Open Access

Annals of Surgical Case Reports & Images

Volume 1 | Case Report

A catastrophic non-survival brain injury and efficacy of nuclear perfusion scan

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Abstract

A Traumatic Brain Injury (TBI) is an injury to the brain that is expected to cause permanent loss of brain function beyond the brain stem level. Efficient coordination and communication are crucial in facilitating the transfer of patients to higher levels of care, which increases the chances of reuniting them with their families and prevents misdiagnosis of brain death. Brain death is defined by the American Academy of Neurology as an irreversible cessation of circulatory and cerebral functions, including brain stem activity. The determination of the futility of care and the use of ancillary tests should be made at each level of care. The American Academy of Neurology has established guideline practices that provide universal medical principles for determining brain death, but physicians must exercise substantial judgment when applying the specific criteria in different circumstances. Although the concept of brain death can be disheartening for patients with severe brain damage, the established criteria for determining it are subject to ongoing debate. This article presents a case of a young female who suffered a TBI and demonstrated a reversal of brain function, including the restoration of full brain stem reflexes and cerebral perfusion as observed in imaging studies. We also discuss the key clinical components of the neurological examination and raise questions about the sensitivity and specificity of nuclear medicine studies in confirming a non-survivable brain injury.

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Received: Jun 17, 2024

Accepted: Jul 18, 2024

Published Online: Jul 25, 2024

Journal: Annals of Surgical Case Reports & Images

Online edition: https://annscri.org

Cite this article: Paik KS. A catastrophic non-survival brain injury and efficacy of nuclear perfusion scan. Ann Surg Case Rep Images. 2024; 1(4): 1038.

Introduction

TBI is defined as any brain injury that is expected to result in permanent loss of brain function above the brain stem level [1]. It is a complex disorder that can vary depending on the specific brain regions affected, the extent of injury, post-injury protocols, and the resulting inflammation of cerebral tissue [1]. TBI is a significant healthcare concern that affects approximately 1.7 million individuals annually in the United States [2-4]. Unfortunately, the incidence of emergency room visits associated with TBI is on an upward trend. An estimated 3 million individuals are believed to experience long-term disabilities resulting from TBI [2-4]. Out of these, about 275,000 individuals require hospitalization, and the devastating toll includes approximately 52,000 fatalities each year [5]. Determining the futility of care in addition to performing ancillary tests must also be made at each level. Logistical coordination and communication are paramount to advance these patients to high levels of care so that there is an increased probability of reuniting them with their family and to prevent a misdiagnosis of brain death, which is often caused by TBI [6]. The diagnosis of brain death is typically made through a clinical examination that assesses brainstem reflexes, apnea testing, and ancillary tests such as Electroencephalography (EEG), nuclear medicine scan, cerebral angiography, and cerebral venography [7]. Regularity to confirm brain death is variable; thus, there are different standards in effect to assess a brain death examination and document the patient as brain dead [8].

Therefore, because brain death is known to be a fatal diagnosis, ancillary testing and further evaluation may be necessary to prevent the misdiagnosis of brain death for specific cases. Nuclear perfusion scan has been widely utilized to evaluate cerebral blood flow and its potential role in diagnosing TBI. Perfusion neuroimaging techniques have been explored in TBI to determine and characterize potential perfusion neuroimaging biomarkers to aid in diagnosis, treatment, and prognosis [9]. We present a case of a young female who suffered from a TBI and initially demonstrated no brain perfusion on nuclear perfusion scan, but later began to show cerebral perfusion on imaging with fully recovered brain and brainstem function. We also discuss the main clinical components of the neurological examination and calling into question the sensitivity or specificity of the nuclear medicine study to confirm a non-survivable brain injury.

Case study

We present a case of an 18-year-old female who suffered a devastating gunshot wound to the head under unknown circumstances. Upon arrival to the emergency department, the patient had a Glasgow Coma Scale score of six, with loss of consciousness and inability to communicate. The brain injury was considered to be nonsurvivable by the neurosurgeon on call and was reportedly verified by a second neurosurgeon. Neurology was consulted and recommended palliative care when our patient had no apparent improvement in neurological combined with negligible intracranial blood flow throughout the sagittal sinus on nuclear medicine study. It was declared that the patient had a non-survivable brain injury as no evidence of radiotracer accumulation was present in the brain. Brainstem reflexes such as the pupillary light reflex, corneal reflex, and oculovestibular reflex were absent. However, the patient had an obscure cough and gag reflex, which led to a transfer to another hospital at the request of the family for a second opinion. A CT Venogram (CTV) was performed at the new hospital to re-evaluate the sinus injury, which demonstrated minimal blood perfusion of the intracranial system. After evaluating the degree of injury and intracranial blood flow on CTV, the neurosurgeon at the new institution proceeded with craniectomy with washout and closure of the wound, at the request of the patient's family. Complications with the procedure were minimal to none and segments of necrotic brain tissue were resected. Post-surgical imaging consisted of a CT Angiogram, demonstrating appreciable blood flow throughout the intracranial vasculature. A few weeks after cranial wound excision and craniectomy, the patient's neurological status showed improvement as she began to follow commands such as squeezing the nurse's hand and responded to peripheral pain response. Furthermore, the patient demonstrated the return of brain stem reflexes such as the pupillary light and corneal reflexes. The patient began speaking single-worded phrases and had a Glasgow Coma Scale score of greater than eight. Our patient was managed with standard hospitalization procedures including an inferior vena cava filter, tracheostomy, and peg tube placement. She has been monitored for intracranial pressures and potential hydrocephalus development.

Discussion

The consequences of an inaccurate diagnosis of irreversible brain injury or brain death can be profound. Patients who are diagnosed as such may be taken off life support, which can have significant implications for the patient and their family. Sensitivity and specificity are important measures of the accuracy of a diagnostic test, including the brain death examination and ancillary tests such as nuclear medicine scan. Despite this, limitations exist and may result in the inadequate diagnosis and prognosis of the patient. This study aims to evaluate the efficacy, sensitivity, and specificity of nuclear perfusion scan as a means of diagnosing TBI and brain death, drawing upon our case report and relevant research studies to support the discussion.

Neuroimaging has evolved to encompass the functional tissue characterization, such as cerebral perfusion. As discussed, a commonly used ancillary test in adults is a radionuclide cerebral blood flow study. Its ability to distinguish normally perfused cerebral tissue from the ischemic penumbra and infarcted areas is useful and provides detailed information on perfusion imaging to assist physicians in making informed decisions regarding treatment options for patients [10-12].

One notable study evaluated the performance of the American Academy of Neurology's clinical practice guidelines for establishing brain blood flow in a multicenter cohort of 492 patients. This research reported a high sensitivity of 88.4% and specificity of 100% for testing intracranial blood flow using nuclear medicine tests [13]. This suggests that nuclear scans are rarely associated with false positives and false negatives. A false positive nuclear scan occurs when the nuclear scan reveals no perfusion and confirms brain death, but the clinical exam is not consistent with brain death. False negative scans reveal perfusion when there is no clinical evidence of brain function by clinical exam.

However, in a study of 229 scans in 219 patients, specificity of radionucleotide scans was 98.5% and specificity of 56%, noting that several patients in the study had no flow on nuclear perfusion despite not being clinically braindead [14]. Another study reviewed a case of an infant with absent brain blood flow on an anterior planar image despite persistent breathing and extensor posturing, hypothesizing possibility of isolated posterior-fossa blood flow, which would not be detectable using nuclear perfusion and conclude that patients having an ancillary radiopharmaceutical brain blood flow test for brain death should have anterior and lateral views without exception [15].

Preserved brainstem function in the absence of blood flow is scarcely reported. However, this potentially reflects an inherent bias because ancillary tests are seldom ordered in patients with preserved brainstem function. Consequently, as seen with our patient, relying solely on nuclear perfusion scans might not be sufficient for confirming brain death. It should be used with caution by healthcare providers or complemented by additional diagnostic approaches.

Conclusion

Nuclear perfusion scans have proven to be an effective diagnostic tool for assessing cerebral blood flow and its relationship to traumatic brain injury. The efficacy of nuclear perfusion scans in diagnosing TBI is supported by research demonstrating its ability to identify altered blood flow patterns and predict clinical outcomes. However, the specificity of nuclear perfusion scans in diagnosing TBI and brain death is variable. Physicians should be aware of false-positive radionucleotide scan in cases that are clinically brain dead. We highlight the use of caution during terminal disconnect of life support. Further research and advancements in technology are necessary to refine and standardize the use of nuclear perfusion scans in diagnosing TBI and brain death, ultimately leading to improved patient care and outcomes.

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