

The Relationship between Brain Computed Tomography Scan Findings and Prognosis in Patients with Missile-penetrating Head Injuries

Husam Ghazi Al-Anbari, Nuha M. Salih Al-Zaubai¹, Ahmed Hashim Matloob², Ali A. Hadi³

Faculty of Medicine, University of Al-Ameed, ¹Faculty of Medicine, ²Faculty of Medicine, University of Karbala, ³Faculty of Medicine, University of Warith Al-Anbiyaa, Karbala, Iraq

Abstract

Background: Missile-penetrating head injury is a challenging problem for treating physicians. In Iraq and during 2003–2007, there was a civil war, which led to multiple casualties after suicide bombings or other clashes with coalition forces. A brain computed tomography (BCT) scan is considered as an initial diagnostic test to evaluate the next management plan. The authors tried to find the relationship between BCT scan findings and patients' outcomes. **Objective:** This study aimed to explore the relationship between BCT scan findings of patients with missile-penetrating head injury and their prognosis. **Materials and Methods:** This was a cohort retrospective clinical study performed in Karbala, Iraq in the period from January 2005 till January 2006. Seventy patients with missile-penetrating head injuries were admitted and evaluated in Al-Hussain General Hospital (affiliated with the University of Al-Ameed). All patients had BCT scans and their outcome was evaluated using a modified Glasgow Outcome Scale. **Results:** In this study, the mortality rate is 15.71%. BCT scan findings are correlated with patients' outcomes, which revealed the injury of one lobe carries the best outcome, whereas those with more than two lobes or posterior fossa injury carry the worse prognosis. Moreover, intraventricular hemorrhage (IVH) showed the highest mortality rate, whereas tract hematoma alone seems to carry a good prognosis with the least mortality. **Conclusion:** BCT scan is essential in both diagnosis and prognosis of patients with missile-penetrating head injury. IVH and posterior fossa injury lead to the highest mortality rate.

Keywords: BCT, head injury, missiles, penetrating, prognosis

INTRODUCTION

Penetrating head injuries are reported in history since the Egyptian era when they treated them with wound greasing.^[1,2] Missile wounds are the most common penetrating head injury in the civilian setting. Although they may be highly lethal and most of the patients need urgent neurosurgical care, the majority of them carry a good prognosis.^[3,4] By definition, penetrating (or open) head injury means breaching of dura matter.^[5-7] This can be caused by missiles (high-velocity projectiles) or objects of lower velocity such as knives or bone fragments from a skull fracture that is driven into the brain. Missile-penetrating head injuries came into the field of medicine after the development of war weapons and early literature started to appear from World War I and World War II.^[2,3,6,7] In 2003, the US military campaign to invade Iraq

yielded a lot of civilian injured people where both US militaries and suicide bombings caused massive injuries to civilian people.^[6,8,9] On the contrary, gunshot wound injured patients show a big challenge to be treated well. Those patients carry high mortality and poor functional and neurological prognosis.^[10] In this study, the patients have all injured civilians with different penetrating missiles.

Missile-penetrating head injuries had been classified several times; one of the former classifications was Cushing's

Address for correspondence: Dr. Husam Ghazi Al-Anbari, Faculty of Medicine, University of Al-Ameed, Karbala City Karbala-Najaf Highway Front of Pole (1238) P.O. No: 198 Karbala, Iraq. E-mail: husam.alanbari@gmail.com

Submission: 18-Aug-2022 **Accepted:** 22-Sep-2022 **Published:** 09-Jan-2023

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: WKHLRPMedknow_reprints@wolterskluwer.com

How to cite this article: Al-Anbari HG, Salih Al-Zaubai NM, Matloob AH, Hadi AA. The relationship between brain computed tomography scan findings and prognosis in patients with missile-penetrating head injuries. *Med J Babylon* 2022;19:640-5.

Access this article online

Quick Response Code:



Website:
www.medjbabylon.org

DOI:
10.4103/MJBL.MJBL_184_22

classification in 1917. This was based on clinical examination findings of the wound with the surgical results.^[3,7,9] Cushing classified missile-penetrating head injuries into superficial, tangential, penetrating, and perforating types, depending on the relationship between the missile and affected skull and brain tissues.^[6,11,12] Matson refined Cushing's classification after World War II, then more improvement was done in the 1970s by Raimondi and Samuelsson who presented the association between neurological condition and mortality rate of civilian injured patients.^[3,6,7]

Brain computed tomography (BCT) technology has evolved to present a better diagnostic method to assess patients with head injuries. BCT started to give both diagnostic and prognostic value to those with missile-penetrating head injuries.^[7,11-13] There are few criteria seen in BCT such as how many brain lobes are affected by missiles, the presence of intracranial bleeding, the affection of posterior fossa or brain stem, any bone fragments or missiles particles, the intraventricular hemorrhage (IVH), midline shift, and any signs of infection or possible vascular structures injuries. These variables can be very well integrated with the clinical outcome of patients.^[2,7,11,14]

In this study, the patients are all civilians and the authors tried to explore the relationship between BCT scan findings and clinical outcomes. The findings are basically anatomical namely how many lobes are affected and whether the posterior fossa is affected or not, or if any tract hematoma or other hemorrhage in the brain. All these variables are to be correlated with prognosis.

Aims of study

- To explore the BCT findings of patients with missile-penetrating head injuries.
- To study the relationship between different BCT scan findings and the prognosis.

MATERIALS AND METHODS

Patients and study design

This was a cohort retrospective clinical study that was completed in Karbala, Iraq between January 2005 and January 2006. The study was performed on 70 patients who presented with different missile-penetrating head injuries at Al-Hussain General Hospital (affiliated with the University of Al-Ameed). These injuries are due to blast shells or machine guns or pistols.

Any patient under the effect of drugs, toxins, or referred from another hospital (after treating them operatively) has not been included in this study.

All patients included in this study were admitted to the neurosurgical ward in Al-Hussain General Hospital (affiliated with the University of Al-Ameed) after performing necessary resuscitation. All patients had a proper neurological examination and the severity of injured patients is classified according to the Glasgow Coma Scale (GCS) as follows:

- Mild head injury includes patients with a score of 13–15.
- Moderate head injury includes patients with a score of 9–12.
- Severe head injury includes patients with a score of ≤ 8 .

A BCT scan was performed on all patients to show brain injuries. The BCT scan findings are classified into two major tables:

- Table 1 shows BCT scan anatomical findings in relation to the outcome scale. These sites can be one or two or more brain lobes or bi-hemispheric or posterior fossa involvement.
- Table 2 shows BCT findings of intracranial hematoma and hydrocephalus in relation to the outcome scale.

Table 1: BCT scan findings according to the anatomical site of injury in relation to outcome scale

Anatomical findings	No. of patients	Percentage %	Outcome scale			
			Good recovery	Moderate disability	Severe disability or vegetative status	Dead
One lobe affection	33	47.1	29	2	2	–
Two lobes affection	19	27.1	1	12	6	–
Three lobes affection or more	6	8.6	–	–	2	4
Bi-hemispheric	10	14.3	–	1	4	5
Posterior cranial fossa	2	2.9	–	–	–	2
Total	70	100%	30	15	14	11

Table 2: BCT scan findings according to the anatomical site of injury in relation to outcome (anatomical sites collapsed)

	Outcome scale				Total
	Good recovery	Moderate disability	Severe disability or vegetative status	Dead	
One lobe	29	2	2	0	33
More than one lobe	1	13	12	11	37
Total	30	15	14	11	70

Chi-squared: $P < 0.01$

The hematoma includes brain tract hematoma, IVH (intraventricular hematoma), and SDH (subdural hematoma).

All patients were admitted to the neurosurgical ward of the hospital; 40 patients were treated conservatively and 30 patients were treated surgically to remove the intracranial hematoma and necrotic or contused brain causing mass effect also to remove accessible bone and metal fragments with wound debridement.

All of them received prophylactic antibiotics and anticonvulsant agents.

The outcome was determined by neurological evaluations and classified according to the Glasgow outcome scale with some modifications, into:

- Good recovery: patients return to preinjury level of function.
- Moderate disability: patients have neurological deficits but can look after themselves.
- Severe disability or vegetative state: patients are unable to look after themselves.
- Death.

Table 3: BCT scan findings according to the anatomical site of injury in relation to living state (anatomical sites collapsed)

	Living state		Total
	Alive	Dead	
One lobe	33	0	33
More than one lobe	26	11	37
Total	59	11	70

Chi-squared: $P < 0.01$

Statistical analysis

For statistical analysis, Pearson chi-squared tests for independence were used whenever appropriate. The significance level was set at $P < 0.05$. Data were analyzed using the SPSS software program, version 21.0 statistical software. To meet the assumption of the chi-square test, groups of the variables have been collapsed. Then BCT findings (both anatomical sites and hematomas) and outcome scale categories were collapsed into two groups in order not to violate the assumptions of the chi-squared test.

Ethical consideration

The study was conducted in accordance with the ethical principles that have their origin in the Declaration of Helsinki. It was carried out with patients verbal and analytical approval before the sample was taken. The study protocol and the subject information and consent form were reviewed and approved by a local ethics committee according to the document number 145 in 05/01/2005.

RESULTS

Seventy patients who presented with missile injuries were admitted to the neurosurgical ward in Al-Hussain General Hospital (affiliated with the University of Al-Ameed). In this study, the mortality rate is 15.71% keeping in mind, all victims under drugs or toxins or referred from another hospital (after treating them operatively) are not included in this study.

Brain computed tomography scan anatomical findings in relation to outcome scale

In this study, 33 (47.1%) patients sustained injury to one lobe, 19 (27.1%) patients with two lobes, 6 (8.6%) patients

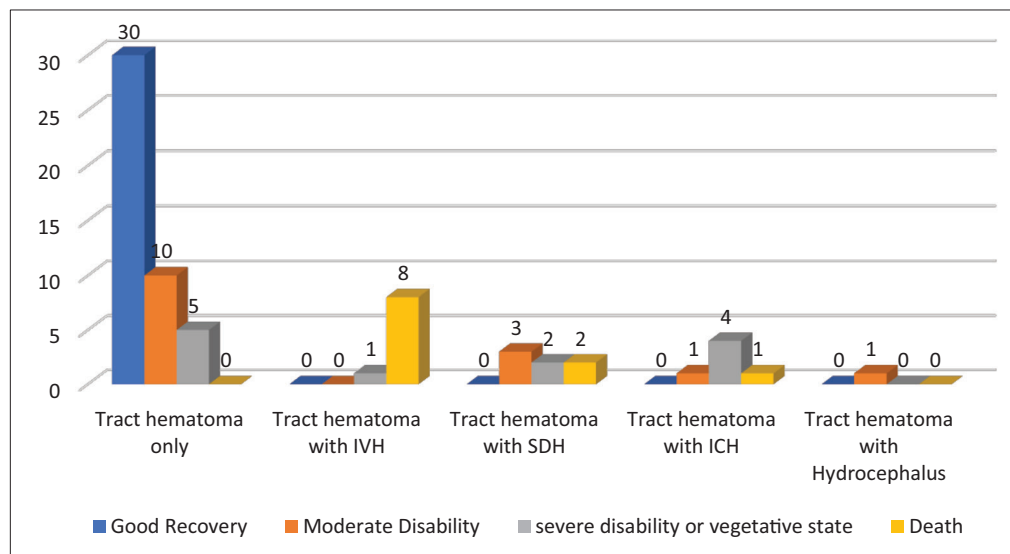


Figure 1: BCT findings with hematoma in relation to outcome scale

with three lobes or more, 10 (14.3%) with bi-hemispheric injuries, and only 2 (2.9%) patients sustained an injury to posterior cranial fossa [Tables 1–3 and Figure 1]. Table 1 and Figure 2 represent these findings. The outcome scale appears as follows [Table 1]:

- The highest incidence rate is with one lobe injury (33) patients (47.1%). The highest mortality rate is with posterior cranial fossa injury (2) patients (100%) followed by three lobes or more injury than bi-hemispheric injuries.
- The mortality rate of posterior cranial fossa injury is 100%.
- The mortality rate of three lobes or more injuries is 66.7% with 23.3% of them sustained severe disability.
- The mortality rate of bi-hemispheric injury is 50% with (40%) severe disability.
- The least mortality rate (6.06%) appears with injury to one lobe and (87.8%) of patients showed good recovery.

To meet the assumption of the chi-square test, groups of the variables have been collapsed. BCT findings

(anatomical sites) and outcome scale categories were collapsed into two groups in order not to violate the assumptions of the chi-squared test

The chi-squared test showed that there is a significant association between the numbers of affected lobe and patients' prognosis ($P < 0.01$).

The chi-squared test showed that there is a significant association between numbers of affected lobes and mortality rate ($P < 0.01$).

Brain computed tomography scan findings of tract hematoma with another brain hemorrhage in relation to outcome scale

In this study, 45 (64.3%) patients presented with tract hematoma only, 9 (12.9%) patients with tract hematoma and IVH, 9 (12.9%) patients with tract hematoma and SDH, and 6 (8.5%) patients with tract hematoma and ICH [Tables 4–6 and Figure 1]. Only one patient (1.4%) presented with tract hematoma and hydrocephalus which appears later after 12 days.

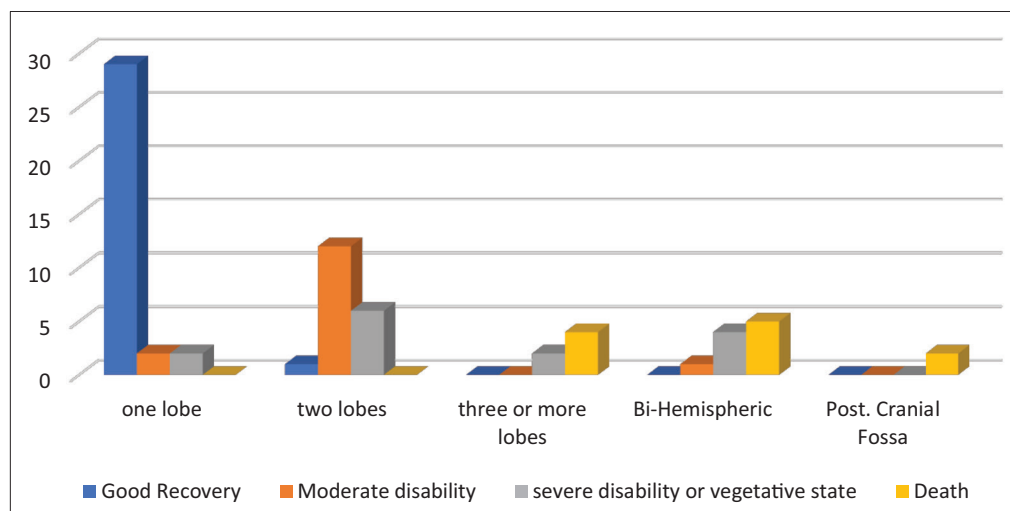


Figure 2: BCT scan anatomical findings in relation to outcome scale

Table 4: BCT scan findings with tract hematoma and other associated hematoma in relation to outcome scale

BCT findings	No. of patients	Percentage %	Outcome scale			
			Good recovery	Moderate disability	Severe disability or vegetative	Dead
1 Tract hematoma only	45	64.3	30	10	5	–
2 Tract hematoma and IVH (intraventricular hemorrhage)	9	12.9	–	–	1	8
3 Tract hematoma and SDH (subdural hematoma)	9	12.9	–	3	4	2
4 Tract hematoma and ICH (intracerebral hematoma)	6	8.5	–	1	4	1
5 Tract hematoma and hydrocephalus	1	1.4	–	1	–	–
Total	70	100%	30	15	14	11

Table 5: BCT scan findings with tract hematoma and other associated hematoma in relation to outcome scale (hematoma types collapsed)

Type of hematoma	Outcome				
	Good recovery	Moderate disability	Severe disability or vegetative status	Dead	Total
Tract hematoma only	30	10	5	0	45
Other hematomas	0	5	9	11	25
Total number	30	15	14	11	70

Chi-squared: $P < 0.01$ **Table 6: BCT scan findings with hematoma in relation to a living state**

	Living state		Total
	alive	dead	
Tract hematoma	45	0	45
Other hematomas	14	11	25
Total	59	11	70

Chi-squared: $P < 0.01$

No death was recorded for those patients, with only tract hematoma; whereas 30 (66.7%) of them showed good recovery. Eight patients with tract hematoma and IVH; out of 9 equal to 88.9% died with only 1 patient out of 9, which is equal to 11.1% ended up with a severe disability, 2 patients with SDH out of 9 died which is equal to 22.2%.

The least mortality rate is with tract hematoma alone, whereas the highest mortality rate is with tract hematoma and IVH.

All patients have tract contusion: 45 (64.3%) patients have only tract contusion, 9 (12.9%) patients have contusion and IVH, 9 (12.9%) patients have contusion and SDH, 1 (1.4%) patient has contusion and hydrocephalus. The highest mortality rate is associated with IVH.

Types of hematoma categories were collapsed into two groups in order not to violate the assumptions of the chi-squared test.

The chi-squared test showed that there is a significant association between type of hematoma and patients' prognosis ($P < 0.01$).

The chi-squared test showed that there is a significant association between type of hematoma and living state ($P < 0.01$).

DISCUSSION

The prognosis of patients with missile-penetrating head injuries is variable; however, this depends on many factors such as the severity of the head injury, the age, the other systemic injury, and other factors.^[4,10,13-19] Few studies showed the mortality rate of missile-penetrating head injuries varies between 10% and 40%, whereas gunshot head injuries in civilians can be as high as 53.5%–88%.^[11,19,20]

In this study, the mortality rate is 15.71% keeping in mind; all victims under drugs or toxins or referred from another hospital (after treating them operatively) are not included in this study. This result is almost similar to other studies since missiles are small particles with a less damaging effect on the brain in comparison to direct gunshot injuries where the mortality rate is higher as seen in other studies.^[3,10,11] The type of missiles might affect patients' outcomes; in this study, the victims are civilians and the injury is almost because by suicide bombing which causes different shapes of missiles but they carry less damaging influence than a direct gunshot.

All patients were subjected to a BCT scan for diagnostic evaluation since it is an easier mode of diagnosis but this added more prognostic value later in patients' management. Moreover, CT scan pictures usually reveal hemorrhagic tracts, intracerebral hemorrhage, midline shift, and metallic or bone fragments or air or skull fractures.^[8,11,17,20]

In this study, patients with posterior cranial fossa injury as seen in BCT carry the highest mortality rate. This has been demonstrated by other studies as well which can be explained as there are vital structures such as the brain stem in this dangerous anatomical area, which can be a leading cause of death.^[5,11,13,14,17,21,22] In addition, bi-hemispheric or more than two lobes' injuries show a worse prognosis with severe disability or vegetative status patients as seen in other studies.^[5,11,13,14,21-23] This is mostly because of possible damage of deep structures such as the hypothalamus or thalamus or indirectly by cavitation effect to damage the brain stem.

The affection of more than one lobe or bi-hemispheric indicates enough energy of the object to enter and cause injury to more than one lobe which correlates positively with damage that happens to the brain with more possibility to affect vital structures such as the hypothalamus or thalamus or indirectly by cavitation effect to affect brain stem. Pabuscu *et al.*^[11] presented in their study a few poor prognostic variables including IVH; in this study, almost the same result was obtained since patients with IVH displayed the worse prognosis.^[3,10,13,15,17,20,22,24-26] All patients showed tract hematoma in this study which is expected as well in any missile-penetrating head injury; nevertheless, interestingly this sign displayed a good prognosis if it

is alone but if it is combined with another intracranial hemorrhage, the prognosis would be worse. This finding was not shown clearly in other studies apart from the fact of a worse prognosis relationship to ICH.^[7,12,14,15,18]

Unfortunately, BCT fails to show vascular injury^[17,22,23] and this was not seen in this study however other studies demonstrated post-traumatic aneurysm or other vascular injuries using BCT angiography.^[27]

Study limitations

1. Retrospective study.
2. Single-center study.

CONCLUSION

Penetrating head injury is a challenging problem and carries high mortality and morbidity rate. Missile injuries in civilian settings appear to be less damaging than in war. BCT scan is essential in both diagnosis and prognosis of patients with missile-penetrating head injury. IVH and posterior fossa injury lead to the highest mortality rate.

Data availability statement

The data analyzed during this study are available from the corresponding author (Dr. Husam Ghazi Al-Anbari, e-mail: husam.alanbari@gmail.com) upon request.

Acknowledgement

The authors extend their gratitude to all medical staff at Al-Hussain General Hospital (affiliated to University of Al-Ameed) for their participation and support for this study.

Financial support and sponsorship

Not applicable.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

1. Paciaroni M, Arnao V. Neurology and war: From antiquity to modern times. *Front Neurol Neurosci* 2016;38:1-9.
2. Agarwalla PK, Dunn GP, Laws ER. An historical context of modern principles in the management of intracranial injury from projectiles. *Neurosurg Focus* 2010;28:E23.
3. Carey ME. Cushing and the treatment of brain wounds during world war I. *J Neurosurg* 2011;114:1495-501.
4. Kaufman HH, Schwab K, Salazar AM. A national survey of neurosurgical care for penetrating head injury. *Surg Neurol* 1991;36:370-7.
5. de Lanerolle NC, Kim JH, Bandak FA. Neuropathology of traumatic brain injury: Comparison of penetrating, nonpenetrating direct impact and explosive blast etiologies. *Semin Neurol* 2015;35:12-9.
6. Kinsman M, Pendleton C, Quinones-Hinojosa A, Cohen-Gadol AA. Harvey Cushing's early experience with the surgical treatment of head trauma. *J Hist Neurosci* 2013;22:96-115.
7. Alvis-Miranda HR, M Rubiano A, Agrawal A, Rojas A, Moscote-Salazar LR, Satyarthee GD, *et al.* Craniocerebral gunshot injuries: A review of the current literature. *Bull Emerg Trauma* 2016 4:65-74.
8. Ramasamy A, Harrison SE, Stewart MP, Midwinter M. Penetrating missile injuries during the Iraqi insurgency. *Ann R Coll Surg Engl* 2009;91:551-8.
9. Breeze J, Bowley DM, Harrison SE, Dye J, Neal C, Bell RS, *et al.* Survival after traumatic brain injury improves with deployment of neurosurgeons: A comparison of US and UK military treatment facilities during the Iraq and Afghanistan conflicts. *J Neurol Neurosurg Psychiatry* 2020;91:359-65.
10. Gressot LV, Chamoun RB, Patel AJ, Valadka AB, Suki D, Robertson CS, *et al.* Predictors of outcome in civilians with gunshot wounds to the head upon presentation. *J Neurosurg* 2014;121:645-52.
11. Pabuscu Y, Bulakbasi N, Kocaoglu M, Ustünsöz B, Tayfun C. A different approach to missile induced head injuries. *Comput Med Imaging Graph* 2003;27:397-409.
12. Wyck DV, Grant G, Laskowitz D. Penetrating traumatic brain injury: A review of current evaluation and management concepts. *J Neurol Neurophysiol* 2015;6:6.
13. Splavski B, Vranković D, Saftić R, Muzević D, Kosuta M, Gmajnić R. [Clinical predictors correlated to outcome of war missile penetrating brain injury]. *Acta Med Croatica* 2006;60:369-73.
14. Smith JE, Kehoe A, Harrison SE, Russell R, Midwinter M. Outcome of penetrating intracranial injuries in a military setting. *Injury* 2014;45:874-8.
15. Weisbrod AB, Rodriguez C, Bell R, Neal C, Armonda R, Dorlac W, *et al.* Long-term outcomes of combat casualties sustaining penetrating traumatic brain injury. *J Trauma Acute Care Surg* 2012;73:1525-30.
16. Zafonte RD, Wood DL, Harrison-Felix CL, Valena NV, Black K. Penetrating head injury: A prospective study of outcomes. *Neurol Res* 2001;23:219-26.
17. Solumsmoen S, Lilja-Cyron A, Buch KF, Kelsen J. [Traumatic penetrating brain injury]. *Ugeskr Laeger*. 2018;180:V03180201.
18. Vrankovic D, Splavski B, Hecimovic I, Glavina K, Dmitrovic B, Mursic B. Analysis of 127 war inflicted missile brain injuries sustained in north-eastern Croatia. *J Neurosurg Sci* 1996;40:107-14.
19. Eftekhar B, Sahraian MA, Nouralishahi B, Khaji A, Vahabi Z, Ghodsi M, *et al.* Prognostic factors in the persistence of posttraumatic epilepsy after penetrating head injuries sustained in war. *J Neurosurg* 2009;110:319-26.
20. Martins RS, Siqueira MG, Santos MT, Zanon-Collange N, Moraes OJ. Prognostic factors and treatment of penetrating gunshot wounds to the head. *Surg Neurol* 2003;60:98-104; discussion 104.
21. Zafonte RD, Wood DL, Harrison-Felix CL, Millis SR, Valena NV. Severe penetrating head injury: A study of outcomes. *Arch Phys Med Rehabil* 2001;82:306-10.
22. Besenski N, Jadro-Santel D, Jelavić-Koić F, Pavić D, Mikulić D, Glavina K, *et al.* Ct analysis of missile head injury. *Neuroradiology* 1995;37:207-11.
23. Kim PE, Zee CS. The radiologic evaluation of craniocerebral missile injuries. *Neurosurg Clin N Am* 1995;6:669-87.
24. Mahoney PF, Carr DJ, Miller D, Teagle M. The effect of helmet materials and simulated bone and tissue layers on bullet behaviour in a gelatine model of overmatch penetrating head injury. *Int J Legal Med* 2017;131:1765-76.
25. Mackerle Z, Gal P. Unusual penetrating head injury in children: Personal experience and review of the literature. *Childs Nerv Syst* 2009;25:909-13.
26. Amirjamshidi A, Abbassioun K, Rahmat H. Minimal debridement or simple wound closure as the only surgical treatment in war victims with low-velocity penetrating head injuries. Indications and management protocol based upon more than 8 years follow-up of 99 cases from Iran-Iraq conflict. *Surg Neurol* 2003;60:105-10; discussion 110-1.
27. Dubey A, Sung WS, Chen YY, Amato D, Mujic A, Waites P, *et al.* Traumatic intracranial aneurysm: A brief review. *J Clin Neurosci* 2008;15:609-12.