

# Neurotrauma in the Syrian War: Analysis of 41,143 cases from July 2013-July 2015

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## Research Article

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# Abstract

**Introduction** Despite nearly a decade of conflict, little is known about trauma and injuries resulting from the Syrian war. **Methods** Secondary analysis was conducted of an administrative dataset of patient presentations to a network of 95 war-affected hospitals in Syria from July 2013 - July 2015. Logistic regression was performed to identify factors associated with mortality of neurotrauma patients. **Results** Of 193,618 overall trauma presentations, 41,143 were for neurotrauma (37,410 head trauma, 1,407 spinal trauma and 3,133 peripheral nervous system). There were 31,359 males (76.2%) and 9,784 females (23.8%). Males aged 19-30 years (10,113; 24.6%) were the largest single demographic group. Presumed non-combatants including females, elders and children under 13 years (16,214; 39.4%) were the largest group of patients overall. There were 16,881 (41.0%) presentations with blunt injuries (blunt/crush injuries) and 21,307 (51.8%) patients with penetrating injuries (shrapnel, cut, gunshot). A total of 36,589 patients (89.6%) were treated and discharged from the hospital, 2,100 (5.1%) were transferred to another facility, 2,050 patients (5.0%) died in-hospital, 26 remained in the hospital (0.1%), 108 (0.3%) had unknown disposition. The median length of hospital stay was 1 day. There were 4,034 (9.7%) neurosurgical procedures documented. Patients with combined neurotrauma and general trauma suffered 30 times higher mortality than neurotrauma alone (aOR: 30.4; 95%CI: 20.8-44.2, p<0.0001). **Conclusion** The Syrian War resulted in large volumes of neurotrauma patients. Presumed non-combatants comprised 39.4% of patients who survived to treatment at a facility. Further study is needed on long-term needs of neurotrauma victims of the Syrian war.

## Introduction

Since early 2011, the Syrian Civil War has produced one of the largest humanitarian crises in recent memory. By early 2016 (5 years in to the war) it was estimated that over 470,000 Syrians had been killed<sup>1</sup>. The conflict has produced the largest displacement crisis in the world with over 5.6 million refugees and a further 6.6 million Syrians internally displaced within the country<sup>2</sup>.

The conflict resulted in the collapse of the formal health sector with many hospitals destroyed and health workers killed<sup>3-6</sup>. Throughout the war, both formal and field hospitals were used to care for the injured in non-government, non-Islamic State (NGNI) regions of Syria<sup>7,8</sup>. Such facilities functioned with limited staff and few specialists assisted primarily by medical and nursing trainees. Injured patients presenting to these hospitals received either definitive trauma care, damage control surgery to stabilize them for transfer, or comfort care for those whose injuries were deemed not salvageable. Patients in need of specialty surgery or prolonged inpatient care were transferred to hospitals outside the country (frequently Turkey) due to limited inpatient capacity and the fact that hospitals themselves were routinely targeted as part of warfighting<sup>3,5,6</sup>. Patients requiring rehabilitative services including prosthetics, occupational and physical therapy as a result of their war injuries were referred to a rehabilitation center established in the Turkish border town of Reyhanli.

Our group previously reported on the neurological injuries suffered by patients in the Reyhanli rehabilitation center<sup>9</sup>. Those reports found that among patients with neurotrauma at the Reyhanli rehabilitation center, the majority were males with peripheral nerve injuries, followed by spinal trauma and cerebral trauma patients<sup>9</sup>. These patients however were likely not representative of the total population of neurotrauma patients in the Syrian conflict as these represented only those who survived to definitive treatment and rehabilitation – presumably those with less devastating injuries. Little is known regarding the actual scale and severity of neurological injuries resulting from Syrian conflict. In this study, we present an analysis of 41,143 neurotrauma presentations over 25 months of the Syrian conflict from hospitals in regions outside the control of the Syrian government and outside the control of the so-called Islamic State.

## Methods

An administrative dataset of patient presentations to a network of 95 non-government, non-Islamic State (NGNI) hospitals between July 2013 and July 2015 was obtained from the Union of Medical Care and Relief Organization (UOSSM). The dataset was initially established by UOSSM to quantify services and to rationalize material and salary support to facilities providing trauma care in Syria. Every known such facility was approached for inclusion.

The variables recorded in the original dataset and their parameters were established by the UOSSM hospital committee and included: patient demographics; injury type, location, and mechanism; procedures performed; and patient disposition. Hospitals sent monthly data along with characteristics of facilities to the UOSSM hospital committee and such data was used to assess the overall volume of major cases across facilities. Data were transcribed from handwritten hospital logs into encrypted Microsoft Excel spreadsheets (Microsoft Corporation (2013), Redmond, Washington) and sent for inclusion in a central database running Microsoft SQL Server software (Microsoft Corporation (2012) Redmond, Washington). Data was collected at Aleppo, Damascus, Damascus (Rural), Dar'a, Deir Ezzor, Hama, Homs, Idleb, and Quneitra.

The administrative dataset was de-identified by UOSSM prior to sharing with study investigators for cleaning and analysis. Patient disposition was often left incomplete. A conservative pre-specified rule was applied to missing disposition where any patient that received an operative procedure or had length of stay longer than one day was designated as “admitted”. Further, age was variously recorded as age in years, estimated age in years, age range (as specified by UOSSM hospital committee), and date of birth. In order to normalize “age” for analysis, a new variable was created using the least specific “age range” to categorize all presentations. Mechanisms of injury were taken as recorded in the administrative dataset by the provider treating the patient.

The resultant cleaned dataset was analyzed to identify the epidemiology of neurotrauma presentations, mechanisms of injury resulting in neuro trauma as well as patient disposition. Neurotrauma mortality was calculated, and logistic regression was performed to calculate the odds ratio (OR) associated with

different types of neurotrauma, different injury mechanisms resulting in neurotrauma, as well as with polytrauma involving neurotrauma. An adjusted odds ratio (aOR) for mortality was calculated after adjustment for age, gender, multiple neurotrauma injuries and combined neurotrauma with general trauma.

SPSS 26 version was used for the analysis. Descriptive statistics were calculated using chi-square test, student's t-test and ANOVA.

## Results

Over the study period, 193,618 trauma presentations were made including 41,143 for neurotrauma [31,359 (76.2%) – male; 9,784 (23.8%) – female] (Table 1). Age information was complete for 35,465 (86.2%). The largest single group were young adult males, age 19–30 years (10,113; 24.6%). Elders (> 60 years) (1,187; 2.9%) were the smallest combined group (Table 1). Taken together, presumed non-combatants including females, children under 13 years and the elderly (n = 15,157), represented 42.7% of patients with known age and 39.4% of all presentations.

There were 16,881 (41.0%) presentations for due to blunt injuries (noted as “blunt/crush”); 16,207 (39.4%) presentations due to penetrating injury from flying objects (“shrapnel” in the dataset); 3,272 (8.0%) presentations for penetrating injury from gunshot wounds; and 1,828 (4.4%) penetrating injuries due to cut/stab. Taken together penetrating injuries accounted for 21,307 (51.8%) presentations. These two major categories of penetrating and blunt injuries exclude 527 (1.3%) presentations for “Blast/Explosion.”(Table 1)

There were 4,034 neurosurgical procedures documented including 3,667 cranial procedures, 138 spinal procedures and 229 peripheral nerve procedures.

A total of 36,859 (89.6%) patients were discharged alive from the facility, 2,100 (5.1%) patients were transferred to another facility for further treatment. The median length of hospital stay was 1 day (S.D. 4.2). In-facility mortality rate for patients with neurological injury was 5.0% (Table 1).

Mortality among neurotrauma patients compared to general trauma patients without neurologic injury was highest for CNS trauma (Head aOR 2.9, CI 95 %: 2.54–3.34, p-value < 0.0001; Spine aOR 1.1; CI95%: 1.01–2.06; p-value < 0.001). Patients with peripheral nerve injuries had decreased mortality compared to the general trauma population (aOR 0.3; CI95% 0.23–0.35; p-value < 0.001) (Table 2).

Mortality increased an order of magnitude for patients with combined neurotrauma (neurotrauma with associated non-neurotrauma injuries) compared to patients with neurotrauma alone (aOR 30.4; CI95% 20.8–44.2; p-value < 0.0001)(Table 2). Mortality was highest for high velocity mechanisms of injury [Blast / Explosion aOR 6.0; Penetrating Injury (Shrapnel) aOR 3.7; Penetrating Injury (GSW) aOR 2.8] (Table 2).

## Discussion

This study of 41,143 neurotrauma presentations from 95 Syrian hospitals represents the largest analysis of neurotrauma patients in the Syrian conflict and one of the largest studies of neurotrauma in conflict published to date. The substantial increased aOR for mortality due to neurotrauma alone as well as for neurotrauma combined with other general trauma injuries reflects both the devastating nature of these injuries as well as the documented lack of specialist and critical care capacity in hospitals caring for those injured in the Syrian conflict<sup>8</sup>.

Even using a pessimistic assumption that all males aged 13–60 are combatants, these data show that approximately 40% of neurotrauma victims in this study were civilians. This fact combined with the finding that more than 80% of neurotrauma was sustained because of blunt/crush injuries or penetrating injuries from “shrapnel” (flying ordinance fragments and/or debris) is consistent with the frequently reported use of aerial bombardment and the use of “barrel bombs” in densely populated civilian areas<sup>10, 11</sup>.

Further, it is important to note that the 5% mortality rate reported for neurotrauma patients only represents *in-facility mortality* for those patients who *survived to arrival for treatment*. Injury mechanisms common in the Syrian war including aerial bombardment; crush injuries from building collapse; penetrating injuries from gunshot wounds, ordinance fragments and debris, coupled with the lack of prehospital care to make this group likely only a fraction of those killed due to neurotrauma. Most published reports of neurotrauma from recent conflicts primarily involve military personnel in Iraq and Afghanistan where neurotrauma – specifically traumatic brain injury – has been called the “signature injury” of those conflicts. Mortality is lower in reports from these conflicts (2% – 3%)<sup>4, 12</sup> – even lower for datasets that include mild-, moderate- and non-combat-related TBI. Further, these studies primarily included military personnel equipped with helmets, battle armour, and with access to rapid medical evacuation to military field hospitals where access to neurosurgical interventions may have resulted in improved outcomes. Few published reports demonstrate the impact of neurotrauma on civilians in modern conflicts. A recent very small study of 44 patients with craniocerebral injuries from the Syrian conflict demonstrated a 25% mortality rate<sup>13</sup>.

## Limitations

While representing the largest known study of neurotrauma from the Syrian conflict, our study was subject to several important limitations. First, our study represents a secondary analysis of an administrative dataset. The purpose of the underlying dataset was not primarily clinical. As such, it lacked key clinical variables like the Glasgow Coma Score or the injury severity score that would have allowed for more detailed comparisons to other published reports of war-related neurotrauma. In addition, analyses were constrained by the definitions used in the underlying dataset (e.g. non-standard age ranges and definitions of injury mechanisms). There may be misclassification issues between injury mechanisms where without clear definitions a patient injured in a building collapse from aerial bombardment could in theory be classified as being injured by “crush”, “blast”, or “shrapnel”. While

presumably such misclassifications likely only occurred in a subset of patients, the lack of clinical documentation and retrospective nature of the study preclude investigating this point further.

In addition, the original administrative dataset aimed to quantify the burden of “war trauma patients” on facilities. It is presumed that other non-conflict trauma presentations resulting in neurotrauma continued to occur (e.g. road traffic collisions, falls, others) but are not reported in these data. For that reason, the results presented here must represent an under-estimate of the true number of trauma presentations to these hospitals. Importantly, mortality estimates in these data reflect only *inpatient mortality*. Patients who died pre-hospital, shortly after arrival, or after discharge are missing from these data. Mortality causes and demographic distribution may be skewed by survivor bias with those that survive to hospital presentation and through their initial evaluation having less severe injuries overall. All these factors would serve to underestimate patient presentations and patient acuity.

Another limitation is that the inability to follow up patients after discharge or to track them through different facilities made estimation of functional outcomes impossible in this study. Future work is needed to document the long-term functional outcomes of survivors of neurotrauma from the Syrian war.

Finally, date of discharge was frequently not captured. Few hospitals had significant inpatient capacity. Most patients were released within one day. Even after operative interventions inpatient stays were brief. Routinely, records with missing discharge dates were assigned length of stay of one day in the administrative dataset. Such modifications were made prior to provision of the underlying dataset to the study investigators. As such, there exist an unknown number of records for which the length of stay may be artificially recorded as shorter than the patient’s actual length of hospitalization.

## **In Conclusion**

The Syrian War has resulted in high volumes of neurotrauma. Civilians represented more than 40% of war-related neurotrauma patients. The high energy mechanisms of injury, lack of protective equipment, lack of prehospital transport, and limited capacity for neurosurgical intervention resulted in significant morbidity and mortality. Of those patients who survived to hospital presentation, the presence of neurotrauma along with other comorbid injuries resulted in a 30-fold increase in mortality. Additional work is needed to assess the long-term functional outcomes of neurotrauma from the Syrian War.

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## Declaration of Interests:

The authors would like to state that they have no financial conflicts to disclose. Four of the authors have worked inside Syria as physicians providing direct medical care (MH, HA, AA, MS).

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## Tables

**Table (1)** Baseline Characteristics of Neurotrauma in Syrian Trauma Hospital (July 1, 2013 to July 31, 2015)

	Male		Female		Total	
	n	%	n	%	n	%
Total Patient Volume	31,359	76.2%	9,784	23.80%	41,143	100.0%
<b>CNS Trauma</b>						
Head Trauma	28,489	76.2%	8,921	21.70%	37,410	90.9%
Spine Trauma	1,071	76.1%	336	0.80%	1,407	3.4%
<b>Peripheral Nerve Trauma</b>						
Peripheral Nerve Trauma	2,531	80.8%	602	1.40%	3,133	7.6%
<b>Age Group, years (n, percent)</b>						
0 - 2	1,078	2.6%	547	1.3%	1,625	3.9%
3 - 12	4,539	11.0%	2,212	5.4%	6,751	16.4%
13 - 18	3,746	9.1%	1,025	2.5%	4,771	11.6%
19 - 30	10,113	24.6%	1,935	4.7%	12,048	29.3%
31 - 40	3,534	8.6%	1,122	2.7%	4,656	11.3%
41 - 50	1,919	4.7%	921	2.2%	2,840	6.9%
51 - 60	996	2.4%	591	1.4%	1,587	3.9%
>60	813	2.0%	374	0.9%	1,187	2.9%
Unknown/Missing Age	4,621	11.2%	1,057	2.6%	5,678	13.8%
<b>Injury Mechanism</b>						
Explosion / Blast	442	1.1%	85	0.2%	527	1.3%
Blunt/Crush	11,240	27.3%	5,641	13.7%	16,881	41.0%
Burn	870	2.1%	338	0.8%	1,208	2.9%
Penetrating Injury (GSW)	2,872	7.0%	400	1.0%	3,272	8.0%
Penetrating Injury (Shrapnel)	13,602	33.1%	2,605	6.3%	16,207	39.4%
Penetrating Injury (Stab/Cut)	1,381	3.4%	447	1.1%	1,828	4.4%

Wound NOS	712	1.7%	204	0.5%	916	2.2%
Other / Unknown	240	0.6%	64	0.1%	304	0.7%
<b>Co-morbid Injuries</b>						
Abdomen	456	1.1%	130	0.30%	580	1.4%
Chest	567	1.3%	174	0.40%	741	1.7%
Neck	3,736	9.1%	691	1.70%	4,427	10.8%
Pelvis	129	3.1%	48	0.10%	177	3.2%
Upper Extremity	3,145	7.6%	631	1.50%	3,776	9.1%
Lower Extremity	2,448	5.9%	425	1.00%	2,873	6.9%
<b>Neurosurgical Procedures</b>						
Neurosurgical Procedures	3,285	10.5%	749	7.7%	4,034	9.8%
<b>Length of Stay – median (days)</b>						
Length of Stay – median (days)	1		1		1	
<b>Facility Disposition</b>						
Discharge from Hospital	27,701	88.3%	9,158	93.6%	36,859	89.6%
In Hospital	21	0.1%	5	0.1%	26	0.1%
Transfer to Other Facility	1,809	5.8%	291	3.0%	2,100	5.1%
Death (within hospital)	1,741	5.6%	309	3.2%	2,050	5.0%
Unknown	86	0.3%	22	0.2%	108	0.3%

**Table (2)** Predicting Inpatient Mortality using Logistic Regression.

	OR	(95% CI)	p-value	Adjusted OR	(95%CI)*	p-value
<b>Central Nervous System (CNS) Injuries</b>						
Brain vs General Trauma	3.5	(3.05-4.00)	<0.0001	2.9	(2.54-3.34)	<0.0001
Spine vs General Trauma	1.8	(1.51 - 2.17)	<0.001	1.1	(1.01 - 2.06)	<0.001
Peripheral Nerve vs General Trauma	0.4	(0.31 - 0.45)	<0.001	0.3	(0.23 - 0.35)	<0.001
Neurotrauma w/ General Trauma vs Neurotrauma alone	31.1	(20.8 - 46.5)	<0.0001	30.4	(20.8 - 44.2)	<0.0001
<b>Injury Mechanism - Neurotrauma</b>						
Blast / Explosion☒	7.1	(5.63-8.95)	<0.0001	6.0	(4.76-7.62)	<0.0001
Penetrating Injury (GSW)	4.5	(3.88-5.19)	<0.0001	2.8	(2.48-3.26)	<0.0001
Penetrating Injury (Shrapnel)☒	4.0	(3.60-4.41)	<0.0001	3.7	(3.29-4.05)	<0.0001
Blunt / Crush	1.9	(1.34 - 3.67)	<0.0001	1.5	(1.18 - 3.45)	<0.0001

\*adjusted for age, sex, co-morbid injuries (general trauma), and multiple neurotrauma.

☒ "Blast" denotes injuries from explosions not only blast wave.

☒ "Shrapnel" indicates penetrating injuries from flying objects.

CNS: Central Nervous System, CI: Confidence Interval, OR: Odds Ratio.