- 9 of 11 patients had occipital fractures and 8.1% of patients with occipital fractures had ATPFH, emphasizing importance of CT for patients with signs of occipital trauma.
- 3 patients with intracerebellar hematomas and no signs of mass effect on CT were successfully managed without surgery.
- Authors advocate immediate surgery for all cases of PFEDH because of unpredictability of deterioration.

	No. of patients	GR (%)	MD (%)	SD (%)	VS (%)	D (%)
All patients	11	54.5	36.4	0	0	9.1

TABLE 1. Continued

Authors (ref. no.)	No. of patients	Class	Inclusion GCS	Treatment	Outcome	Description	Conclusion
Wang et al. (26)	13	III	All GCS	Surgery	GOS 3–6 mo	Retrospective series of 13 patients who underwent surgery for PFEDH to identify clinical features that may lead to early diagnosis and to evaluate outcome with respect to initial GCS.	• Early CT should be prompted by the presence of occipital soft tissue injury, drowsiness, occipital fracture, and diastasis of lambdoid suture. • GCS inversely related to outcome (no statistics). **No. of patients / GR (%) / MD (%) / SD (%) / VS (%) / D (%)** GCS 15–14: 7 / 100 / 0 / 0 / 0 / 0 GCS 13–8: 2 / 50 / 50 / 0 / 0 / 0 GCS 7–3: 4 / 50 / 0 / 25 / 0 / 25
Wong (28)	25	III	All GCS	Surgery and nonsurgical	Mortality at discharge	Retrospective series of 25 patients with PFEDH comparing outcome of surgical versus nonsurgical management with respect to initial CT characteristics, including volume, thickness, degree of shift, and presence of associated frontal contusion.	• Patients managed expectantly with PFEDH volume >10 cm^3, thickness >15 mm, and shift >5 mm had significantly higher mortality than patients managed surgically with equivalent CT characteristics. • 100% survival in all patients with PFEDH volume ≤ 10 cm^3, thickness ≤15 mm, and shift ≤ 5 mm, regardless of treatment. • Associated frontal ICH significantly increased mortality in both groups. **No. of patients / D (%)** Vol >10 cm^3/early OR[e]: 9 / 11.1 Vol >10 cm^3/expectant: 4 / 75 Vol <10 cm^3/early OR[f]: 8 / 0 Vol <10 cm^3/expectant: 4 / 0 Thickness >15 mm/early OR[g]: 13 / 7.7 Thickness >15 mm/expectant: 4 / 75 Thickness <15 mm/early OR[f]: 4 / 0 Thickness <15 mm/expectant: 4 / 0 Shift >5 mm/early OR[e]: 5 / 0 Shift >5 mm/expectant: 1 / 100 Shift <5 mm/early OR[f]: 12 / 8.3 Shift <5 mm/expectant: 7 / 28.6 Associated frontal contusion[h]: 6 / 66.7 No frontal contusion: 19 / 0 [e] $P < 0.05$, [f] P = n.s., [g] $P < 0.01$, [h] $P < 0.001$.
Zuccarello et al. (29)	10	III	Unknown	Surgery and nonsurgical	Mortality	Retrospective series of 10 patients with traumatic posterior fossa mass lesions to describe factors related to management and prognosis.	• Mortality 40% (includes all lesion types). • No comparison between groups able to be made. **No. of patients / D (%)** EDH: 2 / 0 Cerebellar hemorrhage + surgery: 2 / 50 Cerebellar hemorrhage, nonsurgical: 3 / 0 Brainstem injury: 3 / 100
Zuccarello et al. (30)	8	III	GCS motor 4–5	Surgery	GOS at discharge	Retrospective clinical series of 8 patients with surgically treated PFEDH to evaluate outcome.	• Importance of CT is emphasized. Note: paper included with n = 8 because of limited number of case series with ≥ 10 patients. **No. of patients / GR (%) / MD (%) / SD (%) / VS (%) / D (%)** PFEDH, total: 8 / 50 / 37.5 / 0 / 0 / 12.5

[a] GCS, Glasgow Coma Scale; GOS, Glasgow outcome score; PFEDH, posterior fossa epidural hematoma; CT, computed tomographic scan; GR, good recovery; MD, moderate disability; D, death; SD, severe disability; VS, vegetative state; n.s., not significant; HCP, hydrocephalus; ATPFH, acute traumatic posterior fossa hematoma; ICH, intracerebral hemorrhage; EDH, epidural hematoma; SAH, subarachnoid hemorrhage; SDH, subdural hematoma; OR, operation.