ScieniQ Publishers

Journal of Neurology and Neuroscience Research

Case Study

Outcome in war related penetrating brain injury

Mohamed Mustafa Ahmed[1] MRCS, MSc, Mujahid Imam[1] MSc, Fawaz Eljili.M. Abdelradi[1] MRCS, MSc, MPH, Ahmed Zidan[2] MD, MRCS Ed, FRCS SN, Bashier Mohammed Bashier[1] MD, Khalid Sieddig.A. Issawi[3] MD, Sawsan.A. Aldeaf[1] MD,PhD, Aymen Drgam[3], Mohammed Hamed[1], Sanna Taha[1], Amna Hussein[4] MD, Ahmed Doomi[5] MD, FACS

[1]Neurosurgery Department, National Center for Neurological Sciences (NCNS), Khartoum, Sudan

[2]Neurosurgery Department, Haj Al Mardi (Al Tamyouz) hospital, Khartoum, Sudan

[3]Neurosurgery department, Atabra teaching hospital, Sudan

[4]University of Arizona Department of Neurosurgery, Banner University Medical Center Phoenix USA

[5]Neurological Surgery Department, University of Pittsburgh Medical Center, Pittsburgh, PA

***Corresponding author**
Fawaz Eljili.M. Abdelradi Neurosurgery Department, National Center for Neurological Sciences (NCNS), Khartoum, Sudan

Received: 11 Nov 2024
Accepted: 21 Nov 2024
Published: 13 Dec 2024

Copyright
© 2024 Fawaz Eljili.M. Abdelradi
OPEN ACCESS

Abstract

Introduction: The ongoing conflict in Sudan since April 2023 has led to a dramatic surge in PTBI cases, impacting a population of 40 million. Despite this urgent need, localized data on PTBI outcomes are critically lacking. High mortality rates and diverse clinical presentations complicate treatment in trauma centers, and the predictive value of radiological findings, such as CT scans, remains underexplored. War related Penetrating traumatic brain injuries (pTBI) pose a significant challenge in neurosurgery and emergency medicine, particularly in conflict zones where their prevalence is markedly heightened. pTBI accounts for approximately 0.4% of all head injuries, its impact is profound; it contributes to around 35,000 civilian deaths annually, underscoring the urgent need for effective management strategies. The complexity of pTBI is not solely due to the physical trauma but also the variability in outcomes, which can be influenced by the mechanism of injury, the extent of anatomical involvement, and the presence of intracranial hemorrhage or infection.

Methodology: This is a retrospective cohort study conducted at NILE RIVER STATE Teaching Hospitals, neurosurgical units in Sudan during the war period (April 2023 to November 2023). The study involved patients with isolated war related penetrating brain injury diagnosed and received full neurosurgical care including all age and both gender. study excluded those were multi trauma patients and those received partial neurosurgical care or those with poor medical records for their neurosurgical care. study aimed to identify factors associated with the outcome. Data were collected using structured questionnaire from the patients' hospital records.Data were analyzed using SPSS version 27.

Results: The study included 50 participants, consisting of 40 males (80%) and 10 females (20%), male-to-female ratio of 4:1. The average age of the patients was 24.6 years, with ages ranging from 1 to 60 years.10 patients (20%) were associated with military situations, while 40 patients (80%) were civilians Cause of Penetrating Brain Injury (PTB). with 25% scoring GOS 3 or lower incontrast, all patients with non-missile PTBI scored above GOS 3, and a higher proportion achieved GOS 4 or 5. Patients with significant midline shift (MLS) had worse outcomes, with all patients exhibiting significant mass effects scoring below 3 on the Glasgow Outcome Scale (GOS). In contrast, patients without MLS showed better outcomes, with 66% achieving a GOS score of 5. The correlation between MLS presence and patient outcomes was statistically significant ($p < 0.001$). A total of 4 out of 13 patients with multi-lobar involvement had poor outcomes (GOS < 3), compared to only 3 out of 29 patients with single-lobe injuries, P-value of 0.009.Seven patients were diagnosed with intraventricular hemorrhage (IVH), while 43 did not have IVH. Among patients with IVH, 28.57% (2 patients) had poor outcomes (GOS < 3), while 71.43% (5 patients) had better outcomes (GOS ≥ 3). In comparison, only 6.98% (3 patients) without IVH had poor outcomes, with the majority (93.02%) achieving a GOS of 3 or higher. P-value = 0.002. 50% of the 14 patients with ICH had poor outcomes (GOS < 3), while only 20% of the 36 patients without ICH fell into this category. Conversely, 80% of patients without ICH had a GOS of 3 or higher, suggesting better overall outcomes compared to 50% of those with ICH.Subarachnoid hemorrhage (SAH) was significantly associated with poor clinical outcomes (P-value < 0.001). Among the 11 patients with SAH, 37% had poor outcomes (GOS < 3), while 64% had better outcomes (GOS ≥ 3). In contrast, only 3% of the 39 patients without SAH had poor outcomes, with 97% achieving a GOS of 3 or higher.

Among 37 patients with bilateral reactive pupils, only one had a GOS score of 3, while the rest had favorable outcomes. In contrast, none of the 13 patients with abnormal pupil reactivity achieved a GOS score of 5, and only 3 patients had a GOS of 4. Notably, 77% of patients with abnormal pupillary reactions had poor outcomes.

In this study of 50 patients, 24 (48%) exhibited clinical weakness in the extremities, while 26 (52%) showed no weakness. Among those with weakness, 18% had Glasgow Outcome Scale (GOS) scores of less than 3, compared to only 4% of patients without weakness. Additionally, 47% of patients without weakness achieved GOS scores of 4 and 5, whereas only 30% of those with weakness reached these higher scores. The P-value for clinical weakness is 0.001.

Conclusion: Penetrating head injury seen in war patients is a challenge neurosurgical cases and had a variety of penetrating cause of injury. The interplay between the nature of the injury, the extent of neurological deficits, and the timing of medical intervention significantly influences prognosis. Continued research into injury mechanisms and recovery, as well as the development of targeted therapeutic strategies, remains essential for improving outcomes in this challenging patient population.

Introduction

Penetrating traumatic brain injuries (pTBI) pose a significant challenge in neurosurgery and emergency medicine, particularly in conflict zones where their prevalence is markedly heightened. Though pTBI accounts for approximately 0.4% of all head injuries, its impact is profound; it contributes to around 35,000 civilian deaths annually, underscoring the urgent need for effective management strategies [1]. These injuries can arise from diverse mechanisms, including high-velocity missile trauma and low-velocity penetrating objects, each presenting unique complications. High-velocity injuries often result in more severe immediate physical damage, while low-velocity injuries may lead to delayed neurological impairments such as seizures and hemiparesis [2].

The complexity of pTBI is not solely due to the physical trauma but also the variability in outcomes, which can be influenced by the mechanism of injury, the extent of anatomical involvement, and the presence of intracranial hemorrhage or infection.

The ongoing conflict in Sudan since April 2023 has led to a dramatic surge in PTBI cases, impacting a population of 40 million. Despite this urgent need, localized data on PTBI outcomes are critically lacking. High mortality rates and diverse clinical presentations complicate treatment in trauma centers, and the predictive value of radiological findings, such as CT scans, remains underexplored. This knowledge gap hinders the development of effective triage protocols and resource allocation. Furthermore, psychosocial factors arising from the conflict—such as displacement, trauma, and limited access to healthcare—may significantly affect recovery, emphasizing the necessity for a comprehensive examination of PTBI outcomes.

Justification & Objectives

This study aims to bridge this knowledge gap by investigating the factors influencing PTBI outcomes at a local trauma center in Sudan. By analyzing clinical presentations, radiological findings, and mechanisms of injury, this research will elucidate the unique challenges faced by PTBI patients in resource-limited settings. The objective is to identify key predictor variables that can guide healthcare professionals in triage, management, and counseling for patients and their families. Understanding these factors is essential for developing targeted management strategies tailored to the specific needs of PTBI patients. Ultimately, this study aims to improve treatment protocols and enhance the allocation of medical resources in conflict-affected regions.

Methodology

Study Design

This study is a retrospective cohort study conducted at NILE RIVER STATE Teaching Hospitals in Sudan from April 2023 to November 2023. The study focused on patients with traumatic penetrating head injuries during this time period, aiming to identify factors associated with 33outcomes and complications. The outcomes were categorized using the Glasgow Outcome Scale (GOS), where a score of 2-3 represented major deficits, and a score of 4-5 represented minor deficits or good outcomes.

Study Setting

The study was carried out in the neurosurgical centers at NILE RIVER STATE Teaching Hospitals, which were established in April 2023 to provide specialized care for war-related brain injuries. These centers include a neurosurgical department, led by a consultant, supported by three registrars from different specialties, and seven interns. Patient management, including diagnostic and surgical interventions, followed the hospital's trauma care protocols. Care was provided across the emergency room, wards, ICU, and operating room (OR), with diagnostic support from CT brain scans.

Study Population

Inclusion Criteria

1. Patients diagnosed with traumatic penetrating head injuries during the study period (April 2023 - November 2023).
2. Patients who received full neurosurgical care at NILE RIVER STATE Teaching Hospitals.
3. Both male and female patients of all ages were included.

Exclusion Criteria

1. Patients who did not complete their treatment or had incomplete medical records.
2. Patients with multiple traumas requiring treatment from different specialties.
3. Patients who were resuscitated but died in the emergency department or had minor injuries not requiring admission.

Data Collection

Patient data were collected retrospectively from hospital records and patient files. In addition, structured questionnaires were used to gather clinical and demographic information, including:

- **Demographic Data:** Age, gender.
- **Clinical Presentation:** Glasgow Coma Scale (GCS) scores, pupil reactivity.
- **Radiological Findings:** CT brain scan results (midline shift, presence of intraventricular hemorrhage [IVH], intracerebral hemorrhage [ICH], or subarachnoid hemorrhage [SAH]).
- **Cause of Trauma:** Missile vs. non-missile injuries.
- **Anatomical Involvement:** Single vs. multi-lobar injuries.
- **Surgical Interventions:** Any neurosurgical procedures performed.
- **Outcomes:** Assessed using the Glasgow Outcome Scale (GOS).
- **Complications:** Postoperative complications, including infections and neurological deficits.

Variables of Interest

The following key variables were assessed to determine their association with outcomes:

1. **Cause of Trauma:** Missile vs. non-missile injuries.
2. **Midline Shift (MLS):** Presence of significant or non-significant midline shift.
3. **Anatomical Involvement:** Whether the injury affected multiple lobes or a single lobe.
4. **Initial GCS Score:** Grouped into three categories: <8, 9-12, and 13-15.
5. **Pupil Reactivity:** Categorized as bilateral reactive, bilateral sluggish, unilateral non-reactive, or unilateral sluggish.
6. **Intraventricular Hemorrhage (IVH):** Present vs. absent.
7. **Intracerebral Hemorrhage (ICH):** Present vs. absent.
8. **Subarachnoid Hemorrhage (SAH):** Present vs. absent.

Statistical Analysis

Data were analyzed using **SPSS version 27** (SPSS Inc., Chicago, IL) and **Mi-**

crosoft Excel 2019 (Microsoft Corp., Redmond, WA). Descriptive statistics such as means, frequencies, and percentages were used to summarize the data. Categorical variables were compared using the **Chi-square test,** and a **p-value of <0.05** was considered statistically significant. Results are presented with **95% confidence intervals (CI)** where applicable.

Ethical Considerations

The study was conducted in accordance with ethical standards and approved by the **National Research Health Ethics Committee (NRHEC)** under the Ministry of Health, Khartoum, Sudan. All patient data were anonymized to ensure confidentiality.

Results:

Demographic Data

The study included 50 participants, consisting of 40 males (80%) and 10 females (20%), resulting in a male-to-female ratio of 4:1. The age distribution of participants was as follows: 17 individuals (34%) were aged 1-17 years, 15 (30%) were between 18-25 years, 3 (6%) were in the 26-30 years' age range, 8 (16%) were aged 31-40 years, and 7 (14%) were over 41 years. The average age of the patients was 24.6 years, with ages ranging from 1 to 60 years .

Regarding conflict involvement, 10 patients (20%) were associated with military situations, while 40 patients (80%) were civilians. The cause of trauma was missile-related in 43 cases (86%), primarily due to firearms, while 7 cases (14%) resulted from non-missile causes . Additionally, 47 trauma cases (94%) were due to assaults, and 3 cases (6%) were classified as accidents.

Cause of Penetrating Brain Injury (PTB)

Patients with missile-related penetrating traumatic brain injury (PTBI) predominantly had poor outcomes, with 25% scoring GOS 3 or lower, indicating severe disability or a vegetative state. In contrast, all patients with non-missile PTBI scored above GOS 3, and a higher proportion achieved GOS 4 or 5, suggesting more favorable recoveries. These findings highlight that non-missile injuries are associated with better prognoses compared to missile-related injuries.

Midline Shift (MLS) Significance

Patients with significant midline shift (MLS) had worse outcomes, with all patients exhibiting significant mass effects scoring below 3 on the Glasgow Outcome Scale (GOS). In contrast, patients without MLS showed better outcomes, with 66% achieving a GOS score of 5. The correlation between MLS presence and patient outcomes was statistically significant **(p < 0.001)**, underscoring MLS as a key indicator of prognosis in penetrating brain injuries.

Extent of Brain Injury

The extent of anatomical involvement had a significant impact on outcomes, as patients with multi-lobar injuries fared worse than those with single-lobe injuries. A total of 4 out of 13 patients with multi-lobar involvement had poor outcomes (GOS < 3), compared to only 3 out of 29 patients with single-lobe injuries. This finding, with a **P-value of 0.009**, emphasizes the influence of the extent of brain injury on recovery.

Intracranial Hemorrhage (IVH and ICH)

Seven patients were diagnosed with intraventricular hemorrhage (IVH), while 43 did not have IVH. Among patients with IVH, 28.57% (2 patients) had poor outcomes (GOS < 3), while 71.43% (5 patients) had better outcomes (GOS ≥ 3). In comparison, only 6.98% (3 patients) without IVH had poor outcomes, with the majority (93.02%) achieving a GOS of 3 or higher. This difference was statistically significant (**P-value = 0.002**), showing that IVH is associated with worse outcomes.

For intracerebral hemorrhage (ICH), 50% of the 14 patients with ICH had poor outcomes (GOS < 3), while only 20% of the 36 patients without ICH fell into this category. Conversely, 80% of patients without ICH had a GOS of 3 or higher, suggesting better overall outcomes compared to 50% of those with ICH.

Subarachnoid Hemorrhage (SAH)

Subarachnoid hemorrhage (SAH) was significantly associated with poor clinical outcomes (**P-value < 0.001**). Among the 11 patients with SAH, 37% had poor outcomes (GOS < 3), while 64% had better outcomes (GOS ≥ 3). In contrast, only 3% of the 39 patients without SAH had poor outcomes, with 97% achieving a GOS of 3 or higher. These results emphasize the critical impact of SAH on prognosis.

Pupillary Reaction

Pupillary reactivity was a strong predictor of outcomes. Among 37 patients with bilateral reactive pupils, only one had a GOS score of 3, while the rest had favorable outcomes. In contrast, none of the 13 patients with abnormal pupil reactivity achieved a GOS score of 5, and only 3 patients had a GOS of 4. Notably, 77% of patients with abnormal pupillary reactions had poor outcomes, highlighting the severity of abnormal pupil reactivity.

Weakness at presentation

In this study of 50 patients, 24 (48%) exhibited clinical weakness in the extremities, while 26 (52%) showed no weakness. Among those with weakness, 18% had Glasgow Outcome Scale (GOS) scores of less than 3, compared to only 4% of patients without weakness. Additionally, 47% of patients without weakness achieved GOS scores of 4 and 5, whereas only 30% of those with weakness reached these higher scores. These findings indicate a significant association between clinical weakness and poorer prognoses in patients with penetrating brain injuries, underscoring the impact of neurological deficits on recovery outcomes. The b-value for clinical weakness is 0.001, suggesting a statistically significant relationship between weakness and poorer outcomes in this study. This indicates that the presence of clinical weakness is a strong predictor of unfavorable prognoses in patients with penetrating brain injuries.

Discussion

This study aimed to assess the relationship between Glasgow Coma Scale (GCS) scores and traumatic penetrating head injury patient outcomes, as measured by the Glasgow Outcome Scale (GOS). Our findings reveal significant associations between GCS scores and survival outcomes, reflecting the scale's predictive value in clinical settings. The data indicated that 14% of participants had GCS scores between 3-8, 20% between 9-12, and 66% between 13-15. Notably, 63% of poor outcome patients had GCS scores below 8, whereas 82% of good outcomes occurred in patients with scores between 13-15. Among patients with GCS scores of 8 or less, all had a poor GOS (score of 3 or less), while 30% of those with GCS scores between 9-12 had poor GOS and 70% had good GOS. In contrast, 97% of patients with GCS scores between 13-15 had a good GOS, with only 3% exhibiting a poor GOS. The statistical significance (P-value <0.001) reinforces the strong association between GCS and patient outcomes. These findings align closely with prior studies been conducted resulting in similar result. which demonstrated that higher GCS scores are linked to improved survival rates [3]. Furthermore, Maragkos et al.'s 2018 meta-analysis similarly highlighted that lower GCS scores (between 3-8) were predictive of poorer outcomes, corroborating the established role of GCS as a reliable predictor of prognosis in traumatic head injury patients.

The outcomes for patients with missile-related penetrating traumatic brain injuries (PTBI) were significantly poorer, with 25% scoring a GOS of 3 or lower, indicating severe disability or a vegetative state. In contrast, all patients with non-missile PTBI scored above GOS 3, and a higher proportion achieved GOS 4 or 5, suggesting more favorable recoveries. This difference is attributed to the injury mechanism; high-velocity missiles

cause extensive brain damage through thermal and kinetic energy [4], while non-missile injuries tend to cause more localized damage [5]. These findings are consistent with [6], who reported that 72% of patients with non-missile injuries scored 5 on the GOS, and none scored below 4 [6].

Midline shift (MLS) is recognized as a critical predictor of outcomes in traumatic brain injuries [7]. Our findings demonstrate that patients with significant midline shifts (>5 mm) consistently experienced poor outcomes, with all patients exhibiting significant mass effects scoring below 3 on the Glasgow Outcome Scale (GOS). Conversely, among patients with MLS less than 5 mm, 84.8% had favorable outcomes, with a p-value of <0.001. Can et al. (2017) reported similar associations between midline shifts and poor outcomes, particularly in sniper shot head injuries. [8], found that a midline shifts greater than 3 mm correlated with worse outcomes [8]. However, [9], suggested that MLS might not be as strongly predictive of outcomes when it only affects one hemisphere [9]. Despite such discrepancies, our study supports the prevailing view that MLS is closely linked to poor outcomes, emphasizing the need for further research.

The extent of anatomical involvement had a significant impact on outcomes, as patients with multi-lobar injuries fared worse than those with single-lobe injuries. A total of 4 out of 13 patients with multi-lobar involvement had poor outcomes (GOS < 3), compared to only 3 out of 29 patients with single-lobe injuries, with a P-value of 0.009. This finding highlights the influence of the extent of brain injury on recovery.

Our study also explored the relationship between pupil reactivity and clinical outcomes in penetrating brain injuries. Among 37 patients with bilateral reactive pupils, only one had a GOS score of 3, while the remainder showed favorable outcomes. In contrast, among the 13 patients with abnormal pupil reactivity, none achieved a GOS score of 5, and 77% had poor outcomes. [9], also reported that abnormal pupil responses predicted poorer outcomes in patients with craniocerebral penetrating injuries, reinforcing our observations [10]. Similarly, [11] and Yousef et al. (2022) highlighted pupil abnormalities as a significant predictor of adverse outcomes [11]. [12], further supported the predictive value of pupil reactivity in their SPIN score for acute civilian penetrating brain injuries [12]. These findings underscore the importance of pupil reactivity as a prognostic factor in penetrating brain injuries across different patient populations and contexts [13].

For intracerebral hemorrhage (ICH), our study found that 28% of pTBI patients had ICH, which significantly worsened patient outcomes, as 50% of these patients had poor outcomes (GOS < 3). In comparison, only 11.1% of patients without ICH had poor outcomes, indicating a stark disparity in prognosis between those with and without ICH. The strong statistical significance (P-value <0.0020) underscores the critical role of hemorrhagic complications in pTBI prognosis. Effective management strategies must include neurosurgical interventions such as craniotomy and decompressive craniectomy, which are essential for addressing immediate pathophysiological concerns and improving patient outcomes. Ultimately, our findings emphasize the importance of preventing and managing ICH in the acute phase of pTBI treatment to enhance overall prognosis.

The presence of weakness at presentation in patients with penetrating traumatic brain injury (pTBI) is a significant prognostic factor influencing clinical outcomes. Weakness, typically assessed through neurological examinations and quantified by the Glasgow Coma Scale (GCS), indicates the extent of brain injury and correlates with injury severity. In this study of 50 patients, 24 (48%) exhibited clinical weakness in the extremities, while 26 (52%) showed no weakness. Among those with weakness, 18% had Glasgow Outcome Scale (GOS) scores of less than 3, compared to only 4% of patients without weakness. Additionally, 47% of patients without weakness achieved GOS scores of 4 and 5, whereas only 30% of those with weakness reached these higher scores. These findings indicate a significant association between clinical weakness and poorer prognoses in patients with penetrating brain injuries, underscoring the impact of neurological deficits on recovery outcomes. The P-value for clinical weakness is 0.001, suggesting a statistically significant relationship between weakness and poorer outcomes in this study. This indicates that the presence of clinical weakness is a strong predictor of unfavorable prognoses in patients with penetrating brain injuries [14].

This correlation arises from underlying pathophysiological mechanisms accompanying pTBI, including direct neuronal damage, secondary injury processes, and the potential for complications such as intracranial hemorrhage and infection [15]. Furthermore, the type of penetrating object and the injury's location can complicate the clinical picture. For instance, injuries caused by high-velocity projectiles are more likely to result in extensive brain damage and subsequent neurological deficits, including weakness [16]. In contrast, low-velocity injuries, such as those from sharp objects, may lead to more localized damage, potentially resulting in better functional outcomes if critical brain areas are spared [17]. Nonetheless, even in low-velocity injuries, the presence of weakness at presentation can indicate significant underlying damage, which may predispose patients to long-term complications, such as post-traumatic seizures or cognitive impairments [2].

Managing pTBI with associated weakness is complex and often requires a multidisciplinary approach. Early surgical intervention to address the injury and prevent secondary complications is critical. Research suggests that timely decompression and removal of foreign bodies can improve outcomes, particularly in patients exhibiting significant neurological deficits at presentation [14,18]. Additionally, rehabilitation strategies must be tailored to address specific deficits, emphasizing the importance of early intervention to maximize recovery potential [18].

Conclusion

Penetrating head injury seen in war patients is a challenge neurosurgical cases and had a variety of penetrating cause of injury. The interplay between the nature of the injury, the extent of neurological deficits, and the timing of medical intervention significantly influences prognosis. Continued research into injury mechanisms and recovery, as well as the development of targeted therapeutic strategies, remains essential for improving outcomes in this challenging patient population.

References

1. Sungkar, A., Wijanarko, F., Saadhi, I., & Setiawati, D. (2022). Late-onset seizure and left hemiparesis after unusual craniocerebral penetrating injury by a rusty sickle: a case report. Open Access Macedonian Journal of Medical Sciences. 10: 98-102. https://doi.org/10.3889/oamjms.2022.7153.
2. Gupta, O., Roy, K., Ghosh, S., & Tripathy, P. (2014). An unusual penetrating transorbital craniocerebral injury. Indian Journal of Neurotraum, 11: 53-56. https://doi.org/10.1016/j.ijnt.2013.12.001.
3. Aarabi, B., et al. (2014). Predictors of outcome in civilian gunshot wounds to the head. Journal of Neurosurgery. 120: 1138-1146.
4. Davidsson, J., & Risling, M. (2015). Characterization of pressure distribution in penetrating traumatic brain injuries. Frontiers in Neurology. 6: 51.
5. Zyck, S., et al. (2016). Treatment of penetrating nonmissile traumatic brain injury. World Neurosurgery. 91: 297-307.
6. Abdelhameid, A. K., & Saro, A. (2019). Non-missile penetrating brain injuries: cases registry in Sohag University Hospital. Egyptian Journal of Neurosurgery. 34: 1-9.
7. Jacobs, B., et al. (2011). Computed tomography and outcome in moderate and severe traumatic brain injury: Hematoma volume and midline shift revisited. Journal of Neurotrauma. 28: 203-215.

8. Aldrich, E. F., et al. (1992). Predictors of mortality in severely head-injured patients with civilian gunshot wounds: A report from the NIH Traumatic Coma Data Bank. Surgical Neurology. 38: 418-423.
9. Kim, K. A., et al. (2005). Vector analysis correlating bullet trajectory to outcome after civilian through-and-through gunshot wound to the head. Neurosurgery. 57: 737-747.
10. Jamous, M. A. (2019). Outcome of craniocerebral penetrating injuries: Experience from the Syrian war. Journal of Neurological Surgery Part A: Central European Neurosurgery. 80: 345-352.
11. Hofbauer, M., et al. (2010). Predictive factors influencing the outcome after gunshot injuries to the head—a retrospective cohort study. Journal of Trauma and Acute Care Surgery. 69: 770-775.
12. Muehlschlegel, S., et al. (2016). Predicting survival after acute civilian penetrating brain injuries: The SPIN score. Neurology. 87: 2244-2253.
13. Wani, A. A., et al. (2011). Missile injury to the pediatric brain in conflict zones. Journal of Neurosurgery: Pediatrics. 7: 276-281.
14. Wyck, D., Grant, G., & Laskowitz, D. (2015). Penetrating traumatic brain injury: a review of current evaluation and management concepts. Journal of Neurology & Neurophysiology, 06(06). https://doi.org/10.4172/2155-9562.1000336.
15. Finnie, J. (2013). Neuroinflammation: beneficial and detrimental effects after traumatic brain injury. Inflammopharmacology. 21: 309-320. https://doi.org/10.1007/s10787-012-0164-2.
16. Sungkar, A., Wijanarko, F., Saadhi, I., & Setiawati, D. (2022). Late-onset seizure and left hemiparesis after unusual craniocerebral penetrating injury by a rusty sickle: a case report. Open Access Macedonian Journal of Medical Sciences. 10: 98-102. https://doi.org/10.3889/oamjms.2022.7153.
17. Splavski, B. (2022). Surgical management of a penetrating brain wound and associated perforating ocular injury caused by a low-velocity sharp metallic object: a case report and literature review. Acta Clinica Croatica. https://doi.org/10.20471/acc.2022.61.03.21.
18. Kumar, N., & Kamble, K. (2023). A combination effect of manual assisted cough techniques and respiratory proprioceptive neuromuscular facilitation on ventilatory decompression craniotomy patients: a case report. International Journal of Research in Medical Sciences. 11: 719-722. https://doi.org/10.18203/2320-6012.ijrms20230195.

Cite this article: Mohamed Mustafa Ahmed MRCS, MSc, Mujahid Imam MSc, FawazEljili.M. Abdelradi1 MRCS, MSc, MPH, Ahmed Zidan MD, MRCS Ed, FRCS SN, Bashier Mohammed Bashier MD, KhalidSieddig.A. Issawi MD, Sawsan.A. Aldeaf MD,PhD, Aymen Drgam, Mohammed Hamed, Sanna Taha, Amna Hussein MD, Ahmed Doomi MD, FACS (2024) Outcome in war related penetrating brain injury. Journal of Neurology and Neuroscience Research (5): 111-115.

Copyright: ©2024 **Fawaz Eljili.M. Abdelradi**. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.