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Extradural hematoma – is surgery always mandatory?

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Abstract: Although surgery remains the treatment of choice for extradural hematomas (EDH), there were many cases reported in the literature with good outcome, even if they were not treated surgically. The aim of this study was to discover the most important factors influencing the management strategy and outcome of EDH and to outline a set of guidelines for the treatment. Fifty-six consecutive adult patients treated for EDH between 2008 and 2012 formed the base of this retrospective study. The patients were treated as follows: 28 cases (50.0%) underwent urgent surgery, 13 cases (23.2%) were managed nonoperatively and 15 cases (26.8%) required delayed surgery. The conservative management was directly related to the volume of the EDH, and the EDH volume over 30 cm3 was a significant prognostic factor for conversion to surgery (95 % CI, $p < 0.001$). Patients in coma (Glasgow Coma Score < 8) have a poorer outcome than patients in good neurological status, regardless of to the therapy followed (95% CI, $p = 0.0034$). The volume of the EDH was not demonstrated to be a prognostic factor related to outcome (95 % CI, $p = 0.2031$). In conclusion, the diagnosis of the EDH must be promptly made by CT scan and the patient should be handled as an emergency and admitted into a neurosurgical center. Surgical indications mainly rely on the patient's neurological status and CT findings.

Key Words: extradural hematoma, brain injury, outcome.

Being one of the leading causes of severe disability and death among young people, traumatic brain injury (TBI) is a very important health and social problem. Mortality rate associated with EDH is between 5 % and 50 % [27, 30]. Death is usually due to respiratory arrest from uncal herniation causing compression of the brainstem [25].

Although surgery remains the treatment of choice for many epidural hematomas, in the last decades more and more studies reporting conservative treatment of small and moderate sized hematomas having a good outcome appeared [12-18]. This management policy needs a close observation of the patient, both clinical and imagistic, as it is well known that even a previously stable patient's state can deteriorate rapidly. Both the volume of extradural hematoma and the neurological status of the patient have been reported to influence the outcome of EDH [14-16, 18].

Though the majority of EDHs continue to require urgent surgical evacuation, adult patients with a supratentorial EDH less than 30 cm^3, less than 15 mm in thickness and with less than 5 mm midline shift, with a Glasgow Coma Scale (GCS) score greater than 8 and without focal deficit could be managed nonoperatively given serial CT scanning and close neurological observation in a neurosurgical center [2, 5].

The aim of this study was to discover the most important factors influencing the management strategy and outcome of EDH and to outline a set of guidelines for the treatment of patients with EDH - conservative or surgical.

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MATERIAL AND METHODS

We conducted a retrospective study on 56 consecutive cases of extradural hematomas admitted to the 3rd Neurosurgical Department of "Bagdasar-Arseni" Emergency Hospital in Bucharest, treated conservatively and surgically between January 1, 2008 to December 31, 2012. Patients diagnosed with EDH after CT scan, but without open or penetrating head injury were included in this study. Patients with concomitant cerebral lesions were also included, but only if the relevant lesion was the extradural accumulation of blood.

Demographic data, the time and mechanism of head injury, neurological evaluation according to GCS before admission and the time of the first CT scan were documented. A thorough clinical assessment and a cranial CT scan were performed on all patients in our emergency department on admission. Repeated neurological examinations were also performed. Patients with a GCS score of 9-15 points were labeled as non-comatose and patients having a GCS < 8 points were included in the category of comatose. Traumatic symptoms and signs were analyzed. Subsequent CT scans were performed if clinically indicated. All CT scans were performed using routine orbital baseline and 10-mm scan slices. The volume of the hematoma was calculated from CT studies by using the Petersen and Esperson formula: (A×B×C) × 0.52, where A, B and C represent the length, width and height of hematomas [19]. The locations of the EDH and associated intracranial traumatic lesions were noted.

Patients were evaluated and treated according to currently accepted international guidelines [2, 20]. Indications for surgery were a hematoma volume greater than 30 cm3 in the supratentorial space and greater than 10 cm^3 in the infratentorial space, a midline shift greater than 5-mm, a clot thickness greater than 15-mm and/or neurological deterioration. For EDH with a volume less than 30 cm^3 in the supratentorial space and less than 10 cm^3 in the infratentorial space, a midline shift less than 5-mm, a clot thickness less than 15-mm, with a GCS score > 8, without focal deficit, we attempted nonsurgical management, with close observation and serial CT scanning. In the case of neurological deterioration, a new CT scan was achieved and surgical removal of the hematoma was performed as soon as possible. Craniotomy provided the removal of the EDH in supratentorial location. Craniectomy was used when the EDH was located infratentorial.

For the study, the patients suffering from EDH were divided into two groups, according to the treatment management. In group I we included patients who required immediate surgery for EDH. Group II was further divided into two: subgroup II A – patients who were treated conservatively, and subgroup II B – patients who were initially treated conservatively, but, in the clinical course a neurological deterioration appeared after at least 72 hours and a delayed surgery was required.

Functional assessment was done at 6 months after trauma, according to Glasgow Outcome Scale (GOS), which include death (D), persistent vegetative state (PVS), severe disability (SD), moderate disability (MD) and good recovery (GD). Good outcome was considered in patients with good recovery or with moderate disability who recovered independence. Patients who were severely disabled, who died or who were in a persistent vegetative state were included in the poor outcome group. The distribution of the good and poor outcome in relation with different factors was examined.

The data were analyzed using Microsoft Excel® 2013 and IBM SPSS Statistics 21.0.

RESULTS

The age ranged from 16 to 81 years, with a median of 32 years. Most patients were in the active period of their life: 35 patients having between 30-49 years. Men were more affected than women (44 men, 12 women, men-to-women ratio = 3.66:1). The mechanisms of trauma included: road traffic accidents (29 cases – 51.8%), falls (13 cases – 23.2%), assault (10 cases – 17.9%) and others (4 cases – 7.1%).

The symptoms and signs of the patients are summarized in Table 1. A GCS score < 12 was recorded in 19 patients, but 12 of them were comatose with a GCS score < 8. When present, the lucid interval lasted between few hours and 3 days (28 patients – 50.0%).

In our series, temporal region was involved in 13 patients (23.2%), followed by frontal (10 patients – 17.85%) and parietal regions (8 patients – 14.28%). Others locations include: occipital region (5 patients – 8.93 %), temporo-parietal region (8 patients – 14.28%), fronto-parietal region (5 patients – 8.93 %), fronto-temporo-parietal region (5 patients – 8.93 %) and posterior cranial fossa (2 patients – 3.57 %).

The patients diagnosed with EDH admitted in our study were treated as follows: 28 patients (50.0%) underwent urgent surgery (group I), 13 patients (23.2%) were managed nonoperatively (group IIA) and 15 patients (26.8%) required delayed surgery because of neurological deterioration or increase of the size of the hematoma (group IIB).

Details of the cases treated by immediate surgery are shown in Table 2.

Details of the cases treated by conservative

Table 1. Clinical features of the series

Signs/Symptoms	Number of patients	Percentage
Lucid interval	28	50.0%
Headache and vomiting	34	60.7%
Altered state of consciousness (GCS < 12)	19	33.9%
Neurodeficits	19	33.9%
Homolateral pupillary changes	7	12.5%
Bilateral pupillary changes	5	8.9%
Bradycardia	14	25.0%

measures are shown in Table 3. There were 13 patients in this group, 11 of them having a GCS score ≥ 12 at admission. Two patients were comatose; they had associated posttraumatic SAH on admission CT scan and presented a poor outcome. One death was recorded, in an elderly man with a GCS score of 12 at admission, with associated intracranial lesions and no lucid interval. Two hematomas with a volume greater than 30 cm^3 were recorded, located in the frontal and parietal region, respectively; the patients had a GCS score of 15 and a good outcome.

Neurological deterioration was the most common reason for delayed surgery, being identified in 7 patients, followed by delayed referral in 5 patients (Fig. 1) and increase in size of the EDH on serial CT scan in 3 patients. All patients had a lucid interval. There was no death, but one patient had a poor outcome in this group (severe disability).

Out of 28 cases with EDH that were managed conservatively at the beginning, 13 cases (46.4 %) had EDH volume < 30 cm^3 and 15 cases (53.6 %) had EDH volume > 30 cm^3. Most of the cases having volume < 30 cm3 resolved with conservative management except two cases, which undergo surgery. Out of 15 cases with an EDH volume > 30 cm^3, 13 got delayed surgery and only 2 cases followed conservative therapy, despite their volume greater than 30 cm^3, as they had a good GCS score [15] from the very beginning (Table 4). Therefore, the conservative management is directly related to the volume of the EDH, and the EDH volume over 30 cm^3 is a significant prognostic factor for conversion to surgery for patients included in the group II (95 % CI, $p < 0.001$).

Patients in coma (GCS < 8) have a poorer outcome than patients in good neurological status, regardless of to the therapy followed (Table 5). This is statistically significant (95% CI, $p = 0.0034$). In contrast with these findings, when we analyzed the volume of the EDH in relation to the patient's outcome, the results are not statistically significant. This demonstrated that the volume of the EDH is an important parameter for conversion of the treatment from conservative to surgery, but it is not a prognostic factor related to outcome (95 % CI, $p = 0.2031$). Other associated cerebral lesions (edema, contusion, subarachnoid hemorrhage, etc.) and/or extra-cerebral lesions could play an important role in determining the prognostic and outcome.

DISCUSSION

Since the first description, the epidural hematoma was considered a neurosurgical emergency and an urgent evacuation was recommended, in order to prevent neurological sequelae or even death. This dogma has been reconsidered. There were many cases of EDH reported in the literature, sometimes of considerable size, with good outcome even if they are not treated surgically [21, 22]. There is a concern to identify the factors that affect outcome, with the aim to document the selection criteria for surgery.

The classical clinical presentation of EDH includes a brief posttraumatic loss of consciousness, followed by a "lucid interval" of variable duration and then headache, depressed conscious state, contralateral hemiparesis and ipsilateral pupillary dilatation. Deterioration usually

Table 2. Details of the cases treated by immediate surgery - 28 patients (group I)

Location	No. of cases	Volume of the EDH	GCS score			Outcome		
			≥ 12	11-9	≤ 8	Good	Poor	Death
frontal	4	<30 cm^3 – 1 >30 cm^3 – 3	2	2	0	4	0	0
temporal	6	>30 cm^3 – 6	2	2	2	5	1	0
parietal	8	<30 cm^3 – 2 >30 cm^3 – 6	5	3	0	8	0	0
occipital	2	>30 cm^3 – 2	1	1	0	2	0	0
fronto-temporal	4	>30 cm^3 – 4	1	1	2	2	1	1
temporo-parietal	3	<30 cm^3 – 1 >30 cm^3 – 2	1	1	1	3	0	0
fronto-temporo-parietal	1	>30 cm^3 – 1	0	0	1	0	1	0
Total	**28**		**12**	**10**	**6**	**24**	**3**	**1**

Table 3. Details of the cases treated by conservative measures – 13 patients (group II A)

No	Sex	Age	Mechanism of injury	Location	GCS score	Lucid interval	Volume of EDH	Other cerebral lesions	Outcome
1	M	81	fall	parietal	12	no	< 30 cm^3	yes	D
2	M	31	RTA	temporal	14	yes	< 30 cm^3	yes	GR
3	F	22	RTA	frontal	15	yes	> 30 cm^3	no	MD
4	M	74	fall	fronto-parietal	13	yes	< 30 cm^3	yes	GR
5	F	25	RTA	parietal	15	yes	> 30 cm^3	no	GR
6	M	43	assault	parietal	12	yes	< 30 cm^3	yes	MD
7	M	45	RTA	fronto-temporal	4	no	< 30 cm^3	yes	SD
8	F	28	RTA	occipital	13	yes	< 30 cm^3	no	GR
9	F	68	fall	frontal	15	yes	< 30 cm^3	no	GR
10	M	29	RTA	temporal	8	yes	< 30 cm^3	yes	PVS
11	M	49	assault	fronto-parietal	14	yes	< 30 cm^3	no	GR
12	F	37	fall	temporal	15	yes	< 30 cm^3	no	GR
13	M	37	fall	frontal	14	yes	< 30 cm^3	yes	GR

RTA – road traffic accidents; GR-good recovery; MD-moderate disability; SD-severe disability; PVS- persistent vegetative state; D-death.

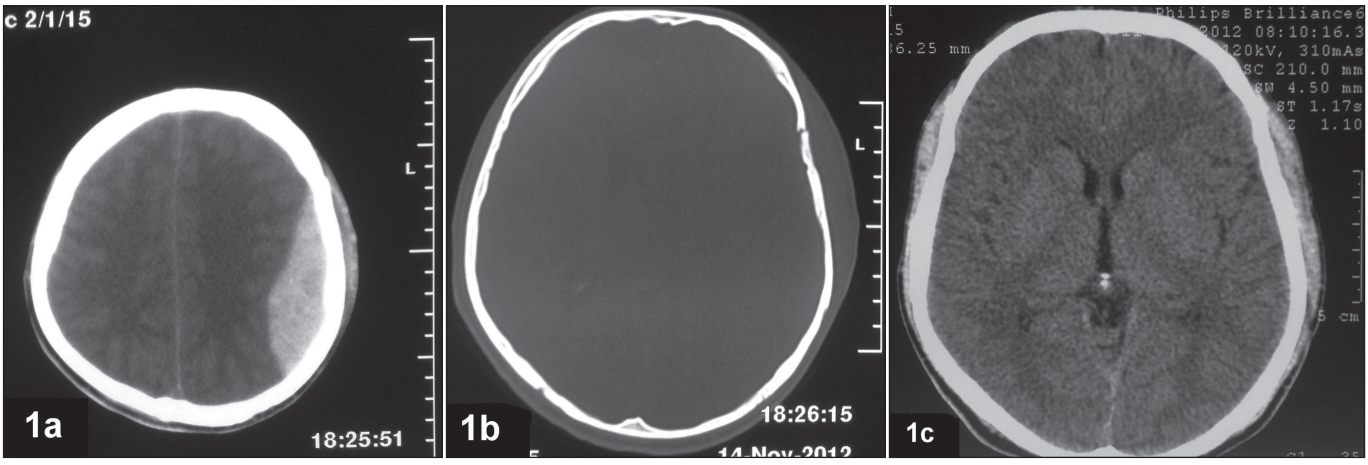

Figure 1. 52 years-old male with head trauma secondary to a road traffic accident, having a GCS score at admission of 12; patient was operated on 72 hours after trauma, because of delayed referral in our hospital. (1a) Axial CT scan showing a left fronto-parietal EDH, with midline shift; (1b) axial CT bone window, showing a left fronto-temporal fracture; (1c) axial CT scan performed 45 days after surgery, showing complete resolution of the EDH.

occurs due to a cerebral herniation. Clinical findings are highly variable, often unreliable for EDH and can delay the diagnosis, the diagnostic method of choice being the CT scan.

Failure to consider EDH in a lucid patient with head trauma will result in delayed treatment and is a major source of medical-legal concern [27]. A lucid patient with EDH may be discharged from hospital and die at home; depending upon the initial severity the cause of death can be considered either the initial hematoma (if the initial severity is extremely high and the treatment options are extremely limited, an instance however only rarely associated with a EDH with lucind intervals), or the omission to diagnose and treat the patient, case in which it can be considered manslaughter [28]. The clinical condition may also resemble alcohol intoxication and patient is sent at home, dying due to an untreated EDH [29]. On the other hand, patients with alcohol intoxication or other forms of intoxication have been associated with a higher incidence of EDH, because they are prone to blunt head trauma, thrombocytopenia and prolonged bleeding times.

Once the diagnosis of EDH was established, the decision to choose a surgical or conservative management rely on the clinical and imaging findings – mainly on the patient's neurological status and size of the hematoma.

In general, all patients harboring an EDH with a volume greater than 30 cm^3 in the supratentorial space and greater than 10 cm^3 in the infratentorial space should be operated on, regardless of GCS score and neurological signs, because it can cause death. For patients with smaller hematomas, neurological status guides the treatment. Urgent evacuation is also indicated in cases with coma (GCS score < 8) and signs of cerebral herniation (increasing drowsiness, pupillary asymmetry, neurological deficits or cardiorespiratory abnormalities). Craniotomy provides complete evacuation of the hematoma, identification and elimination of the source of the bleeding and prevention of the reaccumulation. Only in cases with an EDH with a volume less than 30 cm^3 in the supratentorial space and less than 10 cm^3 in the infratentorial space, a thickness less than 15 mm, a midline shift less than 5 mm, a GCS score greater than 8, without focal deficit may conservative management be justified [2, 4, 5, 7, 24, 25]. When non-surgical management is attempted, the patient should be admitted in a neurosurgical center, under very close neurological observation, with serial CT scans, in order to act quickly on sudden decompensation. The first follow-up CT scan should be obtained within 6 to 8 hours after trauma [2].

If neurological deterioration appears, surgical evacuation of the EDH should be performed as soon as

Table 4. Management strategy in relation to the EDH volume in patients included in group II

Management	Volume of the EDH		Total
	< 30 cm^3	> 30 cm^3	
Conservative therapy (group IIA)	11 cases	2 cases	13 cases
Delayed surgery (group IIB)	2 cases	13 cases	15 cases
Total	13 cases (46.4 %)	15 cases (53.6 %)	28 cases

Table 5. Six-month outcome for the entire population (n = 56 cases)

Parameters		Good outcome* (no. of cases)	Poor outcome** (no. of cases)	Total (no. of cases)
GCS score	≥ 12 - 15	36	1	37
	11 - 9	9	2	11
	≤ 8	4	4	8
Volume of EDH	< 30 cm^3	13	4	17
	> 30 cm^3	35	4	39

*Good outcome (GR, MD), **Poor outcome (SD, PVS, D).

possible. A delay in surgical treatment could be related to a worse prognosis or death [18, 32]. In general, temporal or posterior fossa location of the EDH could be lethal by rapidity with which the patient can deteriorate clinically [2, 15, 30]. Also, in pediatric patients, a nonsurgical management is a risky strategy, since there is less room for clot [25]. Therefore, in these cases when an EDH has a high risk of death, the threshold for surgery should be lower. In our series, the EDH volume more than 30 cm^3 was a significant prognostic factor for conversion to surgery (95 % CI, $p < 0.001$), but, was not found to be a prognostic factor related to outcome (the results were not statistically significant - 95 % CI, $p = 0.2031$).

There are studies focused on the factors determining delayed surgery [32, 36, 38, 39]. Chen *et al.* demonstrated that low sistolic blood pressure (as a result of concurrent systemic traumatic lesions), the presence of coagulopathy, decompressive craniectomy and a shorter time interval between injury and the first CT scan were the risk factors for the development of progressive epidural hematoma, which represent 9.2 % of the cases in his studies [38]. Therefore, routine follow-up CT scans was recommended for all patients who deteriorate or at 12 to 24 hours after admisssion for patients with hypotension or coagulopathy. Bezircioglu *et al.* found that the only factor associated with delayed surgery in EDH was the temporal location of the hematoma [36]. Other studies was conducted on patients with small EDH expectantly managed and a skull fracture transversing a meningeal artery, vein, or major sinus and a CT within 6 hours of trauma have been identified as risk factors for deterioration and neurosurgical intervention [32, 39].

In our series, 15 out of 28 patients (53.6 %) deteriorated in the course of conservative treatment and required surgical evacuation (group IIB). Of these 15 patients, there was one patient with poor outcome and no death.

Conservative management could be applied in selected cases with a normal outcome, but this attitude mandates close neurological evaluation and serial CT scanning in a neurosurgical center [2, 5, 16, 24, 25, 40, 41]. Resolution of the hematoma on CT images occurs over a period of 3 to 15 weeks [42].

CONCLUSIONS

The diagnosis of extradural hematoma must be considered in all cases of head trauma and must be promptly made by CT scan. The patient should be handled as emergency and admitted into a neurosurgical center. Surgical indications mainly rely on the patient's neurological status and CT findings. Evidence-based guidelines recommend urgent evacuation of an extradural hematoma with a volume greater than 30 cm^3 in the supratentorial space and greater than 10 cm^3 in the infratentorial space and in any patient with EDH and coma (GCS score < 8) or signs of cerebral herniation.

Non-surgical management could be attempted in adult patients with an EDH with a volume less than 30 cm^3 in the supratentorial space and less than 10 cm^3 in the infratentorial space, a thickness less than 15 mm, a midline shift less than 5 mm, a GCS score greater than 8 and without focal deficit. In this case, the patient should be managed with serial CT scan, under adequate neurological observation. If a neurological deterioration appears, clinical and imagistic evaluation and surgery should be available. Patients with a temporal or posterior fossa EDH and children with EDH require special atention. In these cases the threshold for surgery should be lower.

Abbreviations:

CI = confidence interval
CSF = cerebrospinal fluid
CT = computerized tomography
D = death
EDH = extradural hematoma
GCS = Glasgow Coma Scale
GD = good recovery
GOS = Glasgow Outcome Scale
MD = moderate disability
PVS = persistent vegetative state
RTA = road traffic accident
SAH = subarachnoid hemorrhage
SD = severe disability
TBI = traumatic brain injury

References

1. Karus JF. Epidemiology of Head Injury. In: Cooper PR, editor. Head Injury. Baltimore ed1993. p. 2-5.
2. Bullock MR, Chesnut R, Ghajar J, Gordon D, Hartl R, Newell DW, Servadei F, Walters BC, Wilberger JE. Surgical management of acute epidural hematomas. Neurosurgery. 2006 Mar;58(3 Suppl):S7-15; discussion Si-iv. PubMed PMID: 16710967. Epub 2006/05/23. eng.
3. Iliescu DB, Ioanz BG, Zetu I, Astarastoae Y. Non-traumatic spontaneous acute epidural hematoma - case report. Romanian Journal of Legal Medicine. 2009 Jun;17(2):111-4. PubMed PMID: ISI:000267439200006. English.
4. Lumenta CB, Mooij JJA, Di Rocco C. Trauma. In: Lumenta CB, Di Rocco C, Haase J, Mooij JJA, editors. Neurosurgery. European Manual of Medicine. Berlin Heidelberg: Springer - Verlag; 2010. p. 249-300.
5. Timmons SD. Extra-axial hematomas. In: Loftus CM, editor. Neurosurgical Emergencies. 2nd ed: Thieme Medical Publishers; 2008. p. 53-67.
6. Netter FH. Central Nervous System Trauma. In: Jones HR, editor. The CIBA collection of Medical Illustrations1986. p. 92-6.
7. Mathur V, Jallo J. Summary and synopsis of the Brain Trauma Foundation head injury guidelines. In: Loftus CM, editor. Neurosurgical Emergencies. 2nd ed: Thieme Medical Publishers; 2008. p. 172-194.
8. Carlos UP, Joas DB, Carneiro L. Extradural haematoma: Analysis of 30 cases. The Internet Journal of Emergency Medicine. 2005;2:2.
9. Meyer SH, Chesnut R. Posttraumatic Extra-Axial Mass Lesions: Subdural and Extradural Hematoma. In: Tindall GT, Cooper PR, Barrow DL, editors. The Practice of Neurosurgery: Lippincott Williams & Wilkins; 1996.

10. Munro D, Maltby GL. Extradural hemorrhage: a study of forty-four cases. Ann Surg. 1941 Feb;113(2):192-203. PubMed PMID: 17857724. Pubmed Central PMCID: 1385674. Epub 1941/02/01. eng.
11. Seeling JM, Marshal LF, Tautan SM, Toole BM, Klauber MR, Bowers SA, Varnell JA. Traumatic acute epidural hematoma: unrecognized high lethality in comatosed patients. Neurosurgery. 1984;15(5):617-620.
12. Ericson K, Hakansson S. Computed tomography of epidural hematomas. Association with intracranial lesions and clinical correlation. Acta Radiol Diagn (Stockh). 1981;22(5):513-9. PubMed PMID: 7331863. Epub 1981/01/01. eng.
13. Tochio H, Waga S, Tashiro H, Takeuchi T, Miyazaki M. Spontaneous resolution of chronic epidural hematomas: report of three cases. Neurosurgery. 1984 Jul;15(1):96-100. PubMed PMID: 6472600. Epub 1984/07/01. eng.
14. Deniz FE, Turk CC, Ismailoglu O, Bozkurt G, Ozcan OE. Rapid spontaneous resolution of epidural hematoma: a case report. Ulusal travma ve acil cerrahi dergisi = Turkish journal of trauma & emergency surgery : TJTES. 2010 May;16(3):280-2. PubMed PMID: 20517759.
15. Dubey A, Pillai SV, Kolluri SVR. Does volume of extradural hematoma influence management strategy and outcome? Neurol India. 2004 Dec;52(4):443-5. PubMed PMID: ISI:000226324100005. English.
16. Bhau KS, Bhau SS, Dhar S, Kachroo SL, Babu ML, Chrungoo RK. Traumatic extradural hematoma - role of non-surgical management and reasons for conversion. The Indian Journal of Surgery. 2010 Apr;72(2):124-9. PubMed PMID: 23133222. Pubmed Central PMCID: 3452499.
17. Illingworth R, Shawdon H. Conservative management of intracranial extradural haematoma presenting late. J Neurol Neurosurg Psychiatry. 1983 Jun;46(6):558-60. PubMed PMID: 6875589. Pubmed Central PMCID: 1027449. Epub 1983/06/01. eng.
18. Islam MM, Bhuyian TH, Hassan MK, Asadullah MATA, Raihan Z, Hossain SS. Management Strategy and Outcome of Epidural Haematoma in Relation to Volume. Faridpur Medical College Journal. 2011;6(2):89-91.
19. Petersen OF, Esperson JO. Extradural hematomas: measurement of size by volume summation on CT scanning. Neuroradiology. 1984;26(5):363-7. PubMed PMID: 6544377. Epub 1984/01/01. eng.
20. Brain Trauma Foundation, American Association of Neurological Surgeons, Congress of Neurological Surgeons, Joint Section on Neurotrauma and Critical Care. Guidelines for the management of severe traumatic brain injury. Journal of Neurotrauma. 2007;24(Supplement 1):S1-S95.
21. Tuncer R, Kazan S, Ucar T, Acikbas C, Saveren M. Conservative management of epidural haematomas. Prospective study of 15 cases. Acta neurochirurgica. 1993;121(1-2):48-52. PubMed PMID: 8475807. Epub 1993/01/01. eng.
22. Chen TY, Wong CW, Chang CN, Lui TN, Cheng WC, Tsai MD, Lin TK. The expectant treatment of "asymptomatic" supratentorial epidural hematomas. Neurosurgery. 1993 Feb;32(2):176-179; discussion 9. PubMed PMID: 8437654. Epub 1993/02/01. eng.
23. Jamieson KG, Yelland JD. Extradural hematoma. Report of 167 cases. Journal of neurosurgery. 1968 Jul;29(1):13-23. PubMed PMID: 5302643. Epub 1968/07/01. eng.
24. Laidlaw J. Extradural hematoma. In: Kaye AH, Black PM, editors. Operative Neurosurgery. London: Churchill Livingstone; 2000. p. 223-31.
25. Greenberg MS. Head trauma. Handbook of Neurosurgery: Thieme; 2006. p. 632-97.
26. Servadei F, Faccani G, Roccella P, Seracchioli A, Godano U, Ghadirpour R, Naddeo M, Piazza G, Carrieri P, Taggi F. Asymptomatic extradural haematomas. Results of a multicenter study of 158 cases in minor head injury. Acta Neurochirurgica. 1989;96(1-2):39-45. PubMed PMID: 2648769. Epub 1989/01/01. eng.
27. American Medical Forensic Specialists Inc. Epidural hematoma. 2013. Available from: http://www.bailey-law.com/docs/epidura-hematoma.htm.
28. Biswas G. Extradural / epidural hematoma. Review of forensic medicine & toxicology: Jaypee Brothers Medical publishers; 2012. p. 213-4.
29. Bardale R. Extradural hematoma. Principles of forensic medicine & toxicology: Jaypee Brothers Medical Publishers; 2011. p. 226-7.
30. Cox WA. Epidural Hematoma 2009. Available from: http://forensicmd.wordpress.com/2009/09/01/edh/.
31. Shkrum MJ, Ramsay DA. Craniocerebral trauma and vertebrospinal trauma. Forensic Pathology of Trauma Common Problems for the Pathologist. Totowa, New Jersey: Humana Press Inc.; 2007. p. 519-607.
32. Knuckey NW, Gelbard S, Epstein MH. The management of "asymptomatic" epidural hematomas. A prospective study. Journal of neurosurgery. 1989 Mar;70(3):392-6. PubMed PMID: 2915245. Epub 1989/03/01. eng.
33. Uzan M, Yentur E, Hanci M, Kaynar MY, Kafadar A, Sarioglu AC, Bahar M, Kuday C. Is it possible to recover from uncal herniation? Analysis of 71 head injured cases. Journal of neurosurgical sciences. 1998 Jun;42(2):89-94. PubMed PMID: 9826793.
34. Heinzelmann M, Platz A, Imhof HG. Outcome after acute extradural haematoma, influence of additional injuries and neurological complications in the ICU. Injury. 1996 Jun;27(5):345-9. PubMed PMID: 8763290. Epub 1996/06/01. eng.
35. Gennarelli TA, Spielman GM, Langfitt TW, Gildenberg PL, Harrington T, Jane JA, Marshall LF, Miller JD, Pitts LH. Influence of the type of intracranial lesion on outcome from severe head injury. Journal of neurosurgery. 1982 Jan;56(1):26-32. PubMed PMID: 7054419.
36. Bezircioglu H, Ersahin Y, Demircivi F, Yurt I, Donertas K, Tektas S. Nonoperative treatment of acute extradural hematomas: analysis of 80 cases. The Journal of trauma. 1996 Oct;41(4):696-8. PubMed PMID: 8858030. Epub 1996/10/01. eng.
37. Wong CW. The CT criteria for conservative treatment--but under close clinical observation--of posterior fossa epidural haematomas. Acta neurochirurgica. 1994;126(2-4):124-7. PubMed PMID: 8042543.
38. Chen H, Guo Y, Chen SW, Wang G, Cao HL, Chen J, Gu Y, Tian HL. Progressive epidural hematoma in patients with head trauma: incidence, outcome, and risk factors. Emergency medicine international. 2012;2012:134905. PubMed PMID: 23320175. Pubmed Central PMCID: 3536037.
39. Sakai H, Takagi H, Ohtaka H, Tanabe T, Ohwada T, Yada K. Serial changes in acute extradural hematoma size and associated changes in level of consciousness and intracranial pressure. Journal of neurosurgery. 1988 Apr;68(4):566-70. PubMed PMID: 3351584. Epub 1988/04/01. eng.
40. Bullock R, Smith RM, van Dellen JR. Nonoperative management of extradural hematoma. Neurosurgery. 1985 May;16(5):602-6. PubMed PMID: 4000431.
41. Cucciniello B, Martellotta N, Nigro D, Citro E. Conservative management of extradural hematomas. Acta neurochirurgica. 1993;120(1-2):47-52.
42. Hamilton M, Wallace C. Nonoperative management of acute epidural hematoma diagnosed by CT: the neuroradiologist's role. AJNR American journal of neuroradiology. 1992 May-Jun;13(3):853-9; discussion 60-2. PubMed PMID: 1590183.