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A 41-YEAR-OLD-MAN WITH DIFFUSE AXONAL INJURY: A CASE REPORT

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Abstract
Diffuse axonal injury (DAI) is a significant pathological feature of traumatic brain injury (TBI) and poses a considerable challenge in clinical neurology. This injury is characterized by microscopic damage to axons in neuronal tracts, especially within the corpus callosum and brainstem, leading to severe outcomes, including high morbidity and mortality. We report a case involving a 41-year-old male who presented to the emergency room of RT Hospital after a motorcycle accident, resulting in a prolonged loss of consciousness lasting over 12 days. The diagnosis of DAI was confirmed through detailed history taking, thorough physical and neurological examinations, and MRI brain imaging, which revealed characteristic axonal damage. This case underscores the prevalence of DAI among motorcycle accident victims, regardless of age, and the typical presentation of prolonged unconsciousness. The patient was treated with an intensive regimen aimed at reducing injury effects and promoting neurological recovery. This included mannitol to lower intracranial pressure, nimodipine for neuroprotection, and phenytoin to prevent seizures. Additionally, amantadine and alinamin F were used to enhance cognitive recovery. Supportive therapies comprised paracetamol for fever, ceftriaxone and levofloxacin as antibiotics, and pantoprazole for gastrointestinal protection. Despite these comprehensive efforts, the prognosis remains poor, with a high risk of lasting neurological deficits. This case highlights the critical implications of DAI in TBI management and underscores the need for early diagnosis and ongoing research to better understand and treat this severe condition.

Keywords: Diffuse Axonal Injury; Traumatic Brain Injury; Motorcycle accident; Neurological Deficit; Case Report

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INTRODUCTION

Diffuse axonal injury (DAI) represents one of the most critical and prevalent pathological features of traumatic brain injury (TBI) (Andriessen et al., 2010; Mittal, 2015). As a microscopic injury affecting axons in the neuronal tracts of the brain, particularly in the corpus callosum and brainstem, DAI is a leading determinant of morbidity and mortality among individuals who sustain traumatic brain injuries (Jatav et al., 2021; Vieira et al., 2016). The urgency of addressing DAI is underscored by its role as a common cause of post-traumatic coma, lasting disabilities, and persistent neurovegetative states (Aldossary et al., 2019; Karakaya & Işıkay, 2021). DAI typically results from mechanical forces exerted on the brain during acceleration and deceleration events, making it prevalent in contexts such as high-speed traffic accidents, falls, and blunt head trauma (Abu Hamdeh, 2018; Angelova et al., 2021; Jang, 2020; R et al., 2020). Traffic accidents, in particular, account for the majority of DAI cases, highlighting a public health crisis that warrants immediate attention (Daugherty et al., 2020; Peterson, 2019; Taylor et al., 2017). While radiological findings can aid in the clinical diagnosis of DAI, definitive diagnosis often requires post-mortem tissue examination (Chelly et al., 2011; H. et al., 2011). Alarmingly, 50-80% of DAI patients may present normal CT scan results, complicating timely diagnosis

and intervention. In contrast, MRI, especially with advanced techniques like diffusion weighted imaging (DWI) and susceptibility weighted imaging (SWI), offers greater sensitivity in detecting DAI (Chen et al., 2020; Grassi et al., 2018; Humble et al., 2018; Mirzaei et al., 2022). Macroscopic examinations may reveal hemorrhagic changes in the white matter, but these often evolve into brown lesions upon autopsy, indicating long-term damage that may lead to brain volume shrinkage. DAI disrupts neuronal connectivity, impairing multiple functional areas of the brain. Severe cases, particularly those presenting with immediate loss of consciousness leading to coma, are associated with high mortality rates (Maybogin, 2020). Prognostic factors influencing outcomes include initial Glasgow Coma Scale (GCS) scores, motor response abnormalities, hypoxia, and other clinical indicators. Understanding these dynamics is crucial for improving patient outcomes and emphasizes the need for ongoing research into effective diagnostic and therapeutic strategies for DAI.

DAI conditions occur due to the effects of mechanical input that occurs in the brain in the cranial cavity when acceleration and deceleration occur, therefore DAI occurs due to traffic accidents, falls, and head injuries due to collisions with objects. The most common cause of DAI is high-speed traffic accidents.

Clinical diagnosis of DAI could be made based on radiological findings, but a definite diagnosis can only be confirmed by post mortem tissue examination. Approximately 50-80% of patients suffering from DAI show normal CT scan results. In more severe cases that show abnormalities, the classic picture can be found in the form of bleeding spots in the corpus callosum, the border between the white matter and gray matter, and the border of the pons with the mesencephalon related to the superior cerebral peduncle. MRI is a more sensitive imaging examination in DAI patients, especially when performed with more recent techniques such as diffusion weighted imaging (DWI), or susceptibility weighted imaging (SWI) (Chen et al., 2020; Grassi et al., 2018). On a macroscopic examination, haemorrhagic appearance will be found on the white matter, but at autopsy it has usually shrunk, leaving a brown lesion, meanwhile long-term damage can cause brain volume shrinkage.

DAI events can lead to malfunction and disconnection of neuronal interconnections, and this can impair many functional areas of the brain. Severe DAI conditions that lead to death are usually DAI in patients with a history of immediate loss of consciousness that progresses to coma without lucid intervals.

The novelty aspect of this study needs to be clarified, emphasizing whether there are any new approaches or findings resulting from this case. For example, if there are more efficient diagnostic methods or innovative therapeutic strategies that can improve patient outcomes, this should be highlighted. Additionally, it is important to list how these findings contribute to a better understanding of DAI in a clinical context and how previous research may have been integrated or expanded with the results of this study. Clarifying the novelty will make an important contribution to the existing literature and affirm the relevance of this research in the development of more effective DAI handling strategies.

Prognostic factors that influence mortality include low initial Glasgow Coma Scale (GCS) scores, abnormal motor responses, hypoxic conditions, hypotension, signs of hypothalamic injury, duration of loss of consciousness, initial pupil size, seizures, age, and gender.

RESEARCH METHODS

A 41 aged male patient who came to the emergency room at RT Hospital, being treated there since December 20th 2022. Patient has single accident while riding a motorcycle and loss of consciousness for more than 12 days. Due to unconsciousness, previously the patient drank liquor but no one knew what happened. At the time of physical examination, he was found to be in a coma with GCS 5 (E1M3V1), blood pressure 120/84 mmHg, pulse 134 bites per minute, respiratory rate 16 times per minute, oxygen saturation 100% and temperature 38℃. Transferred to ICU on December 22nd 2022. On physical examination, there were stitch marks on the right temporal, wounds on the face and lips. On chest examination, coarse crackles were found in both lung fields. Abdomen and genitalia within normal limit, patient is sweating on the skin.

The patient's GCS was 5 (E1M3V1) and was in coma. The pupils in this patient were anisochorous with a diameter of 3mm/4mm. The direct light reflex was +/+ and the indirect light reflex were +/+. On other neurological examinations, no positive signs of meningeal irritation were found for neck stiffness, Brudzinski I-IV, laseque and kernique.

On examination of cranial nerves, there was a neurological deficit in the optic nerve in the form of no blinking when examining the threat of blinking in 4 quadrants of the eye. On the oculomotor nerve, trochlearis, abducens, vestibulocochlearis, spontaneous movement of the eye was found, there was no nystagmus, and positive doll's eyes. The vestibuloocular reflex or caloric test was not examined. In the trigeminal and facial nerves, positive corneal reflexes, facial symmetry, and grinning responses when given painful stimuli were found. On the glossopharyngeal and vagus nerves, a gag reflex was found when the ngt was pulled or moved.

Motor examination revealed passive free movement of all four extremities, motor strength examination shown 4444 in the right extremities and 3333 in the left extremities, for muscle tone found hypertonicity in the left and right superior and inferior extremities, positive physiologic reflex and there were no pathological reflexes on this patient.

On sensory examination it is difficult to do, but it is found that the patient's hands and feet withdraw from the stimulus given. On examination of autonomic function found excessive sweating in this patient.

Laboratory examination on 22nd December, 2022 shown an increase in ESR (61mm/hour), an increase in neutrophils (88%), an increase in prothrombin mass (19.2 seconds), an increase in hs-CRP (486.9 mg/L). Hemoglobin (15.2g/dL), Platelets (225x103/ uL), Leukocytes (9.1x103/ uL). From the results of a chest photo examination, the heart: CRT > 50% enlarged to the left and the aorta has a widened aortic arch configuration.

Head MSCT examination on 20th December, 2022 shown minimal left temporal subdural haemorrhagic and subarachnoidal haemorhagis sulci and left right parietal gyri. Left right maxillary intranus hemorrhage, left superior orbital cavity. Left periorbital hematoma and left frontal cephalhematoma. Fracture of the anterior medial wall and floor of the left maxillary sinus

MRI brain examination on 23rd December, 2022 shown contusion cerebri in the left frontotemporal lobe, hyperacute impression, accompanied by perifocal edema, mild SAH in the frontotemporoparietoccipital region bilateral sulci, thin SDH subacute early impression in the left temporal region, about 0.36 cm thick, acute infarction in the body-splenium corpus callosum, the left cerebral sulci periphery is slightly narrowed. There is no

significant subfalcine/transtentorial herniation was seen, suspected bilateral maxillary hematosine, left frontal, left > right ethmoidalis-sphenoidalis and right hematomastoid, soft tissue hematoma left frontal, right occipital.

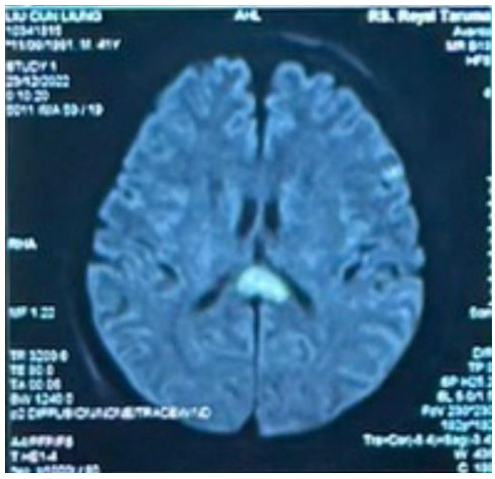

Figure 1. MRI brain examination shown acute infarction in the body-splenium corpus callosum

Patients were treated with drugs such as paracetamol 3x1 gr, ceftriaxone 2x2 gr, levofloxacin 1x750gr, pantoprazole 6mg/hour, vitamin K 3x1 amp, tranexamic acid 3x1 amp, amantadin 2x100mg IV, mannitol 4x150mg, nimodipine 1mg/hour, phenytoin 3x100mg IV, meropenem 4x1 gr, amikasin 1x1 gr, and alinamin F 1 amp.

RESULTS AND DISCUSSION

Traumatic brain injury (TBI) presents in various forms ranging from mild alterations of consciousness to an unrelenting comatose state and death. In the most severe form of TBI, the entirety of the brain is affected by a diffuse type of injury and swelling. TBI pathogenesis is a complex process that results from primary and secondary injuries that lead to temporary or permanent neurological deficits (Galgano et al., 2017; Li et al., 2023; "Traumatic Brain Injury: Current Treatment Strategies and Future Endeavors," 2016). Traumatic brain injury is classified as mild, moderate, and severe based on the Glasgow coma scale (GCS). Traumatic brain injury patients with GCS of 13 to 15 are classified as mild, including the majority of traumatic brain injury patients. Patients with a GCS of nine to twelve are considered to have a moderate traumatic brain injury, while patients with a GCS below eight are classified as having a severe traumatic brain injury. Clinically, the definition of diffuse axonal injury is a state of coma that persists for six hours or more after the event of traumatic brain injury that may result in edematous lesions or brain ischemia. Clinical manifestations that may appear in DAI include decreased consciousness (Glasgow Coma Scale < 8), concussion (especially headaches), post-concussion symptoms (shaking feeling, nausea, vomiting, and weakness), and if it was severe, it can cause a persistent vegetative. In this case, the patient was unconscious from the time he was taken to the emergency room with GCS 5 (E1M3V1) and 12 days after being admitted he remained unconscious.

The most common etiology of diffuse axonal injury involves high-speed motor vehicle accidents. The most common mechanism involves an accelerating and decelerating motion that leads to shearing forces to the white matter tracts of the brain. This leads to microscopic and gross damage to the axons in the brain at the junction of the gray and white matter. In this patient, there was a single accident that caused head trauma and on MRI brain, there was an acute infarction of the splenium body in the corpus callosum.

Patient appeared to be in a decerecrate posturing with profuse sweating and raised temperature of 38°C. In the acute recovery phase after traumatic brain injury, there can be alterations in autonomic functions. Patients can be found with tachypnea greater than 30 breaths/min, tachycardia above 120 beats/min, and systolic blood pressure above 160 mmHg. However, if the episode of autonomic abnormalities is prolonged, syndromes like decerebrate or decorticate posturing, increased muscle tone, and profuse sweating can be found. The syndrome is henceforth termed as dysautonomia. Dysautonomia itself can be divided into three phases in which the patient seems to reach the end of regular paralysis or sedation which lasts for 1 week. Physiological changes will soon progress to dysautonomia syndromes. This profuse sweating will last for about 74 days after injury. Phases end with dystonia and spasticity that varies throughout severity. Dysautonomia itself is associated with severe diffuse axonal injury, hypoxia, younger age, and brainstem injury. Posturing patients usually have dramatically increased energy expenditure that is related to increased noradrenaline concentrations. In this case, patient given amantadine 2x100mg as antagonis receptor of non-competitive NMDA to increase brain metabolism in the frontoparietal network and is widely used as neurostimulant to accelerated the pace of functional recovery during active treatment and improve consciousness in patients with post-traumatic disorders of consciousness (Khalid et al., 2019).

MRI results revealed an acute infarction in the corpus callosum. Patients with diffuse axonal injury may present with multiple areas of punctate hemorrhage in the deep white matter, corpus callosum, and dorsolateral pons. Lesions in corpus callosum were consistently found to be related with poorer outcomes in past studies with only up to one out of three patients can expect good recovery.

Treatment of patients with diffuse axonal injury is geared toward the prevention of secondary injuries and facilitating rehabilitation. It appears to be the secondary injuries that lead to increased mortality. These can include hypoxia with coexistent hypotension, edema, and intracranial hypertension. Therefore, prompt care to avoid hypotension, hypoxia, cerebral edema, and elevated intracranial pressure (ICP) is advised. ICP monitoring is indicated in patients with a GCS of less than 8. The decision for surgical intervention for craniotomy is dependent on the injury type and the patient's neurologic exam. Skull fractures, EDHs, SDHs, large vessel injuries, and intraparenchymal contusions trigger treatment specific algorithms, each supported by their respective data. Guideline based indications for surgery in acute epidural hematoma are aEDH larger than 30cc and more than 15mm thick and >5mm of midline shift. Meanwhile, guideline-based indications for surgery in acute subdural hematoma are thickness greater than 10mm or midline shift greater than 5mm on CT brain. This patient had mild SAH in the frontotemporoparietoccipital region bilateral sulci, thin SDH subacute early impression in the left temporal region, about 0.36 cm thick and treated conservatively. This patient given alinamin F to preserve mitochondrial function caused by traumatic brain injury, which is a

major plus for brain injury recovery. In addition, thiamin is used as neuroprotective to prevent the damage in the brain.

CONCLUSION

This conclusion summarizes the case of a 41-year-old man diagnosed with diffuse axonal injury (DAI) based on history taking, physical and neurological examinations, and MRI results. DAI frequently occurs in individuals involved in motorcycle accidents, regardless of age, and is typically accompanied by loss of consciousness upon hospital admission. In this case, the patient was treated with a comprehensive range of therapies, including mannitol to reduce cerebral edema, nimodipine to enhance cerebral perfusion, and phenytoin and amantadine to manage neurological symptoms. Supportive therapies included paracetamol as an antipyretic, ceftriaxone and levofloxacin antibiotics to prevent infection, and pantoprazole for gastric protection. Despite this comprehensive treatment approach, the patient's prognosis appears to be poor. Findings from examinations indicate a high risk of neurological deficits, even if the patient manages to regain consciousness. This underscores the importance of appropriate management and continuous monitoring for patients with DAI, as well as the need for further research to explore interventions that may improve long-term outcomes for these individuals. This conclusion highlights that, while treatment can assist in recovery, significant challenges remain in fully restoring neurological function after serious injuries such as DAI.

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