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# Cerebrospinal fluid leak after combat penetrating gunshot wound to the head

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## ABSTRACT

**Introduction:** Cerebrospinal fluid leak is a common complication after head gunshot wounds, which commonly leads to infectious complications. This complication may prolong hospital staying and prevents soldiers from return to operation theatre as soon as possible.

The purpose of this article is to determine the impact of the quality of primary surgical debridement and other factors that influenced the presence of cerebrospinal fluid leak in the military staff with gunshot wounds to the head.

**Materials and methods:** This is a retrospective study of 20 military cases with cerebrospinal fluid leak, which were admitted during the combat actions in Eastern Ukraine in the period from March 2014 to the end of December 2017. Information was collected on demographics, evacuation assistance, type of injury and infectious complications. R commander version 4.2.0 (<http://www.r-project.org>) was used for statistical analysis. Statistical significance was defined as  $p < 0.05$ .

**Results:** Cerebrospinal fluid fistulas were detected in 20 cases (25,31%). Factors affecting the rate of leaks are number of re-operations ( $p < 0.001$ ), multiple sites of injury ( $p = 0.002$ ), ventricular injury ( $p < 0.005$ ). CSF leakage significantly lengthens hospitalization time.

**Conclusions:** CSF fistula influenced significantly rate of infection complication. Reoperation should follow initial surgery in cases of CSF leak development. To avoid development of cerebrospinal fluid fistulas, the operation should be performed by neurosurgeons in specialized department.

## INTRODUCTION

Cerebrospinal fluid leak (CSFL) is a common complication of gunshot wounds to the head, which in many cases lead to infectious complications [3, 8]. Such patients should receive high-quality and comprehensive medical care, but not all front-line hospitals have neurosurgeons and trained personnel capable of correctly diagnosing and determining tactics. In the conditions of war presence of CSFL is often ignored, which can have even fatal consequences [19]. The effectiveness of medical care that will be provided in the next stages, and how quickly the injured personnel will return to combat missions, depends on the correct diagnosis and the chosen tactics.

The purpose of this article is to determine the impact of the quality of primary surgical debridement and other factors that influenced the

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**Keywords**  
CSF fistula,  
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gunshot wound,  
surgical debridement

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presence of cerebrospinal fluid leak in the military personnel with gunshot wounds to the head.

## MATERIALS AND METHODS

The study is based on medical records of patients that were treated at National Military Medical Clinical Centre "Main Military Clinical Hospital" (NATO Role IV) from 1st of May 2014 until 31st of December 2017. All patients were servicemen who were injured during military action in the Eastern Ukraine.

Medical information was collected from patient records and include demographics, clinical examination findings during evacuation and at the treating hospitals, laboratory results, computed tomography scans. Surgical and medical interventions after injury also were collected.

Statistical analysis was performed using R version 4.1.2 (<http://www.r-project.org>). In univariable analysis, variables were compared between groups by Fisher's exact test for categorical variables and the Wilcoxon signed-rank test for numerical variables. Statistical significance was defined as  $p < 0.05$ . Local ethics committee approval was obtained before the study.

## RESULTS

Among 79 patients with penetrating head injury, we found 20 cases (25,31%) with CSFL who were treated in our department and participated in military conflict in Eastern Ukraine. The average age of the wounded was  $28.5 \pm 8,69$  years (min 19.9, max 54.5), all injured were males. The average number of days in the hospital was  $68.4 \pm 40,89$  (min 6, max 157). The average number of days in intensive care unit is  $15.2 \pm 24,87$  (min. 2, max. 88). The type of CSF leak was defined as one nasal, one orbital, two cases of otorrhea and 16 wound leaks.

The most of wounded on battlefield received assistance in the form of self-help or mutual aid, a sterile bandage was applied to stop the bleeding, painkillers were administered. Antibiotics were not administered in all cases, but no exact details could be extracted from medical records.

Consciousness upon admission to the hospital was assessed using the Glasgow Coma Scale (GCS) and presented in Table 1. The neurological status was evaluated in all patients, pyramidal signs were detected in 14 wounded which correlated with traumatic origin of the injury.

**Table 1.** GCS score on admission to main hospital

GCS	Number
15 - 14	11
13-12	4
10	1
6	2
4	1
Not evaluated	1

The vast majority, 13 observations, were injured with missile fragments, five observations injured with bullets and two patients were injured due to the blast wave. Type of injury included: penetrating (11), perforating (4), ricochet (2), tangential (1), and blast wave related injuries (2). Injuries reached or passed through the ventricular system were found in nine cases.

Isolated craniocerebral trauma was diagnosed in 10 cases, in five cases injuries of more than two anatomical areas were found, average Injury Severity Score (ISS) was  $28.8 \pm 7,42$  (min 18, max 49).

All patients underwent head computed tomography (CT) on admission. Epidural hematomas were visualized in two cases, subdural hematomas in seven, intracerebral hemorrhage in eight, depressed fractures in three, and intraventricular hemorrhages were found in five cases.

According to CT, bone fragments were detected in 16 cases, in 10 cases, bone fragments remained unremoved after the first surgery during previous stage. Metal fragments were revealed in 14 patients, and in 6 patients these fragments were removed at the previous stage.

All victims underwent surgery. Reoperation was performed in 16 cases. The terms of reoperation were different (Table 2).

**Table 2.** Patients which were reoperated because of different causes and types of infection complications

Id. number	AIS	Type of complication	Type of CSFL	Number of reoperations
12383	25	meningitis	wound	2
12691	33	-	wound	2
12823	25	meningoencephalitis	wound	1
15287	29	-	rhinorrhea	2
20064	35	-	wound	1

9126	26	abscess, ventriculitis	wound	2
21745	25	encephalitis	wound	1
24244	25	abscess, ventriculitis	wound	2
14020	34	-	rhinorrhoea	1
28726	26	meningoencephalitis	wound	2
32057	25	meningitis	wound, otorrhea	1
13255	25	meningitis	wound	1
21464	26	abscess, ventriculitis, empyema	wound	1
20429	26	meningitis	wound	2
161	26	meningoencephalitis	wound	3
24493	45	meningitis	rhinorrhoea	2

Fourteen patients (70%) developed infectious complications (Table 2). Diagnosis of infectious complications was based on the following data: clinical symptoms, hyperthermia, redness around the wound, leukocytosis, neutrophilic pleocytosis in the CSF, positive meningeal signs, and CT data. In 9 cases the culture was sent from the wound, and in 3 of them *Pseudomonas aeruginosa* was detected.

Two patients with otorrhea were managed conservatively with dehydration and antibiotic therapy. One of them was also diagnosed with purulent otitis. The otorrhea spontaneously disappeared in these two patients on the 5th and 7th posttraumatic day respectively. One patient with nasal CSF leak was also treated conservatively. A patient with transorbital CSF leak underwent reoperation by multidisciplinary team with the reconstruction of the anterior cranial fossa.

Treatment outcomes were assessed using Glasgow Outcome Score (GOS) and are shown in Table 3.

**Table 3.** Outcomes in patients with CSF fistula

GOS1	1
GOS2	1
GOS3	11
GOS4	6
GOS5	1

**Table 4.** Analysis of factors that influence rate of infection CSF fistulas

	Yes CSF fistula N=20	No CSF fistula N=59	P value
Year of admission			
2014	9 (45%)	19 (32.2%)	0.502
2015	7 (35%)	18 (30.5%)	
2016	3 (15%)	12 (20.3%)	
2017	1 (5%)	10 (16.9%)	
GCS on admission to main hospital <sup>1</sup>			0.294
GCS 3-5	1 (5.3%)	3 (5.2%)	
GCS 6-12	5 (26.3%)	7 (12.1%)	
GCS 13-15	13 (68.4%)	48 (82.8%)	
Type of penetrating agent			0.542
Bullet	5 (25%)	11 (18.6%)	
Missile	13 (65%)	45 (76.3%)	
Blast wave	2 (10%)	3 (5.8%)	
Multiple site of injury	9 (45%)	7 (11.9%)	0.003
ISS on admission	26 (25-30)	25(25-31)	0.357
Ventricular injury	9 (45%)	9 (15.3%)	0.011
Repeated surgeries	16 (80%)	14 (23.7%)	<0.001

## DISCUSSION

Based on the literature data, CSFL varies from 4.75% to 25.6% [6; 7]. The frequency of CSFL in our study was 25.31%. This is most likely due to the fact that the evacuation and medical care system was not well established in the early stages of the war. Wound CSF leak, otorrhea and rhinorrhoea negatively affect treatment outcomes [2; 3; 8; 11; 15]. In our study it was not a significant factor ( $p=0.196$ ) but we found significant correlation between presents of CSF leak and the number of hospitalization days ( $p=0.007$ ).

The most common type of CSF leak was CSF leak from the wound, less commonly diagnosed were CSF otorrhea and rhinorrhoea. Some authors also distinguish transorbital CSF leak [2; 8]. In our series we also had one case.

Some authors reckon that there is a direct relationship between the patient's condition on admission and the development of CSF leak [18]. They state that a lower GCS score has an influence on the rate of CSF fistulas. We could not find such a relationship, likely due to lack of information about GCS score on admission at the third and second

echelon, where they mainly hospitalized from combat theatre.

In nine patients canal passed through or reached the ventricular system, and the postoperative clinical course after the first surgery was accompanied by wound CSFL. Our and literature data [2; 3] show that injury to the ventricular system contributes significantly to the risks of CSF leak ( $p = 0.01$ ).

Early detection of CSFL is crucial to prevent the possible development of meningitis or abscess [16]. In 20 wounded with CSFL, the number of infection complications reached 70% (14 patients), its twice as many as in the group without CSF leak, and this is definitely influence rate of infection complications (IC) in wounded cohort ( $p = 0.002$ ).

The most common cause of wound CSF leak is misinterpretation during primary surgical examination (PSE) of the wound and the impossibility of transferring an open penetrating wound into a closed one. If, after PSE, there is CSF leak from the wound, then preference is given to early reoperations before the development of infectious complications. Same was also recommended by some authors [11].

Neurosurgical treatment should be performed in specialized neurosurgical departments, after a precise examination of the patient, assessment of the general and neurological conditions and nature of the wound. These measures work as a prevention of CSF leak and IC, with chances to reduce mortality [3; 10; 11; 17]. High level of wound CSF leak in our study in the early period of hostilities may be due to the fact that interventions were mainly carried out in frontline hospitals, where working conditions are quite tense, complicated by massive admissions, which usually affects the quality of care [9]. Evidence of this is the large number of repeated surgeries ( $p < 0.001$ ) associated with the presence of wound CSF leak, which is comparable to other reports [2; 13].

Watertight closure and dural reconstruction is mandatory during surgery [8, 19]. In all our surgeries, we performed reconstruction with the fascia lata. Though we agree that other options like using the pericranium and temporal fascia [2 - 4; 14] or an allograft [7; 8], and artificial dura [20] are also valuable. In addition, plastic of meningea prevents the risk of epilepsy and facilitate cranioplasty in the future, prevents brain prolapse in the wound [4]. All reoperations were performed using magnifying

techniques, which in our opinion improves the results and allows to better sewing the defects [12].

In the presence of CSF leak our strategy includes multiple lumbar punctures and insertion of continuous lumbar drain. Thirty-degree head elevation, antibiotic prophylaxis, control of hydration, electrolytes are important. Similar approach was reported by other authors [2; 6-9; 13].

One case of otorrhea was diagnosed on the first day after injury and closed spontaneously within 72 hours after injury. Two wounded, who were diagnosed with otorrhea, received medical treatment (moderate dehydration therapy). In other series where the conservative approach and continuous lumbar drain were ineffective, patients underwent surgery [14]. Described cases with manifestation of otorrhea within 48 hours of injury [11], also described cases with later manifestations of otorrhea after craniofacial injury [21].

## CONCLUSION

CSF leaks are the risk factor of infectious complications after head gunshot wounds. The presence of CSF leaks prolongs hospitalization time.

Primary surgical treatment of penetrating gunshot wounds to the head is the main element in the prevention of CSF leak and infectious complications. It is important to transfer a gunshot wound from a penetrating to a closed non-penetrating; it is the first step to avoid CSFL. Primary surgical wound exploration better to perform in specialized neurosurgery departments, after a precise examination of patients using not only X-ray, but also CT.

## Limitations

This study has several limitations. Firstly, some of the data were missing due to its retrospective design. In addition, the relatively small sample size did not allow us to analyze the contribution to CSF leak of other important factors.

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