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Dear. Dr. Ergun Daglioglu, The article that you have submitted to the Ulusal Travma ve Acil Cerrahi Dergisi (Turkish Journal of Trauma & Emergency Surgery) entitled 'Iliskili Lezyonlarla Birliklte Olan Travmatik Beyin Omurilik Sivisi Kacaklarinin Cerrahi Tedavisi - Surgical Management of Traumatic Cerebrospinal Fluid Fistulas with Associated Lesions' has been accepted for publication following peer review.  
  
We wish you success and hope to communicate with you again.  
  
Recep Guloglu, MD  
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**Surgical Management of Traumatic Cerebrospinal Fluid Fistulas with Associated Lesions**

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***Abstract***

**Background:** Head trauma is associated with a significant risk of cerebrospinal fluid (CSF) fistula.

**Materials and Methods:** Here we report 22 cases subjected to operative intervention for otorrhea, rhinorrhea and oculorrhea with associated traumatic lesions. Majority of the cases had moderate to severe head trauma with Glascow Coma Scale (GCS) score under 14. The study group includes 11 cases with depression fractures, 6 with epidural hematomas and 4 with tension pneumocephalus.

**Results:** Rhinorrhea was the most common presenting symptom encountered in 15 cases whereas otorrhea was prominent in 7 and oculorrhea in 2 cases. Two patients having rhinorrhea had also oculorrhea and otorrhea. The patients were operated with unilateral approaches in 12 and bifrontal approaches in 10 of the cases.

**Conclusion:** Early surgical intervention should be performed in cases presenting with CSF fistula and associated traumatic lesions without considering conservative management to provide an effective control of associated complications due to CSF fistulas.

**Keywords:** CSF fistula; oculorrhea; otorrhea; rhinorrhea; surgery; trauma

**Introduction**

Trauma is the most commonly encountered reason for cerebrospinal fluid (CSF) fistula. Two percent of the head trauma and %20 of the skull base fractures have the risk of traumatic CSF fistula [1,2] About one fifth of CSF fistulas are seen as otorrhea due to middle cranial fossa fractures and the remaining 80% is seen as rhinorrhea secondary to anterior cranial fossa fractures [3,7]. Treatment starts at early recognition and verification of the exact site of leakage since infectious complications are the major causes of morbidity at the acute and subacute stage [1,3,7,9]. Although CSF leaks, particularly mild ones, do resolve spontaneously, some tend to persist and necessitate other treatment modalities including daily lumbar punctures or external lumbar drainage. Despite conservative measures, a portion of CSF leaks do not cease and surgical treatment should be performed. Some of the CSF fistula patients require urgent surgical repair due to associated pathologies [5,10,11]. This group is unique in that the cases are usually subjected to moderate or severe head trauma requiring surgery due to associated lesion together with rhinorrhea, oculorrhea or otorrhea which tends to persist. Although there are conservative measures advocated for the definitive treatment, appropriate timing of surgery is also crucial to prevent complications particularly in fractures involving sinuses.

In the present study, we report our indications for urgent surgical repair of traumatic CSF fistulas via the anterior and middle cranial fossa with a specific interest on associated traumatic lesions like depression fractures, epidural hematomas or tension pneumocephalus.

**Materials and Methods**

***Patient Selection***

The study includes 22 patients who were admitted to Ankara Numune Education and Research Hospital in 5 years. The patients presented with acute head trauma and associated CSF fistulas (rhinorrhea, oculorrhea and otorrhea). The study group was selected among 65 patients who presented with traumatic CSF fistulas. All of the patients managed conservatively (closed lumbar drainage or observation alone) before CSF fistula repair except associated lesions which should be operated urgently such as depression fractures, epidural hematoma, etc (23). Sixteen patients were male and 6 were female. Seven patients were in pediatric (<16 years) and 15 cases were in adult group with a mean age of 27 years at presentation. The patients were further classified into three groups as mild (5 cases with GCS score between 14 and 15), moderate (13 cases with GCS score between 8 and 13) and severe head trauma (4 cases with GCS score 7 or less). Patient characteristics on presentation and details of clinical management are summarized at Table 1.

Site of the CSF fistula might not be determined accurately without CT cisternography and we relied on axial and coronal milimetric high-resolution CT scans since some of the cases were operated in an urgent manner. However we performed metrizamide CT cisternography for a few cases operated in a delayed fashion. The success of surgery was assessed clinically and provocative tests like CT cisternography was not performed unless overt CSF fistula was detected clinically. The therapy was found to be successful at the early period if there was no recurrent CSF fistula for successive 7 days. Glasgow Outcome Scale (GOS) was also used as an adjunct measure to assess clinical success.

**Surgical Technique**

Wide exposure through intracranial approaches provides enough space for the removal of associated traumatic pathologies and adequate closure of the defect. If frontal and ethmoidal sinuses are involved, the craniotomy should extend to frontal sinuses and cranialization with proper positioning at the operation and CSF drainage may aid in the minimization of frontal lobe retraction. Among 22 cases studied in the present report, unilateral approach was performed in 12 and bilateral approach in the remaining 10 cases. A unilateral frontal or temporal craniotomy was preferred in patients with unilateral injury with otorrhea or rhinorrhea whereas a conventional bifrontal craniotomy was the most common procedure in bilateral approaches. Dural repair was performed in all cases either with fascia lata or galeal graft. Surgical techniques regarding the interventions were summarized on Table 1.

Closure with viable or nonviable grafts can be performed. However we suggest that nonviable fascia lata or galeal grafts are practical to use when compared with pericranium flaps especially in wide defects. Depending on our previous experience about non viable grafts, we usually notice that most of them revascularize a few months after surgery. We prefer to preserve pericranium for the viability of bone flap. Thus we preferred surgical repair of the fistulous point with viable graft in all cases of the present study. Fibrin glue was used as an adjunctive measure almost for every case to increase the success of surgical repair. Antibiotics were given intravenously at full regimen when CSF fistula was detected and continued 7 days (oral or intravenous) after surgical intervention.

**Results**

On admission, 7 patients had otorrhea, 15 patients had rhinorrhea and 2 patients had oculorrhea (some patients had multiple findings, a patient with oculorrhea also had rhinorrhea and a patient with otorrhea had also rhinorrhea). Seventeen patients were operated after conservative treatment while remaining 5 cases were urgently operated for associated intracranial lesions and complications. Besides otorrhea, rhinorrhea or oculorrhea, associated pathologies were classified as linear fractures (8 cases), depression fracture (11 cases), Le Fort fractures (3 cases), epidural hematoma (6 cases), cerebral contusion (9 cases), intracerebral and subarachnoid hemorrhage (4 cases) and wound CSF fistula (1 case) (some patients had multiple findings). One patient was operated in an emergent basis due to the presence of wound CSF fistula. Unilateral approach was performed in 12 patients and the remaining 10 cases were operated by bifrontal approaches with ligation of the superior sagittal sinus. All of the patients were subjected to dural repair with either fascia lata or galeal graft however no synthetic material was used for duraplasty. In urgently operated patients with associated lesions such as epidural hematoma, intracerebral hematoma and pneumocephalus, CSF fistula repair was done at the same operation. Depression fractures were surgically reconstructed. Among the patients with depression fractures, 7 patients were also subjected to orbital reconstruction for severe orbital roof fractures. Distribution of lesion localizations was demonstrated on Table 1.

At the postoperative period, meningitis (5 cases), urinary tract infection (1 case), pulmonary infection (1 case), deep venous thrombosis (1 case) and transient diabetes insipidus (3 cases) were seen as complication. There was no mortality rate. Complications were managed successfully by conservative measures. All of the patients were followed up for a mean of 32 months and their last neurological examination revealed the GOS (Glasgow Outcome Scale) score was 4 in 6 cases and 5 in 16 cases.

***Illustrative Cases***

***Case 2:***A fifteen-year-old femalepatientwith head trauma admitted with aGCS score of 10 and otorrheawas seen at the initial examination (Table 1).**A**xial CT (Computerized tomography) scan showed aleft sided fronto-temporal epidural hematoma, fracture lines at the orbita, temporal and occipital bones (Fig. 1a and 1b). She was operated for evacuation of hematoma and surgical repair of otorrhea. At the operation the defect at the tegmental portion of the temporal bone was repaired with fascia lata graft and fibrin glue. At the postoperative period, her neurological status improved significantly and she was discharged from the hospital on the seventh postoperative day. There was no otorrhea on follow-up examinations and postoperative changes were noted on CT scan (Fig. 1c).

***Case 4:***A forty-year-old malepresented with rhinorrhea, sudden loss of consciousness, tension pneumocephalus and anterior cranial fossa fracture involving fronto-ethmoid bone (Table 1). Priorly he had been operated at another center for an unknown traumatic lesion. Axial CT image showed severe tension pneumocephalus extending from anterior cranial fossa to lateral ventricles and compressing cerebral cisterns (Fig. 2a). Right sided frontal craniotomy was performed and frontal sinus fracture was repaired with galealgraft and fibrin glue. Clinical condition improved dramatically at the early postoperative period. CSF leakage also ceased and there was no rhinorrhea on follow-up. Postoperative axial CT image shows successful decompression of pneumocephalus (Fig. 2b).

***Case 11:***A seventeen-year-old malepresented with clouding of consciousness, rhinorrhea, hemiparesis and tension pneumocephalus (Table 1). He had a history of head trauma 25 days ago. Axial CT image showed left frontal tension pneumocephalus (Fig. 3a and 3b). Metrizamide CT scan could not be performed due to patient’s general condition and urgency of the operation. He was operated with a bifrontal approach for evacuation of pneumocephalus and repairing the dural defect over the anterior cranial fossa. At the operation, the dural defect extending from frontal to the posterior portion of ethmoid bone was repaired. On the postoperative course, polyuria and severe hypernatremia was seen and desmopressin was used for diabetes insipidus treatment. Serum ADH (Antidiuretic hormone) level was normal, however GH (Growth hormone) and cortisol levels were moderately low. CT scan showed successful resorption of pneumocephalus (Figure 3c). Magnetic Resonance Imaging (MRI) of the sellar region didn’t show any abnormality except hypointense signals on T1-weighted MR images (Figure 3d). Findings of diabetes insipidus resolved completely 5 months after trauma.

**Discussion**

CSF fistula presenting with associated traumatic lesions is a challenging situation for neurosurgeons particularly for timing of the surgical repair. Management may be quite difficult because of a dilemma due to patient’s general condition and the risk of the planned surgical approach. Tension pneumocehalus, persistent otorrhea and rhinorrhea are the main indications for surgical treatment. Here we report our experience regarding anterior and middle cranial fossa fractures particularly presenting with otorrhea, rhinorrhea and oculorrhea. CSF leakage is a serious condition which could be complicated with severe meningitis and pneumocephalus. It occurs when the barriers retaining CSF around the brain were breached. There are various methods advocated for the treatment of CSF fistulas. But there is still a debate about the timing of surgical intervention. Associated lesions necessitating immediate surgical intervention is the most important factor to decide for the timing of surgery.

Conservative management strategies include elevation of head about 30-45 degrees, fluid restriction and diuretic treatment, daily lumbar punctures and intermittent or continuous lumbar drainage. If the patient is not to be operated in an emergent manner due to lack of an associated lesion, conservative treatment methods are performed under combined antibiotic prophylaxis. CSF leakage was reported to stop 4.1 days (mean value) after trauma and 5.3 days after lumbar drainage, and ratio of spontaneous cessation was reported to be 61 % [9,11]. Surgical treatment should be considered in cases with persistent leak more than 1 week [4,12]. However, there are some exceptions to this principal management strategy such as high risk elderly patients, patients with diabetes mellitus and immunosuppressed condition, associated intracranial pathologies or profuse leaks. CSF leakage should be managed in these patients without any delay [4,11,13]. Similarly, patients with severe head trauma or low GCS should be managed with radical surgical measures since the risk of infectious complications or neurological deterioration is quite high [9,11]. Surgical intervention should also be considered for cases with subdural or epidural hematomas, tension pneumocephalus, depression fractures including comminuted skull base fractures or patients with severe contusion and edema. These lesions require decompressive measures, which all limits the use of lumbar drainage or temporary lumbar punctures for CSF fistulae

Wide exposure provides enough space for the removal of associated traumatic pathologies and adequate closure of the defect. If frontal and ethmoidal sinuses are involved, the craniotomy should extend to frontal sinuses and cranialization with proper positioning at the operation and CSF drainage could aid in the minimization of frontal lobe retraction. Closure with viable or nonviable grafts was reported in the previous studies and there was no difference in success14. However we suggest that fascia lata graft is proper to use especially in wide defects to preserve pericranium for the viability of the operative area and bone flap. We did not prefer any artificial material for surgical repair because of our prior surgical experience.

Anterior cranial fossa fractures involving cribriform plate, ethmoid or frontal sinus frequently give rise to rhinorrea and forms the second leading cause of tension pneumocephalus and surgical treatment may be required [15,17 ]. Dural tear and entrapped air could be sequelae of fractures involving anterior cranial fossa via siphon effect or a Valsalva maneuver. Entrapped air is usually seen as intracerebral, subdural and intraventricular in decreasing order of frequency and could be associated with rhinorrhea or sometimes oculorrhea. Furthermore, traumatic oculorrhea is very rare and conservative management of oculorrhea is controversial [18]. Although there are asymptomatic and conservatively managed cases, surgical intervention is usually necessary to close the associated dural defect particularly behind the orbit and decompression of tension pneumocephalus [16,17,19,20]. In evidence of acute clinical deterioration and signs of increased intracranial pressure (ICP), or pressure on adjacent cerebral tissue or ventricular wall, or presence of the Mount Fuji sign, urgent surgical intervention is indicated [21]. Many cases present within a few weeks, several months or even years after head trauma. However cases presenting with sudden neurological deterioration and low GCS should be immediately operated before performing a contrast enhanced CT study for the exact localization of fistula. In the present report, 4 cases were operated for delayed pneumocephalus, rhinorrhea-otorrhea and clinical deterioration.

Anterior or middle fossa fractures are associated with a significant morbidity rate due to related complications. Trauma to the anterior and middle cranial fossa could give rise to CSF leak and there is an increased risk for infectious complications after 1 week [1,9,22,23] . However in another report, antibiotic prophylaxis is usually ineffective for the minimization of risk of meningitis [24]. In the present study, infection ratio is detected to be 23% which does not seem to justify our main idea of urgent surgical intervention for the prevention of early posttraumatic morbidity. The ratio is seemed to be high although nearly all cases were lacking the awaiting period for conservative management. Nevertheless, the study group includes 8 patients with severe and 6 patients with moderate head trauma which does not appear to be high.

Apart from infectious complications like meningitis, trauma itself could also causes hypopituitarism. Hypopituitarism is a well known complication of moderate to severe cerebral trauma [25,26] . However the condition is not associated with radiological abnormalities on regular CT or MR studies. Hypointense signals on T1-weighted MR images of Case 11 are accepted as non-specific findings. GH and gonadal sex steroid secretion levels are very sensitive to cerebral trauma however deficiency of steroid and thyroid hormones would certainly influence the clinical condition [25]. Deficiency of posterior pituitary hormones could result in diabetes insipidus which give rise to metabolic problems after head trauma [27,28]. Although the condition is transient in most of the cases, disorders of water imbalance could increase the severity of traumatic cerebral edema or neurological condition hence result in increased morbidity and mortality. Awareness of the levels of pituitary hormones could assist in good clinical outcomes.

Postoperative use of lumbar drainage catheters or lumbar punctures should be reserved for cases having persistent postoperative CSF fistulas. Although lumbar drainage catheters provide minimal invasive treatment of CSF fistulae in uncomplicated cases, it may cause severe complications such as subdural hematoma, herniation, meningitis and other infectious problems.

**Conclusion**

The present report emphasizes the importance of early surgical intervention for head trauma with CSF fistula particularly presenting with associated lesions like depression fractures, subdural hematomas, wound CSF fistulas and pneumocephalus. Repair for CSF fistulae should not be delayed and combined approaches both for associated lesion and fistula should not be avoided even though it bears high risk of morbidity and mortality.

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***Figure and Table Legends:***

***Fig. 1:***15 year old femalepresents with otorrhea and epidural hematoma with a GCS score of 10 on admission. **A.** Axial bone window CT image shows the fracture line at the tegmental (arrow) and mastoid portion of the temporal bone as well as orbita. **B.** Axial CT scan shows a growing epidural hematoma on the same side. **C.** Postoperative axial CT image reveals decompression of the hematoma and better visualizations of mesencephalic cisterns.

***Fig. 2****:*40 year old malepresents with rhinorrhea and sudden loss of consciousness. It was learnt from the history that he had been operated at another center for a traumatic lesion several years ago. **A.** Axial CT image shows severe tension pneumocephalus extending from anterior cranial fossa to cerebral cisterns and lateral ventricles. **B.** Postoperative axial CT image demonstrates almost complete resorption of pneumocephalus.

***Fig. 3:***17 year old malepresents with apathy, hemiparesis, rhinorrhea and tension pneumocephalus. He had a history of head trauma one month ago. At the postoperative period the patient experienced findings of diabetes insipidus. **A.** Axial CT image shows left frontal tension pneumocephalus. **B.** Coronal CT scan reveals the bony defect over the ethmoid bone (arrow). **C.** Postoperative axial CT image reveals disappearance of pneumocephalus with minimal hemorrhage at the operation lodge. **D.** Sagittal T1-weighted MR image at the early postoperative period demonstrates hypointense changes on hypothalamopituitary axis and hardly visualized pituitary stalk.

**Table 1:** Clinical presentation of 22 cases and details about the management strategy.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Patient Number** | **Age** | **Sex** | **GCS on Admission** | **Presentation** | **Localization** | **Associated Lesion** | | | | **Surgical Treatment** | | **Complications/ Reoperation** | **GOS** | **Follow-up (Months)** |
| **Hematoma/ Injury** | **Fracture** | **TP** | **Wound CSF fistula** | **Approach** | **Orbit recons** |
| **1** | 60 | M | 10 | Rhinorrhea | Bifrontal | SAH, CC | DF | - | - | BFC | + | DVT, UTI | 4 | 39 |
| **2** | 15 | F | 10 | Otorrhea | Left temporal | EDH, CC | LF | - | - | TPC | - | - | 5 | 30 |
| **3** | 14 | F | 13 | Otorrhea | Left temporal | CC | DF | - | - | TPC | - | Transient DI, Meningitis | 5 | 42 |
| **4** | 45 | M | 7 | Rhinorrhea | Right Frontal | - | DF | + | - | FC | - | - | 5 | 53 |
| **5** | 14 | M | 14 | Rhinorrhea | Bifrontal | - | DF | - | - | BFC | - | Meningitis | 4 | 36 |
| **6** | 37 | M | 15 | Rhinorrhea | Left frontal | - | LF | - | - | FC | - | - | 5 | 44 |
| **7** | 25 | M | 7 | Otorrhea | Left frontotemporal | EDH, CC | LF | - | - | FTC | - | - | 4 | 45 |
| **8** | 33 | M | 13 | Rhinorrhea | Right frontal | EDH | LF | - | - | FTC | - | Reoperation, Transient DI | 5 | 38 |
| **9** | 32 | M | 12 | Rhinorrhea | Left temporal | EDH | LF | - | - | FTC | - | - | 4 | 19 |
| **10** | 37 | M | 8 | Rhinorrhea | Right frontal | - | DF | + | - | BFC | - | - | 5 | 23 |
| **11** | 17 | M | 13 | Rhinorrhea | Left frontal sinus | CC | LF | + | - | BFC | - | Transient DI | 5 | 26 |
| **12** | 47 | F | 11 | Rhinorrhea | Right frontal and orbit | CC | Lefort 3 | - | - | BFC | + | Meningitis | 5 | 25 |
| **13** | 7 | F | 8 | Rhinorrhea | Right frontoorbital | CC | DF | - | - | FTC | + | - | 5 | 32 |
| **14** | 17 | F | 11 | Rhinorrhea | Left frontotemporal | CC | DF | - | - | BFC | + | - | 5 | 41 |
| **15** | 14 | M | 14 | Rhinorrhea | Bifrontal | - | LF | - | - | BFC | - | - | 5 | 38 |
| **16** | 31 | M | 8 | Otorrhea | Left mastoid | - | DF | - | - | TPC | - | - | 5 | 39 |
| **17** | 8 | M | 14 | Otorrhea | Right occipitomastoid | - | DF | - | + | TPC | - | - | 5 | 57 |
| **18** | 23 | F | 8 | Otorrhea | Right Mastoid fracture | CC, EDH | LF | - | - | TC | - | - | 5 | 61 |
| **19** | 12 | M | 4 | Rhinorrhea, oculorrhea | Left frontoorbital | SAH | DF | - | - | BFC | + | Reoperation, meningitis | 4 | 7 |
| **20** | 42 | M | 7 | Oculorrhea | Right orbital | EDH, ICH | Le fort 3 | - | - | FTC | + | Pulmonary infection | 4 | 2 |
| **21** | 24 | M | 12 | Rhinorrhea, Otorrhea | Right temporomastoid, right ethmoid | ICH | DF | + | - | BFC, TC | - | Meningitis | 5 | 4 |
| **22** | 42 | M | 14 | Rhinorrhea | Right frontoethmoidal | - | Le fort 2 | - | - | BFC | + | - | 5 | 3 |

M: male, F: female, EDH: epidural hematoma, SAH: subarachnoid hemorrhage, CC: contusion cerebri, ICH: intracerebral hematoma, DF: depression fracture, LF: linear fracture, BFC: Bifrontal craniotomy, TPC: temporoparietal craniotomy, FC: frontal craniotomy, FTC: frontotemporal craniotomy, TC: temporal craniotomy, TP: Tension pneumocephalus, CSF: cerebrospinal fluid, DVT: deep venous thrombosis, UTI: urinary tract infection, DI: diabetes insipidus

Figure 1

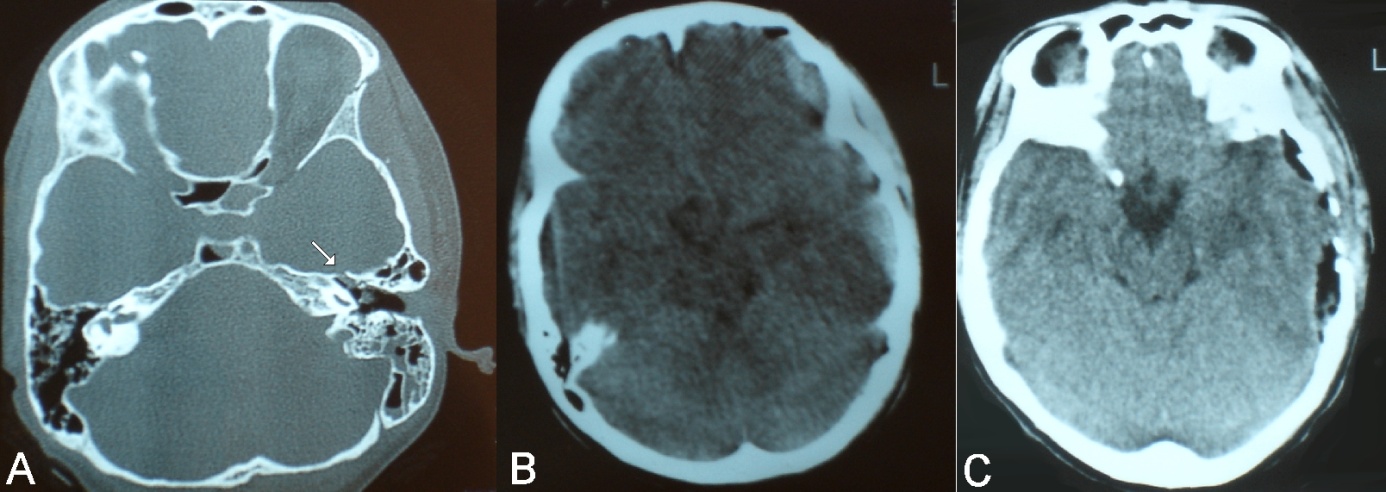


Figure 2

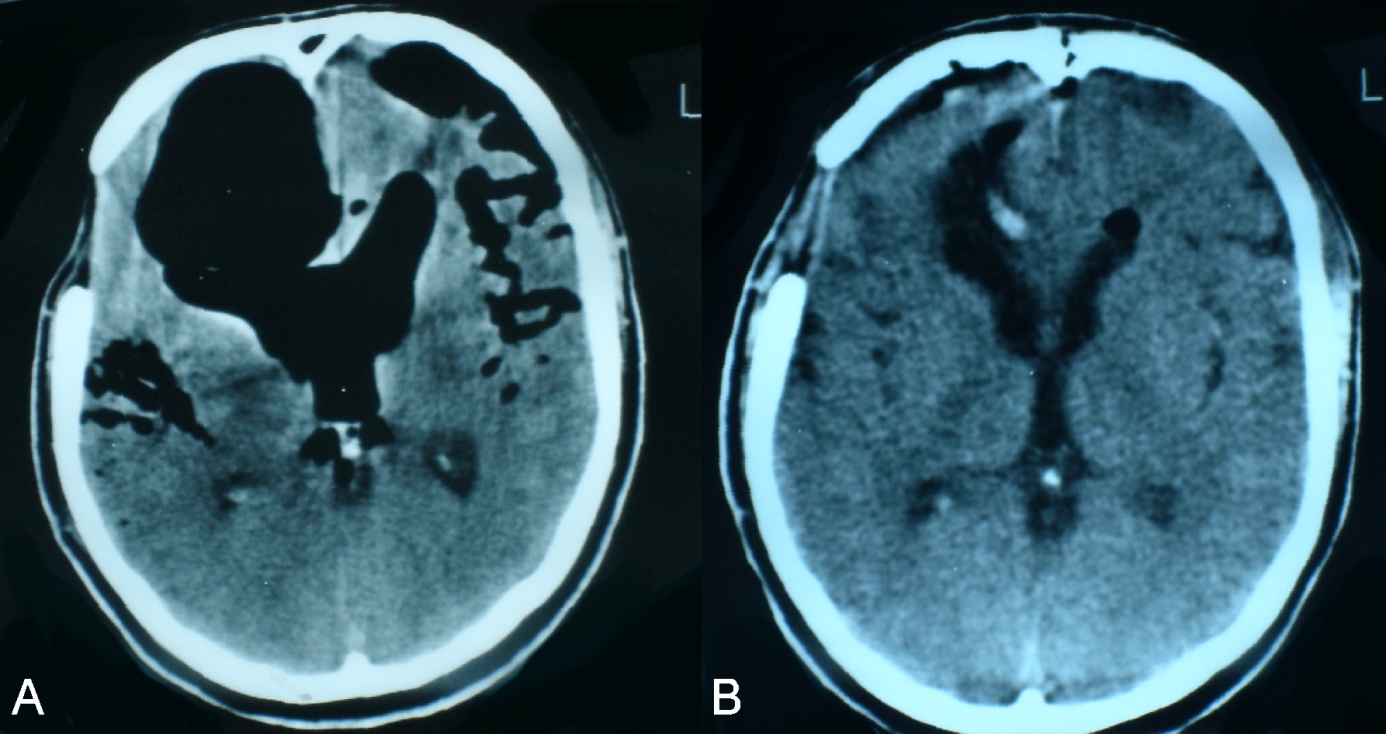


Figure 3

