LATIN Neurosurgery

Prognostic factors in intracranial epidural hematoma: lessons learned

Factores pronósticos en el hematoma epidural intracraneal: lecciones aprendidas

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ABSTRACT

Introduction: *Intracranial epidural hematoma (IHE) is considered a neurosurgical emergency. Its knowledge has been increasingly highlighted in the literature.* **Materials and Methods***: The present literature review, was performed through the PubMed/MEDLINE, Embase, and Google Scholar databases, published over 50 years. A total of 116 articles from 1975 to 2022 were selected for their relevance to the topic at hand.* **Results***: The main factors influencing the prognosis of patients with IHE are: patient age, the time between injury and treatment, Glasgow Coma Scale (GCS) score ≤ 8 on admission or before surgery, presence of pupillary abnormalities/associated intracranial lesions.* **Conclusion:** *The prognosis is determined by several factors, the most important of which is the GCS grade at the time of admission, as discussed extensively in the literature. The functional outcome has been excellent when IEH is detected early and treated.*

Keywords: *epidural hematoma intracranial; head injury; treatment outcome; prognostic factors.*

RESUMEN

Introducción: *El hematoma epidural intracraneal (HEI) es considerado una urgencia neuroquirúrgica. Su conocimiento ha sido cada vez más destacado en la literatura.* **Materiales y Métodos:** *La presente revisión bibliográfica se llevó a cabo utilizando las bases de datos PubMed/MEDLINE, Em-base y Google Scholar, publicadas durante 50 años. Se seleccionaron un total de 116 artículos de 1975 a 2022 por su relevancia para el tema en cuestión.* **Resultados:** *Los principales factores que influyen en el pronóstico de los pacientes con EHI son: edad del paciente, tiempo entre la lesión y el tratamiento, puntuación en la escala de coma de Glasgow (GCS) ≤ 8 al ingreso o antes de la cirugía, presencia de anomalías pupilares/lesiones intracraneales asociadas.* **Conclusión:** *El pronóstico está determinado por varios factores, siendo el más importante el grado de la GCS al momento del ingreso, ampliamente discutido en la literatura. El resultado funcional ha sido excelente cuando la EHI se detecta a tiempo y se trata.*

Palabras clave: *hematoma epidural intracraneal; traumatismo craneoencefálico; resultado del tratamiento; factores pronósticos.*

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Received Apr 20, 2025
Accepted Apr 22, 2025

1 INTRODUCTION

Intracranial epidural hematoma (IHE) is defined as a blood collection located between the dura mater and the internal bone plate of the skull[1,2]. IEH occurs in 0.2% to 6% of patients admitted with traumatic brain injury (TBI) and in 9% to 12% of severe TBI[1,3-9]. It corresponds to 20% of surgical interventions for intracranial hematomas of traumatic origin[1]. Usually affects young male adults[3,10-12]. The typical clinical picture is an initial loss of consciousness, followed by a return to a normal state of consciousness (lucid interval), followed by focal neurological signs associated with worsening of the state of consciousness.

IHE represents an extremely significant cause of morbidity and mortality in patients with moderate and severe TBI. Prognosis depends on trauma mechanism, age, volume, and location of hematoma, GCS score on admission, the presence of the lucid interval, pupillary abnormalities, motor response, interval between trauma and treatment, elevated intracranial pressure, and neuroimaging findings (associated intradural injury, hematoma volume, midline shift)[3,13-37]. Prognosis can also be affected by geographical factors, based on the distance between the accident site and the reference hospital. The authors review the main prognostic factors in patients with IEH and discuss their findings.

2 LITERATURE SEARCH

We conducted a literature review based on a data survey found in the literature. The descriptors used in the medical subject headings (MeSH) and Descritores em Ciência da Saúde (DeSC) were: Epidural hematoma intracranial, head injury, treatment outcome, prognostic factors. A detailed literature search was performed in the PubMed/MEDLINE, Embase, and Google Scholar databases in December 2022, and the related bibliographic searches were published in the period between 1975 and 2022. A total of 116 articles from 1975 to 2022 were selected for their relevance to the topic at hand. Ethical approval and patient consent were not required as this is a systematic review based on published studies.

3 DISCUSSION

3.1 Lesson 1: Age

IEH mainly affects people in their second and third decades of life[3,7,9,11,38-40]. It affects about 3% of patients under the age of two and 6% of patients over the age of 60[8,38,40]. Due to anatomical and physiological variations, such as increased cranial malleability and elasticity, the middle meningeal artery accommodated in a shallow sulcus (allowing this artery to shift without being injured during trauma), increased adherence of the dura mater to the skull, and a less prominent cranial diploe (reducing the possibility of IEH development), IEH is less common in childhood[41-44].

According to some authors[23,24], patients over the age of 61 have a poor prognosis. They assert that older age results in less favorable functional recovery. An elderly patient may present with an atypical presentation and is frequently associated with focal neurological signs; thus, a computed tomography (CT) of the brain has been recommended early for diagnostic elucidation. The elderly patient typically has multiple comorbidities, and because of the use of anticoagulant drugs and the risk of falling, they have a reduced capacity to recover neurological functions[45].

Several authors have reported that age influences the poor prognosis[4,27,39,46-52]. According to Onodera et al.[53], advanced age and GCS score at admission are predictors of poor prognosis in patients undergoing surgical treatment for IEH. Young adult patients had a better prognosis, according to Ayub et al.[33]. Age had no effect on prognosis in Ali et al.[54] patient series.

3.2 Lesson 2: Localization

The location of the IEH is also significant because it influences the prognosis and directs the neurosurgeon's surgical approach[55]. The preferred location is supratentorial in 90% of patients and infratentorial in 10%. It is unilateral in 95% of cases and bilateral in 5%[40,56].

IEH is almost always found over the convexity of the cerebral hemisphere in the middle fossa, with the temporal and temporoparietal regions being the most common (70% of cases)[2,3,6,9,10,26,32,39,40,42,52,54,57-59]. Approximately 10% of cases were found in the frontal region, 10% in the parieto-occipital region, and 10% in the posterior fossa, with the vertex and clivus being less common[52,60].

In cases of IEH located in the temporal region[32,61,62], a high mortality rate has been reported. Other authors[39,40,42,63] have reported that temporoparietal location was associated with a high mortality rate.

3.3 Lesson 3: GCS score on admission

The clinical presentation depends on the size, location, and hematoma growth velocity, plus the presence or absence of associated intradural lesions. Some symptoms associated with IEH are headache, nausea, vomiting, seizures, and focal neurological deficit[44]. Small-volume IEHs are usually asymptomatic. According to Haselsberger et al.[64] the prognosis depends on the GCS score and neurological status on admission. Several authors[15,34,65,66] associated the presence of pupillary abnormalities and low GCS score on admission with a poor prognosis. Other authors[1-4,15,19,27,28,30,31,39,67-70], have suggested that the most important predictor of prognosis is the GCS score before the surgical procedure. Many authors reported that prognosis is influenced by both the score on admission and the volume of the hematoma[21,27,71]. The literature has reported a high mortality rate in unconscious patients at the time of surgery[27,34,40,42,57]. Mortality ranges from 1.3% to 71% in patients admitted to the emergency department in a comatose state[65]. Considering patients with GCS score on admission between 13-15, 85% have a good outcome; GCS on admission between 9-12 (67%) and GCS score on admission between 3-8 (39%)[11].

3.4 Lesson 4: Presence of Lucid Interval

The classical evolution of loss of consciousness after trauma accompanied by complete recovery of consciousness (lucid interval), followed by mydriasis (homolateral to the hematoma), followed by uncal herniation and contralateral hemiparesis with a decrease in the consciousness level, occurs in 10% to 33% of cases[3,5]. The lucid interval is initially associated with IEH, because of the anatomical particularities that allow the development of the hematoma without immediate clinical manifestations after the injury, due to the non-compression of adjacent structures. This clinical sign is not specific to IEH and may occur in other expanding mass lesions[72,73].

The lucid interval takes 1-24 hours[1] and is found in 2.4% to 58% of occurrences[1-3,74,75]. It usually occurs in isolated and voluminous IEH that can be demonstrated by CT imaging with findings of active bleeding (swirl sign). Gutowski et al.[76] reports that in patients with IEH, the signs and symptoms progress rapidly, are often associated with alterations in the level of consciousness in a brief time interval after injury and do not present with the classic "lucid interval" sign. Increasingly, a reduction in the incidence of the lucid interval has been demonstrated, due in part to the earlier use of brain CT in moderate and severe TBI cases. The presence of the lucid interval is not mandatory but is considered a significant parameter in terms of prognosis.

The prognosis is generally excellent if surgical intervention, when possible, is performed before the onset of clinical signs, in particular signs of uncal herniation. Therefore, every TBI with a history of loss of consciousness benefits from a CT scan. The IEH should be detected before the onset of changes in consciousness and focal neurological signs for a better patient prognosis[39,77].

3.5 Lesson 5: Presence of motor deficit

Patients with better motor function in the first clinical picture have better outcomes, and the absence of motor deficit is an important prognostic factor for these patients[61,78]. According to Özkan et al.[30] the presence of pyramidal signs is an independent risk factor for poor prognosis.

3.6 Lesson 6: Presence of pupillary compromise

Pupillary reactivity to light plays an important role in the evaluation and helps the examiner localize the intracranial hematoma. Monitoring pupillary reactivity provides information about a secondary and continuing outcome (elevation of intracranial pressure), and the presence of mydriasis is a predictor of poor prognosis[79,80]. Unilateral mydriasis (anisocoria) is identified in 6% to 44% of IEH cases[2,3,19,57]. Other authors[15,26,27,30,81] pointed out that the presence of pupillary alteration may confer a poor outcome on these patients.

Bilateral pupillary non-reactivity is associated with high mortality[50-69]. Dubey et al.[15] reported that the presence of pupillary abnormalities associated with a low GCS score at admission is associated with a poor prognosis. For Cohen et al.[14] mortality increases three times more in patients with anisocoria, and the prolonged presence of this sign for more than 70 minutes confers 100% mortality.

3.7 Lesson 7: Presence of associated comorbidities

The presence of arterial hypertension, bradycardia, and respiratory irregularities has been rare but is associated with significant mortality[30,34]. Bradycardia associated with elevated blood pressure is directly related to increased intracranial pressure (ICP). According to Brazdzionis et al.[82] the presence of comorbidities such as obesity, diabetes mellitus, arterial hypertension, hyperlipidemia, illicit drug use, tabagism, cancer, psychiatric diseases, and chronic renal disease are involved in the poor prognosis of patients operated on for IEH.

Onodera et al.[53] demonstrated that there was no significant difference between the findings of vital signs, blood pressure, and body temperature between patients who had good and poor prognoses. According to Ayub et al.[33] the presence of associated injuries such as cervical spinal cord injury, chest trauma, and cerebral edema increase the mortality rate.

3.8 Lesson 8: CT findings: fracture trace, hematoma volume, swirl sign, midline shift, hematoma thickness, and presence of associated lesions

CT is essential to determine the location, volume, and thickness of the hematoma, in addition to the presence of a mass effect, deviation of midline structures, ventricular system and basal cisterns, and associated intracranial lesions, and helps to assist treatment decision-making[1,2,21,59,71,83-86]. When CT is performed six hours post-injury, the patient is at high risk for complications from a developing hematoma[10,16]. The incidence of skull fracture trace varies from 60% to 86.7% of cases[1,7,9,11,15,17,26,38,71,87]. The absence of fracture trace on plain skull radiography does not exclude the presence of IEH[88]. Fracture trace crossing the middle meningeal artery pathway or dural venous sinuses confers a tendency for hematoma expansion even after conservative treatment[89]. Several authors have described that the presence of cranial fracture trace is associated with a worse prognosis[42,90].

CT findings that correlate with poor prognosis are superior hematoma volume (30-150 ml), midline deviation (>10-12 mm), presence of the "swirl sign" indicating active bleeding, and presence of isolated intracranial lesions. Several studies have shown that IEH volume is one of the main factors influencing prognosis[15,22,27,39,40,44,70,71,91-93]. Supratentorial hematoma volume (> 30 ml) or in posterior fossa/ temporal region (> 25 ml) have immediate surgical indication.

According to Singh et al.[25], a large IEH (> 80 ml) is associated with a poor prognosis. Voluminous IEH causes a large mass effect demonstrated by midline deviation and brainstem compression, causing significant deterioration of the neurological status and leading the patient to a poor prognosis[4,33,35,39,92]. Pereira et al.[91] reported no relationship between hematoma volume and patient age and stated that hematoma volume is independent of the presence of associated intracranial injury. These authors found a relationship between the volume of the hematoma and its location, the smallest volume being located at the temporal region, also observed by Ersahin et al.[61] who associated large IEH in this region with high mortality.

Rivas et al. 40 associated the volume of the hematoma with the severity of deviation of midline structures in comatose patients preoperatively, and consequently with a poor prognosis. Other authors 2,21 reported that surgical outcomes were considered better when the hematoma volume was less than 30 ml, compared to those with a volume > 30 ml.

According to Özkan et al[30], hematoma volume and the presence of pyramidal signs were considered independent risk factors for mortality in patients with IEH. The comatose state is more associated with the presence of voluminous IEH[40]. Badhe and Bhamre[2] associated hematoma volume and GCS score on admission as the most important factors in prognosis. For Wang et al.[93] Voluminous IEH causes internal cerebral herniation within 3-24 hours after injury, inducing a persistent suppression of cerebral blood flow and venous drainage, resulting in massive cerebral infarction and cerebral edema.

In the hyperacute form of IEH the "swirl sign" can be seen on the CT scan, which is a hypodense spiral area within the hematoma, representing active arterial hemorrhage and indicating the need for immediate surgery for cerebral decompression. The presence of this sign is associated with a poor prognosis[34,94].

A midline deviation > 5 mm with worsening of the neurological condition has a very poor prognosis. Other authors report that the main factor influencing the therapeutic decision is the presence of deviation of midline structures at CT[1,15,17,20,26,30,39,40,76,95]. IEH thickness greater than 1.5 cm has shown an unfavorable evolution[1,14,15,26,27,30,40].

Several authors[1,29,96] report that between 10% and 55% of cases of IEH are associated with other intracranial lesions, which leads to a high number of "atypical" clinical presentations that cause a mortality rate of 20% to 50% of cases. Other authors have described that the presence of associated intracranial lesions is common in patients with IEH and is associated with a poor prognosis[17,27,39,40,53,76]. In cases with associated intracranial lesions, conservative treatment is contraindicated[27,97]. According to Kvarnes and Trumphy[6], the presence of intracranial lesions is associated with a two to four times higher mortality compared to those without other intracranial lesions. The presence of brain swelling and diffuse axonal lesions associated with IEH is associated with a poor prognosis[33,98]. It has been re the literature has reported that patients with low GCS scores of associated lesions (brain contusion) increase mortality[11,19,29,57].

3.9 Lesson 9: Late initiation of treatment

The patient outcome tends to be unfavorable when associated with the delay between injury and surgical decompression[23,24,54,99,100,101,102]. Several authors associate comatose state and delay in surgery as important factors in prognosis[3,17,30,34,39,100,103]. Other authors found no relationship between the time taken for surgery and the prognosis[28,104]. For Gnani et al.[105] the delay in definitive treatment leads to cerebral ischemic complications due to prolonged compression and cerebral herniation.

Ayub et al.[33] observed that young patients who underwent surgery and were operated on early and with absent or minimal associated intracranial injury, recover better than those patients in whom surgery was performed late. Ayogu et al.[28] reported that patients operated on within six hours of the presentation showed no significant improvement in outcome when compared to those operated on more than six hours from the presentation. Neurological conditions preoperatively and the interval between trauma and surgery are important factors in prognosis[99,100].

One of the contributing factors to the delay in performing surgery is the delayed transportation from the accident site to the referral hospital[99,100]. According to Ramazam et al.[106], the delay between transportation from the injury site and the hospital and the presence of bilateral IEH are associated with poor prognosis. Kattak et al.[59] reported that mortality is reduced when a diagnosis is made early and treatment indicated immediately. Beketi et al.[107] reported that delayed treatment and a low GCS score on admission confer a poor prognosis. Ayub et al.[33] reported that the time between injury and surgery and the volume of the hematoma are important factors affecting prognosis. In the study by Ozkan et al.[30] the mortality of patients undergoing surgery within 6 hours of injury was 23.5%, reducing to 18.5% when operated on within the first 6 hours of trauma.

Important considerations should be made regarding the timing of repeat CT, especially in cases of conservative treatment. According to Sullivan et al.[108] the increase in IEH volume occurs in 23% of cases and the average time for this increase to occur is 8 hours after trauma, which would be the time to perform a new CT. The IEH may increase in volume between 6-8 hours after the injury[21].

3.10 Lesson 10: Treatment

IEH is classified as a neurosurgical emergency[1,4,9,71,109]. The therapeutic decision and timing of treatment should be individualized based on the patient's age, hematoma size, location, and neurological status[18,110]. Multiple associated comorbidities, associated intracranial lesion, cerebral ischemia, antithrombotic treatment, and elderly patient, influences surgical treatment prognosis[25]. According to Cheung et al.[11], the surgical outcome of IEH is also affected by important factors such as the presence of anisocoria, the time between the injury and surgery, the hematoma volume, and the GCS score at admission.

Conservative treatment has been recommended in patients with a preserved level of consciousness, no focal neurological deficit, no associated intracranial injury, and IEH of small volume (<30 ml), thickness (<15 mm), and midline deviation (<5 mm), constant clinical observation, and the ability to perform control CT[10,15]. In the event of neurological deterioration, immediate surgery is advised. Other authors[10,111] refer to conservative treatment when the thickness is greater than 20 mm. Bullock et al.[26] demonstrated that a volume ranging from 12-38 ml was suitable for conservative treatment. According to Chen et al.[112], hematomas greater than 30 ml in volume, thickness greater than 15 mm, and midline deviation greater than 5 mm are strong indications for surgical drainage. There is also disagreement regarding IEH of the posterior fossa; several authors recommend surgical treatment in all cases due to the possibility of significant mass effect in a small space[95]. According to Wong[113], IEH located in the posterior fossa with a volume less than 10 ml, thickness less than 15 mm, midline deviation less than 5 mm, and the absence of another intracranial hematoma has an excellent outcome when conservative treatment is used.

According to Chen et al.[112], supratentorial IEH with a volume greater than 30 mL, a thickness greater than 15 mm, and a midline deviation greater than 5 mm necessitates immediate surgical intervention. Early diagnosis followed by surgical treatment should be taken into consideration in some cases, according to Choi et al.[110]; in their series, 50% of the patients had positive surgical outcomes. Patients with a low GCS score, pupillary abnormalities, a bulky hematoma, and a large deviation of midline structures, according to Hamilton and Wallace[114], require immediate surgical intervention.

3.11 Lesson 11: Mortality

The mortality rate for HE ranges from 0% to 33%[9-11,27,32,40,56,90,95,103,112,115]. According to Sthephanov[103], pre-CT mortality ranged from 16% to 52%, while post-CT mortality ranged from 8% to 14%. This author concluded that the most important factor in reducing mortality was prompt transport of the patient to a neurosurgical referral center. Jones et al.[116] reported that mortality has decreased from 29% to 8% in the last 35 years. According to Lee et al.[27], before the use of CT in emergency departments, mortality ranged between 40 and 80%, but after the use of CT became routine, mortality dropped to 9%. Other authors[1,6,32] have shown that late diagnosis and the presence of associated intradural lesions are major contributors to high morbidity and mortality.

4 CONCLUSIONS

IEH is a common pathology in patients with moderate to severe TBI and is considered a neurosurgical emergency. Its symptoms are variable. The CT scan is the preferred method of diagnosis. The prognosis is determined by several factors, the most important of which is the GCS grade at the time of admission, as discussed extensively in the literature. Preoperative GCS score, the presence of anisocoria, the volume of hematoma, and the presence of associated intracranial lesions all have a significant impact on surgical outcomes. A good outcome is associated with isolated IEH, hematoma volume less than 60 ml, GCS score greater than 8, absence of anisocoria, and surgical intervention within six hours of trauma. The functional outcome has been excellent when IEH is detected early and treated.

The main prognostic factors of patients with IEH should be investigated further to better determine the elements that contribute to a favorable outcome, reducing morbidity and mortality in these patients.

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Funding: *Nothing to declare.*
Conflict of interest: *The authors declare no conflicts of interest*
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