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Gunshot Penetrating Brain Injury: Predictors of Outcome Based on CT Brain

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Abstract

Background: Initial presentation of the patient with gun shot wounds to the head (GSWH) is important key to for the decision making that carry hopeful functional outcome. A forementioned predictors, scoring system was ascheived to predict the outcome.

Aim of Study: Identifying a novel classification of management.

Patients and Methods: The records of 140 patients with penetrating military missile head injuries treated by the authors by Facilities in Northern Sinai and Kasr Al-Ainy between 2011 and 2018. The data were collected respectively. We advocated a classification that involve the whole parenchyma in midaxial CT brain, zone 1 is the outermost zone that extend from inner table to external capsule, zone 2 is located from external capsule to the lateral edge of the thalamus and zone 3 is the innermost and the highly risk zone that extend from the lateral edge of thalamus to the midline.

Results: We demonstrated the correlation between the Glascow Outcome Score (GOS) and different zones. We recorded 52 patients in zone 1, 37 patients in zone 2 and 51 patients presented in zone 3. The survivors in zone1 and zone 2 were 89 patients (63.5%) however the survivors in zone 3 were 51 (36.4%) and all of them presented with severe disabilities and also involve the vegetative patients and the 5 patients who died.

Conclusions: Authors determined age, pupil, GCS score and bullet trajectory as the important predictors of functional outcome. The authors advocated a broader classification in CT brain to be correlated significantly with morbidity and mortality.

Key Words: *Gun shot – Penetrating – Outcome – Zone – Classification.*

Introduction

MANAGEMENT of penetrating military injuries in a war zone setting is different from common civilian penetrating brain injuries that we usually experience in our practice due to variable factors **[1-5]** : (1) Technical factors (missile caliber and velocity); (2) Lack of sophisticated medical facilities in a war zone; (3) Lack of equipment and supplies; and (4) lack of sufficient medical personnel and experienced neurosurgeons on site. Several predictors for survival with accepted negative prognostic factors including low Glascow coma scale on arrival,bihemispheric injuries,ventricular involvement,and non reactive pupil **[6,7]** . Fewer than half of the civilians who get benefits from neurosurgical interventions in the form of debridement, repair, and decompressive craniotomy **[1,8-10]** .

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Patients and Methods

This is a retrospective study of 140 patients with penetrating military missile head injuries treated by the authors in Northern Sinai and Kasr Al-Ainy between 2011 and 2018.

We excluded patients with: (1) Associated injuries as they may affect the outcome and survival. (2) Age below 10 years. (3) Military personnel and (4) Patients with early withdrawal of care by decision of his family. Patient demographics, clinical findings, CT findings, missile location.

CT provide data about inlet,exit ,bullet trajectory,extraaxial or intraaxial hematoma, intraventricular hemoorrhage, edema and midline shift. Different surgical management were described such as the decompressive craniectomy **[1,3,11]** , dural closure, **[11,12]** bone reconstruction, **[11]** and extraction of bullets **[4,12,13]** . Civilian GSWH is open wounds and neurosurgeons should be minded to customized surgical procedures according to the type of injury **[14]** .

Acute intervention:

Routine Prophylactic antibiotics for all patients with rescucitation. Evacuation of hematomas more than 0.5ml midline shift. External ventricular drainage for intraventricular hemorrhage and debridement for all wounds for herniated brainSmall entrance wound caused by small bellets managed by wound closure, antibiotics and local wound care without extensive surgical intervention [15,16] authors described number of fatal zones to help in prediction of outcome such as zona fatalis, [17] posterior fossa, [7] XYZ planes, [4] and danger zone [5].

We describe a novel classification of gunshot injuries to the brain based upon the location of the intracranial bullet. We divide the brain in mid-axial CT cuts into three circumferential zones which are roughly equidistant. The coronal and sagittal views further outline the boundaries of each zone. Thus, the brain is divided into three zones according to where the missile passed or stopped. If multiple fragments and bullets where we apply it to the largest one that devastating the brain.

- Zone 1: The outermost zone, it extends from the skull to the external capsule medially. This is the safest zone which include small bone fragments, small hematoma and depressed fracture.
- Zone 2: The middle zone. It extends from the external capsule to the lateral border of the thalamus.
- Zone 3: The innermost zone it extends from lateral edge of thalamus to midline.

This zone include also the brain stem and also reach lateral ventricle, third ventricle, fourth ventricle with higher risk of infection, intraventricular hemorrhage, hydrocephalus and carries high risk of devastating injury. And this denote high velocity injury. This may be simplified by 360 degree two equidistance circle. Fig. (1). We follow tram track sign that described by Rosenfeld et al. [4] to identify in which zone the patient will be categorized.So this may be applied for broad and large devastating injuries.

GCS is recorded for all patients after resuscitation and documented on hourly basis. Glascow (GOS) outcome score is recorded on discharge and follow-up outpatient visits was done after 1 ,3, and 6 months to record the complications.

Case presentation:

42 years old male patient admitted to casuality department with gun shot injury, resuscitation was done intubated and admitted to ICU and GCS was 7/15. The patient underwent debridement by extending the skin incision at the inlet and cutting bone edges to reach intact dural edge all through and repaired by pericranial graft. The GCS improved and became 12/15 and extubated by the second day. The patient discharged on third day and wound was clean without CSF leak or collection. Fig. (2).

Results

We have male predominance, 125 paients (89%) were male however the female were 15 (10%) with mean age was 28±16.4 years where 102 patients (72%) in age groups 20-50 years. Our demographic data shown in Table (1). Our patients were classified into 3 groups according to their admission GCS. We had 61 patients presented with GCS 9-15,55 patients presented with scores of 6-8 and 24 patients presented with scores 3-5. Regarding GOS, we have five patients died (3%) and the survivors were 135 patients (96.4%) with variable degree of disabilities and one patient persiteted in vegetative state. Table (2) showed the GOS in relation with admission GCS and illustrated also in Diagram (1). According to different zones we have 52 patients in zone 1, zone 2 had 37 patients and 51 patients presented in zone 3 as showed in Table (3) that illustrate the relation between the GOS in patients with different zones where the survivors in zone1 and zone 2 were 89 patients (63.5%). Zone 3 involve 5 patients who died, also the vegetative patient and 45 Patients (78.9%) with severe disabilities so zone 3 involve 51 (36.4%) of these GOS of total number of the patients however zone 1 and zone 2 only involve 12 patients (8%) which presented with sever disability. Zone 1 and zone 2 include 77 patients (55%) with mild, moderate and good recovery.

135 patients (96.4%) had undergone surgical intervention however we only have done simple suture and dressing in 5 patients. The inlet were more incidence in frontal bone (31.4 %) and temporal bone (25%) as demonstrated in Table (1). 55 patients (39%) were operated with hematoma evacuation and decompressive craniotomy where 42 patients in zone 1 and zone 2 and we found that 38 patients (27%) were mild, moderate disability and good recovery. 13 patients (9%) were presented in zone 3 and all of them had recovered with severe disabilities.

Statistical analysis:

Data were coded and entered using the statistical package for the Social Sciences (SPSS) version 26 (IBM Corp., Armonk, NY, USA). Data was summarized using frequency (count) and relative frequency (percentage) for categorical data. For comparing categorical data, Chi square (χ^2) test was performed. Exact test was used instead when the expected frequency is less than 5 (Chan, 2003). p-values less than 0.05 were considered as statistically significant. Chan YH (2003): Biostatistics 103: Qualitative Data-Tests of Independence. Singapore Med J., 44 (10): 498-503.

Table (1): Demographic.

Sex:	
Male	125
Female	15
Age:	
10-20	20
21-30	15
31-40	55
41-50	32
51-60	18
Entry wound:	
Frontal	44
Temporal	35
Parietal	22
Occipital	20
Posterior fossa	19
Surgical procedures:	
Debridement	70
Hematoma evacuation	35
Decompressive craniotomy	20
External ventricular drainage (EVD)	10
Pupils:	
Reactive	89
Non reactive	51

Complications: CSF leak in 20 patients (14%) who developed hydrocephalus treated with CSF diversion where 15 patients (10%) presented in zone 3. 20 patients (14%) had intraventricular hemorrhage (zone 3) and they had undergone EVD and followed by VP shunt and the other 10 patients developed hydrocephalus in follow-up and operated by VP shunt, two patients developed pseudoaneurysm, 44 patients had eplilepsy and continue for along period on antiepileptics. Brain abscess and meningitis occurred in 22 patients with 18 patients in zone 3 (12%) of total number of patients and only 4 patients (2%) who presented in zone 2.

Table (2): Correlation between Glascow coma scale and Glascow outcome score.

Glascow coma scale	No. of patients with Glascow outcome score of:					Total
	1	2	3	4	5	
9-15		1	10	16	34	61 (43.5%)
6-8	2		33	10	10	55 (39%)
3-5	3		14	6	1	24 (17%)
Total	5	1	57	32	45	140

Table (3): Correlation between different zones in CT brain & Glascow outcome score.

Zones in CT brain	No. of patients with Glascow outcome score of:					Total N (%)	p-value
	1	2	3	4	5		
Zone 1	0	0	2 (3.5%)	10 (31.3%)	40 (88.9%)	52 (37.1%)	<0.001
Zone 2	0	0	10 (17.5%)	22 (68.8%)	5 (11.1%)	37 (26.4%)	
Zone 3	5	1	45 (78.9%)	0	0	51 (36.4%)	
Total	5	1	57	32	45	140	

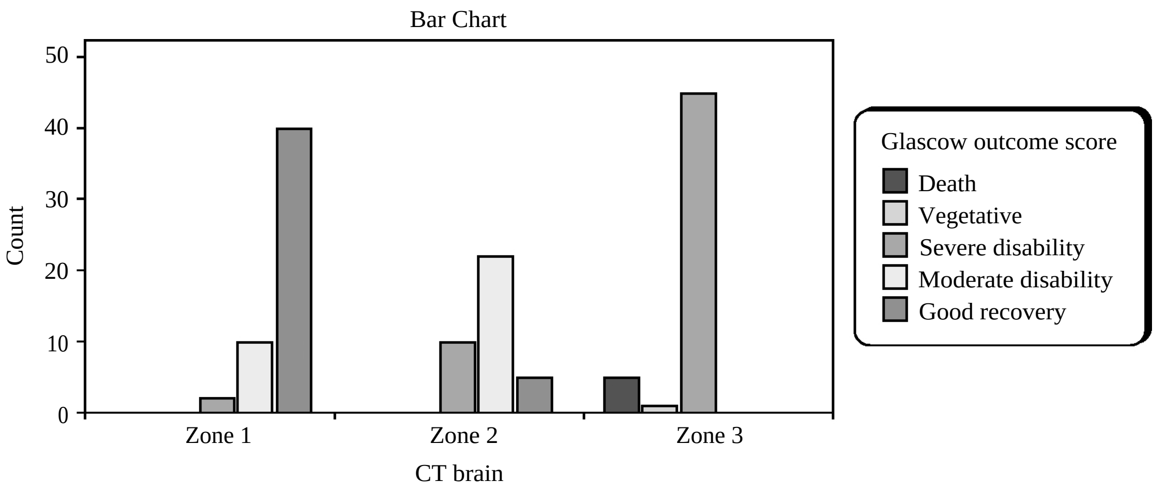
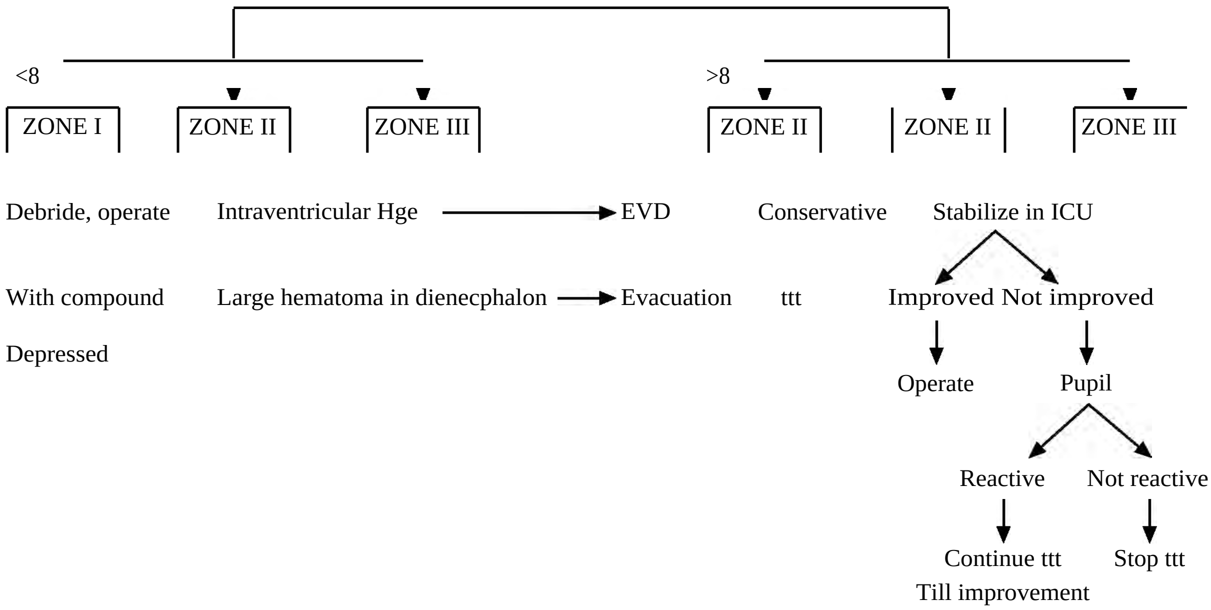


Diagram (1): Correlation between different zones in CT brain & Glascow outcome score.

Suggested algorithm for intervention according to zones
GCSI, CT brian



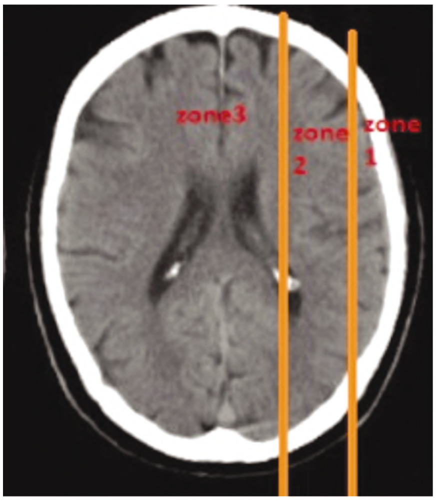


Fig. (1): CT brain axial cut showing zone classfication.

Fig. (2): CT brain axial cut showing circle the demonstrate equidistance circle of zone distribution.

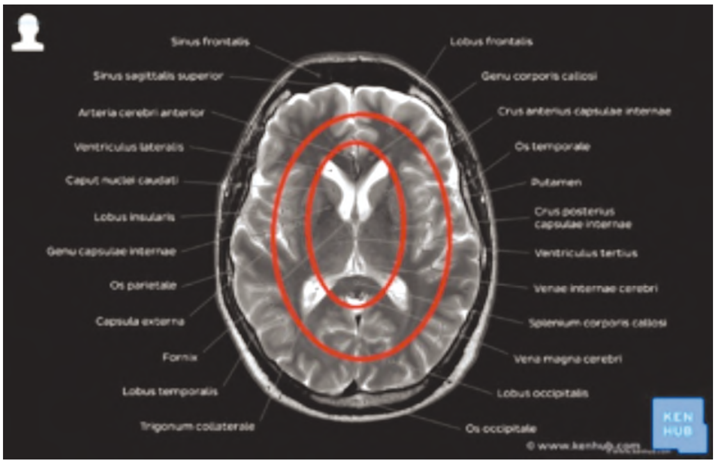


Fig. (3): Axial MRI brain showing zone classification.

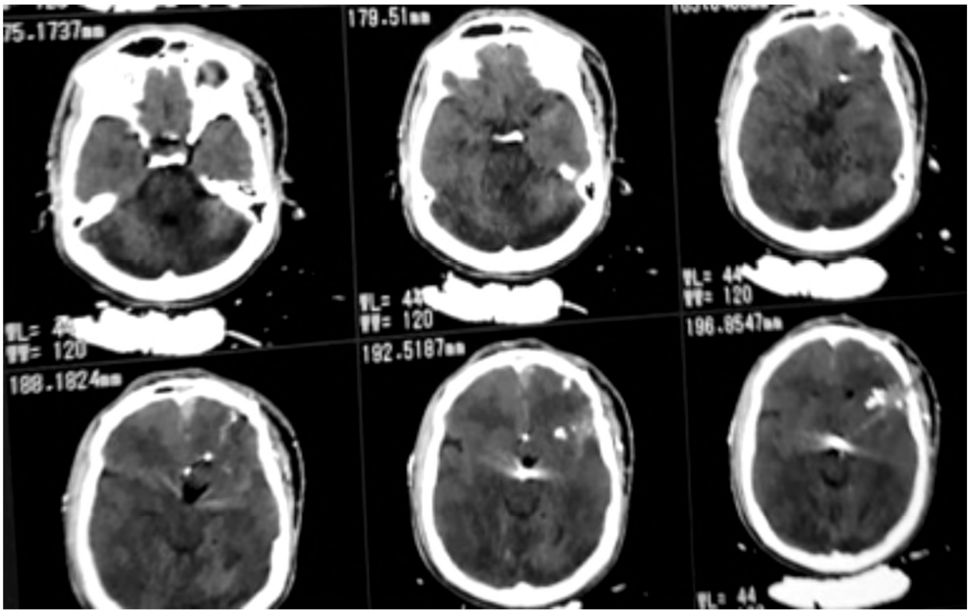


Fig. (4): CT Brain showing the shot and bone fragment reaching all zones.

Discussion

Authors described brain injuries regarding lobar [18], lobar with deep structure bihemispheric or posterior fossa or single zone affection [4,5,7,17].

But we described whole brain parenchymal affection whatever the trajectory or affected area of the brain as whole brain divided into three zones to be broader classification with variable outcome that showed difference between patients who presented to us with different zones in initial CT brain.

Pupillary reaction represents a critical indicator for outcome and decision of management in patients with GCS 3-5 [19], we observed 89 patients (63.5%) had reactive pupil with 40 patients (28%) in zone 1 and 32 patients in zone 2 (22%) in contrast to 17 (12%) patients in zone 3. Non reactive pupil presented in 51 patients (36%) with 44 patients (31 %) in zone 3. Zone 1 and zone 2 are significantly correlated with reactive pupil as a strong predictor of hopeful outcome.

Authors described treatment algorithms for the prediction of outcome according to their management [6,20,21]. War Head Injury Score suggested by Turina et al., for predicting mortality in military penetrating craniocerebral trauma based upon GCS score and Injury Severity Score to predict the mortality [22]. They found a weak correlation between their scoring system applied on acute penetrating head injury out of the war zone and military injuries [22].

The survivors in our study in zone 1 were 52 patients (37%) and zone 2 were 37 patients (26%) with only 2 patients with severe disability in zone 1 and 10 patients only in zone 2 (7%). We reported that 50 patients (35%) with mild, moderate disability and good recovery in zone 1 and 27 patients (19%) in zone 2 however zone 3 include the vegetative patient and the other 45 survivors (78.9%) had severe disability. So, we highlighted the higher incidence of morbidity in zone 3. Zone 3 include also 5 patients who died.the patients presented to us with infection were 22 patients and 18 patients (12%) in zone 3 in contrast to only four patients (2%) presented in zone 2. We also reported that zone 1 carry better prognosis than zone 2 as the patients with GOS 4 and GOS 5 were 50 patients (35%) compared to 27 patients (19%) presented in zone 2. Based on this findining the morbidity is higher in zone 3 than zone 2 and zone 1 may be due to that zone 3 had the laongest tract with serious devastating injury in the brainstem, basal cisterns and ventricle.

Intraventricular trac represent a bad prognostic factors because the excellent transmission shockwave from CSF that fills the ventricle [23,24]. We found 20 patients in zone 3 with intraventricular hemorrhage because this zone include lateral, third and 4th ventricle with higher incidence in hydrocephalus with net result management of VP shunt in 20 patients (14%). We reported CSF leak in 20 patients where 15 patients (10%) were presented in zone 3 because it contains main basal cisterns.

Zone 3 carries higher incidence of intraventricular hemorrhage and CSF leak more than zone 1 and zone 2. Aggressive surgical management improve the outcome and ICP monitor and ventilation provide an important factor [25]. We had 55 patients (39%) had undergone hematoma evacuation and decompressive craniotomy where 28 patients (20%) in zone 1 and 14 patients (10%) in zone 2 and we found that 38 patients (27%) were mild, moderate disability and good recovery anly 4 patients presented with severe disability. 13 patients (9%)were presented in zone 3 and all of them had recovered with severe disabilities. So we focused that early intervention carry hopeful prognosis in zone 1 and zone 2 more than zone 3. We have suggested algorithm that may help in intervention and prognosis.

Conclusion:

This classification may be helpful as a predictor of outcome and we hope that our study pave the way for further prospective study to use this protocol and algorithm to be a simple guide of management.

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إصابات الطلق النارى للرأس توقع الناتج للحالات بناء على الأشعة المقطعية للمخ

تعتبر إصابات الطلق النارى للرأس من أسباب الوفيات الحتمية أو تمثل نسبة خطورة عالية للحالات التى تظل على قيد الحياة سواء بتدخل جراحى أو بدون تدخل.

تمت الدراسة بأثر رجعى على ١٤٠ حالة فى القصر العينى ومستشفيات شمال سيناء فى الفترة ٢٠١١–٢٠١٨ وقد تم تقسيم الإصابات بالرأس على حسب تصنيف جديد أ كثر شمولية لتعدد الإصابات حيث تم تقسيم الإصابة على حسب الأشعة المقطعية إلى ثلاث مناطق تم تسميتهم إلى منطقة ١ ومنطقة و ٢ منطقة ٣.

حيث وجد الآتى: الذين ظلوا على قيد الحياة فى المنطقة ١ عددهم ٥٢ و ٣٧ مريض فى المنطقة ٢ و ٥١ مريض فى المنطقة ٣ وقد وجد المرضى بدرجة وعى أفضل وعدم وجود ضعف بالأطراف أو ضعف بسيط فى المنطقة ١ والمنطقة ٢ أما المنطقة ٣ قد تضمنت الوفيات وعددهم ٥ حالات وكل المرضى بهذه المنطقة قد وجدوا بتأثر شديد فى درجة الوعى وكذلك حركة الأطراف.

الدراسة تضمنت المقارنة والربط بين درجة الوعى عند دخول المريض ودرجة الوعى عند خروجه وضمنت الربط بين درجة الوعى أثناء خروجه من المستشفى ومكان إصابة المريض فى الأشعة المقطعية سواء منطقة ١ أو منطقة ٢ أو منطقة ٣.

لذلك قد لخصت هذه الدراسة أن الناتج النهائى للحالات قد كانت أفضل فى المنطقة ١ عن المنطقة ٢ وكلاهما أفضل من المنطقة ٣.