https://doi.org/10.31288/oftalmolzh202452126

# Psychological and neuropsychological status of patients with both blast-related ocular injury and mild traumatic brain injury late after the traumatic event

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***Purpose:*** *To determine the psychological and neuropsychological status of patients with both blast-related ocular injury and mild traumatic brain injury (TBI) late after the traumatic event.*

***Material and Methods:*** *Thirty patients with blast-related ocular injury, reduced visual function and comorbid mild TBI were included in the study. The following methods of psychological and neuropsychological assessment were used: formalized interview; Suicidality, Post-traumatic Stress Disorder (PTSD), Alcohol Dependence, and Drug Dependence scales of the Mini-International Neuropsychiatric Interview (MINI); Raven's Progressive Matrix scale; Personal and Social Performance (PSP) scale; PROMIS® Pain-Interference scale; Hospital Anxiety and Depression Scale (HADS); Mazes subtest of the Neuropsychological Assessment Battery (NAB); and Repeatable Battery for the Assessment of Neuropsychological Status (RBANS).*

***Results:*** *The following significant correlations were found: PSP functioning and support from the family ($r = 0.533$, $p = 0.002$); total RBANS score and Mazes subtest score ($r = 0.466$, $p = 0.009$); total RBANS score and self-reported stress score (negative correlation, $r = -0.492$, $p = 0.006$); HADS depression and self-reported stress score ($r = 0.646$, $p = 0.000114$); PROMIS pain scale and PTSD scale ($r = 0.482$, $p = 0.007$). No association was found between the number of mild TBI events experienced and neuropsychological and psychological measurements.*

***Conclusion:*** *Blast-related mild TBI concomitant with ocular injury has a substantial and long-term impact on casualty's cognitive and psychological functions. In such patients, the most prominent cognitive deficits occur in the domain of executive function (including cognitive control and planning and problem-solving skills). In the presence of reduced visual function, these deficits have a substantial impact on total cognitive scores, scores of other psychic functions (namely, attention and memory) and significantly affect the patient's capacity for independent functioning.*

**Keywords:**
blast-related ocular injury, mild traumatic brain injury, neuropsychology, clinical psychology, post-traumatic stress disorder

## Introduction

Current military conflicts have resulted in significantly increased rates of blast-related mild traumatic brain injury (TBI). This type of injury is especially insidious since it is often accompanied not only by physical damage but also by a complex of psychological and cognitive abnormalities that may significantly worsen the process of rehabilitation. Studies on military conflict casualties have demonstrated that numerous factors, both related and unrelated directly to the injury, may impact the speed and quality of recovery after mild TBI. These factors include demographic, personality-related psychological, and social and cultural factors, which may be of crucial importance, especially at the late phase of recovery.

In mild blast-induced TBI, brain damage may persist significantly longer than in impact-induced TBI [1] and may be accompanied by cognitive and psychosocial disorders. In a systematic review of characteristics and impact of US military blast-related mild TBI, the most frequently related comorbidities were post-traumatic stress disorder (PTSD), depression, anxiety, sleep disorders, attention disorders, and cognitive disorders [2]. Therefore, the sequelae of mild blast-related TBI may affect the patient's capacity for rehabilitation, adaptation and reintegration into the social and professional environment. Findings of studies suggest that additional screening and symptomatic treatment for blast-exposed patients may be warranted [1].

Comorbidities such as ocular injuries significantly affect the patient's status [3, 4]. Traumatic ocular injuries, especially those secondary to blast injuries, frequently cause considerable stress in patients. This type of trauma not only affects the integrity of the visual system, but also has serious psychological sequelae that can worsen the

recovery process. Patients with blast-related traumatic ocular injury and concomitant mild TBI are at high risk for developing PTSD and depression a few months after a traumatic event, even in the absence of evidence of serious cognitive or neurological disorders [5, 6].

Recovery is particularly problematic in patients that have undergone enucleation or evisceration of the globe, when they are under great emotional pressure associated with the loss of the body part and the need to adapt to new realities of their life. Despite successful prosthetic restoration, many individuals experience fear of negative social evaluation and difficulties in social integration [7]. To the best of our knowledge, there is lack of studies reporting on the psychological and neuropsychological status of patients with both blast-induced ocular injury and mild TBI late after the traumatic event. There is, however, a need in comprehensive studies for the status of patients with both blast-related TBI and ocular injury, which is essential for predicting the course and developing effective treatment and rehabilitation techniques for these conditions [8, 9].

**The purpose** of this study was to determine the psychological and neuropsychological status of patients with both blast-related ocular injury and mild TBI late after the traumatic event.

### Material and Methods

Clinical observations were conducted in SI "The Filatov Institute of Eye Diseases and Tissue Therapy of the National Academy of Medical Sciences of Ukraine", within the framework of a Department of Post-traumatic Eye Pathology-led research project entitled "To Determine Risk Factors Affecting the Functional Prognosis of Restorative and Reconstructive Surgery for Blast-Induced Ocular Injury" (State Registration No. 0123U101170), and a Laboratory of Educational Psychology (H.S. Kostiuk Institute of Psychology)-led research project entitled "Potential of Genetic Psychology in the Study of the Interaction of Subjects in the Educational Space " (State Registration No. 0121U107603). The study was conducted in accordance with the standards set forth in the Helsinki Declaration and was approved by the Bioethics Committee of SI "The Filatov Institute of Eye Diseases and Tissue Therapy of the National Academy of Medical Sciences of Ukraine" (Committee Minutes No. 3 dated April 14, 2022). Informed consent was obtained from all study subjects.

Thirty patients with blast-related ocular injury, reduced visual function and comorbid mild TBI/concussion were included in the study. All patients were examined by a neuropathologist and diagnosed with mild TBI as per the VA/DoD Clinical Practice Guideline for Management of Concussion/Mild Traumatic Brain Injury [10]. They did not require special neurological treatment when they were in-patients of the Filatov institute. These patients underwent psychological and neuropsychological assessment within the framework of routine medical care after reconstructive surgery for blast-related ocular injury, not earlier than 3 months after the traumatic event.

The examination within the framework of this study was conducted by a clinical psychologist/ neuropsychologist.

General ophthalmological examination was performed in all patients. Of the total patients, 65% were diagnosed with Zone 1 or Zone 2 open globe injury, and the rest, with closed globe injury, as per the Birmingham Eye Trauma Terminology [11]. In addition, approximately 30% of lesions were bilateral. Open globe injuries were mostly penetrating corneoscleral injuries with iris and lens lesions. No significant difference in the rate of retinal detachment was found between the eyes with open globe injuries and the eyes with closed globe injuries. All wounded patients received reconstructive microsurgical treatment.

The psychological and neuropsychological assessment was performed postoperatively after reconstructive microsurgical treatment for blast-related ocular injury. The time since injury of mild TBI was 3 months or longer; this corresponds to the late TBI period according to the classification by the International Brain Injury Association.

The inclusion criteria were age of 22-45 years, the presence of blast-related ocular injury and concomitant blast-related mild TBI, visual acuity of at least 0.3 (Snellen visual acuity, 6/20), and average or above-average intelligence as measured by scores on the Raven's Progressive Matrices.

Exclusion criteria were (1) a high risk of suicidal behavior; (2) personality disorders or traits that may affect treatment compliance or determine an increased risk of impulsive, uncooperative, sexually uninhibited and/or aggressive behavior; (3) common exhibition of marked abnormalities in consciousness, speech and/or behavior; (4) acute psychotic symptoms; (5) marked side effects of treatment; (6) the presence of other factors seriously impeding the establishment and maintenance of long-term productive contact, or (7) the presence of the neurological condition preventing participation in the study.

The following methods were used:

(1) Formalized interview

(2) Suicidality, Post-traumatic Stress Disorder, Alcohol Dependence, Drug Dependence scales of the Mini-International Neuropsychiatric Interview (MINI) [12]

(3) Raven's Progressive Matrix scale [13] for differentiation among subjects based on their Raven's test scores as measures of general intelligence

(4) Personal and Social Performance Scale (PSP) [14]

(5) The 8-item pain interference scale (8a) included in the PROMIS profile [15]

(6) Hospital Anxiety and Depression Scale (HADS) [16, 17]

(7) Mazes subtest in the Executive Functions module of the Neuropsychological Assessment Battery (NAB) [13, 18], and

(8) Repeatable Battery for the Assessment of Neuropsychological Status (RBANS with alternative forms) to assess cognitive impairment in Immediate Memory, Delayed Memory, Attention, Language, and Visuospatial/Constructional domains [13, 19].

The major methods employed in this study had been included in the list of valid methods of psychological diagnosis that can be used for psychological diagnosis and assessment of the quality of psychological care [13].

Neuropsychological and Psychological Study Design. The following methods were used to determine whether patients conform to inclusion/exclusion criteria: formalized interview; Suicidality, Post-traumatic Stress Disorder, Alcohol Dependence, and Drug Dependence scales of the MINI; and Raven's Progressive Matrix scale for differentiation among subjects based on their Raven's test scores as measures of general intelligence.

In the next phase of the study, we assessed psychoemotional status, neuropsychological status, and performance of subjects to identify potential psychological and neuropsychological traits in patients with blast-induced ocular injury and mild TBI late after the traumatic event.

First, the formalized interview was applied to obtain the information on the self-assessment of stress and social support as well as biographic data. The PSP scale was used to assess personal and social performance.

The HADS was employed to assess anxiety and depression in patients. Medical records and the MINI PTSD module were used to determine whether a patient had PTSD. In addition, chronic pain was assessed as a possible contributor to increased anxiety and depression.

The RBANS (with alternative forms) was used to assess cognitive functions in Immediate Memory, Delayed Memory, Attention, Language, and Visuospatial/ Constructional domains.

Subjects were administered the NAB Mazes subtest in the NAB Executive Functions module to evaluate their planning and decision-making abilities.

Descriptive and variance statistical analyses were employed. Samples were checked for normality. Non-parametric tests (like Spearman rank correlation) were performed because some variables were not normally distributed. Resultant data are presented as mean (standard deviation (SD)). The level of significance was set at $P < 0.05$.

## Results

The clinical assessment with the MINI enabled checking the sample for exclusion criteria and demonstrated the absence of a high risk of suicidal behavior and no alcohol dependence or other conditions preventing participation in the study. The mean RPM score was 93 ± 7, which conformed to the inclusion criterion regarding intelligence.

The formalized interview demonstrated that all subjects were males. Of the total study patients, 5 (17%) were aged 20 to 30 years, 17 (57%), 30 to 40 years, and 8 (26%), 40 to 45 years. Fifty percent of patients were married. In addition, of the total subjects, 8 (26%) reported no support, 7 (23%), inadequate support, and 15 (51%), adequate support from the family.

Twenty-four subjects (80%) were involved in active combat. Thirteen participants (44%) had been exposed to a single blast event, 8 (38%) reported two blast exposures, and 10 (33%) reported multiple blast exposures (range 3–6) causing mild TBI.

Subjects self-assessed their current stress levels. Twenty-five subjects (83%) reported no or mild stress, and 5 (17%) rated their stress as 4 to 7 on a scale of 1 to 10.

Pain was assessed with the PROMIS Pain Interference scale, and 93.3%, 3.3% and 3.3% of patients reported no chronic pain, moderate chronic pain and marked chronic pain, respectively.

All subjects were found to have difficulties in domains of functioning. The functional impairment was rated as marked (a score of 10 to 19 on a scale of 1 to 24) in 93.4%, and moderate in 6.6% of subjects. Marked functional impairment was primarily manifested by aggressive behavior, hyperexcitability, difficulties with self-care, low social functioning, and loss of communication with the family. Moderate functional impairment was related mostly to low socially useful activities.

HADS and MINI PTSD module were used to assess the emotional status of study subjects, and subclinical and clinical depressive disorders and subclinical anxiety disorders were found in these subjects (Table 1).

Only 30% of subjects exhibited an adequate level of executive functioning whereas 43% exhibited markedly decreased level of executive functioning (Table 2). Mean Mazes subtest score was 15.33 ± 7.517. Decision-making and planning were the primarily altered executive functions.

Patients with both blast-related TBI and ocular injury were administered the RBANS (with alternative forms) to assess cognitive impairment. The mean total RBANS

**Table 1.** Presence and severity of anxiety and depression in patients with both blast-related ocular injury and mild traumatic brain injury (expressed as the number and percentage of patients)

| HADS subscale | No | Subclinical | Clinical |
|---|---|---|---|
| Anxiety | 26 (87%) | 4 (13%) | 0 |
| Depression | 23 (77%) | 3 (10%) | 4 (13%) |

Note: HADS, Hospital Anxiety and Depression Scale

**Table 2. Executive function assessment in patients with both blast-related ocular injury and mild traumatic brain injury**

| Range of scores for the Mazes subtest in the NAB Executive Functions Module (total score range, 0-26) | Number of patients (percentage) |
|---|---|
| 22-26 | 9 (30%) |
| 20-12 | 8 (27%) |
| 0-11 | 13 (43%) |

Note: NAB, Neuropsychological Assessment Battery

score was 77 ± 10.6, which was 14.4% lower than the age-adjusted norm. Only 3 subjects had a total RBANS score larger than the lower limit of the age-adjusted normal range. The mean total RBANS score was lower than the age-adjusted norm, i.e., 27 subjects (90%) had moderate or marked cognitive impairment (Table 3).

In the late period after the traumatic event, the mean scores for the domains of Immediate Memory (66 ± 12.3), Attention (81.1 ± 16.4) and Delayed Memory (71.6 ± 17.4) in patients with blast-induced ocular injury and mild TBI were lower than the age-adjusted norm (90-120) (Figure 1).

Finally, correlation analysis was performed to identify potential relationships between the scales of different tests for neuropsychological and psychological measurements and demographic characteristics. The following significant correlations were found: PSP functioning and support from the family ($r = 0.533$, $p = 0.002$); total RBANS score and Mazes subtest score ($r = 0.466$, $p = 0.009$); total RBANS score and self-reported stress score (negative correlation, $r = -0.492$, $p = 0.006$); HADS depression and self-reported stress score ($r = 0.646$, $p = 0.000114$); PROMIS pain scale and PTSD ($r = 0.482$, $p = 0.007$). All other pairwise comparisons showed no significant correlation ($p > 0.05$). In addition, no association was found between the number of mild TBI events experienced and neuropsychological and psychological measurements.

## Discussion

The results of this study highlight such an important issue as the cognitive and psychological sequelae of blast-related injury. Military conflicts like the war in Ukraine result in increased rates of specific injuries, including blast-related TBI and blast-related ocular injuries. This consideration is, in particular, relevant for the late period after the traumatic event, when the physical sequelae may be less pronounced, but cognitive and psychological sequelae continue affecting the patient's quality of life.

Studies on veterans of the wars in Iraq and Afghanistan have found that cognitive impairment gradually disappeared, whereas psychological disorders like depression, anxiety and PTSD persisted for long periods in patients with combat-related mild TBI [20]. These findings are in contrast with our findings, in which 86.7% of subjects continued showing low cognitive function late after the traumatic event. This indicates that cognitive

**Table 3.** Distribution of patients with both blast-related ocular injury and mild traumatic brain injury on the basis of deficit in cognitive function (individual total RBANS scores)

| Total RBANS score | Number of patients (percentage) |
|---|---|
| >90 (age-adjusted norm) | 3 (10%) |
| 66-90 (moderate deficit in cognitive function) | 23 (76.7%) |
| <65 (marked deficit in cognitive function) | 4 (13.3%) |

Note: RBANS, Repeatable Battery for the Assessment of Neuropsychological Status

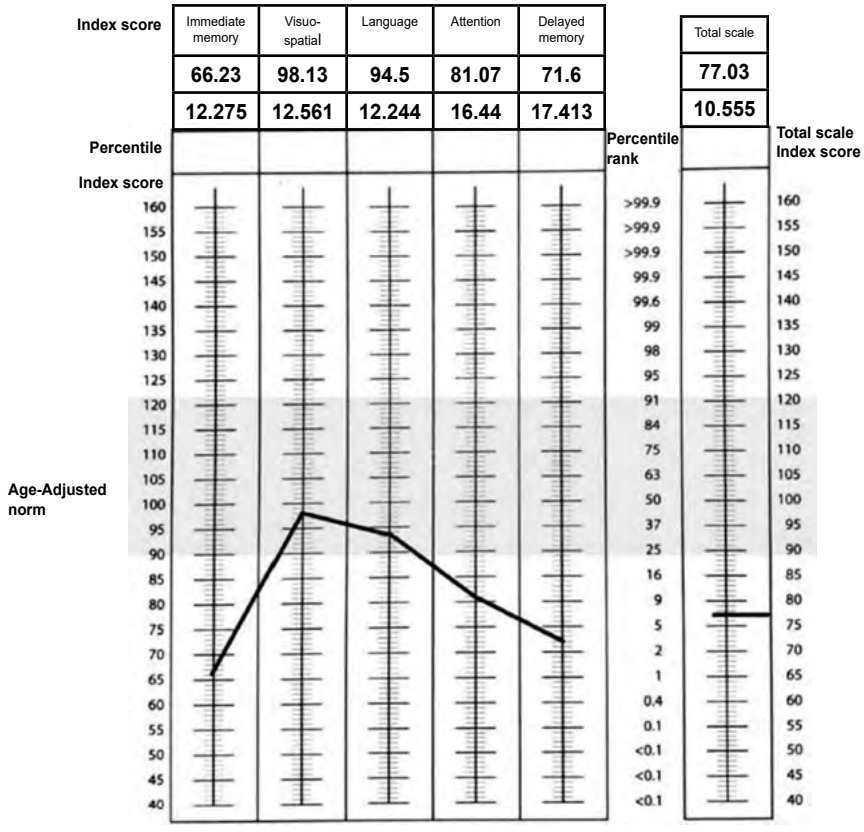


**Fig. 1.** Results of the assessment of cognitive deficit using the Repeatable Battery for the Assessment of Neuropsychological Status (RBANS with alternative forms) in patients with both blast-related ocular injury and mild traumatic brain injury. Scores are presented as mean and standard deviation. The age-adjusted norm for the score is larger than 90, and the range presented is 40 to 160.

impairments may be not just short-term manifestations, but the long-term sequelae of blast-related ocular injury concomitant with mild TBI which significantly affect the patient's life. It is noteworthy that low executive functions like cognitive control and planning and problem-solving skills are the most prominent cognitive deficits in patients with blast-related ocular injury. These executive function abnormalities significantly affect total cognitive scores, scores of other functions (e.g., attention and memory) as well as the capacity for independent functioning. This fact, along with post-injury visual loss also indicates the need for the follow-up in the course of treatment and rehabilitation, which should be taken into consideration.

Issues of long-term cognitive dysfunction secondary to such combination injuries have been insufficiently studied previously and need further research.

We found psychological disorders to be also common in casualties, with anxiety, depression and PTSD noted in patients. This is in agreement with findings of others, which demonstrate high psychological deficit in casualties with blast-related injuries [21]. Therefore, a comprehensive approach to the rehabilitation of such patients is required, which should include not only physical recovery, but also providing support for psychosocial needs. Providing diagnosis and treatment of cognitive impairment should be an essential part of the rehabilitation process. This underscores the need for thorough research on the patient's cognitive domains, especially late after the traumatic event.

Given a significant impact of cognitive impairment on everyday activities and adaptation of patients, measures for improvement in cognitive functions (neuropsychological rehabilitation) should be included in the rehabilitation plan. This will be helpful for improving functional limitations and will contribute to social adaptation and better quality of life in patients with blast-related ocular injury concomitant with mild TBI.

Particular attention should be given to the support from the patient's family. Because the family plays a key role in the process of patient's recovery and reintegration into society after injury, psychological follow-up and teaching cooperative skills should be an important part of the rehabilitation process.

In addition, psychological support is required at all stages of care in order to reduce stress and the risk of psychological disorders like PTSD. This includes not only psychological counseling but also teaching self-control skills that may help patients cope with stress and prevent psychoemotional problems.

Given the results obtained, the topic requires further research. It is especially important to investigate the long-term cognitive and psychical sequelae of blast injury for better understanding of the mechanisms of long-term cognitive and psychological deficits, developing effective techniques for their diagnosis and treatment, and assessing the impact of social and demographic factors on the recovery process.

The cognitive deficits detected in our patients justify the need for a revision of the approaches for the diagnosis and treatment of combination injuries to both the eye and the brain, with a focus on the neuropsychological rehabilitation which should include comprehensive examination and rehabilitation of the cognitive functions (restorative training).

Psychological support should include the patient's family, which plays a key role in the process of patient's adaptation and reintegration into society after injury. Provision of comprehensive psychological care, psychological counseling, teaching self-control skills and follow-up at all stages of treatment and rehabilitation enable coping with stress and are of crucial importance for reducing the risk of the development of psychological disorders.

## Conclusion

Blast-related mild TBI concomitant with ocular injury have a substantial and long-term impact on casualty's cognitive and psychological functions. In patients with blast-related mild TBI concomitant with ocular injury, the most prominent cognitive deficits occur in the domain of executive function (including cognitive control and planning and problem-solving skills). In the presence of reduced visual function, these deficits have a substantial impact on total cognitive scores, scores of other psychic functions (namely, attention and memory) and significantly affect the patient's capacity for independent functioning.

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## Disclosures

*Received: 15.07.2024*

*Accepted: 17.10.2024*

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***Author contributions:*** *N.B.: conception, design, and research; data analysis and interpretation; drafting the manuscript. Author B.L.: conception, design, study design; data analysis and interpretation. V.U.: conception, study design; data analysis and interpretation; drafting the manuscript. Author N.U.: conception, design, and research; analysis and interpretation of data; revision of manuscript. All authors have read and approved the final version of the manuscript.*

***Funding:*** *The article is a part of the research work on the topic "Determination of risk factors affecting the functional prognosis of restorative and reconstructive operations for blast injuries of the visual organ", state registration number 0123U101170*

***Conflicts of interest:*** *The authors declare that they have no conflicts of interest that could influence their opinions on the subject matter or materials described and discussed in this manuscript.*

***Disclaimer:*** *The views expressed in this article are their own and not the official position of the institution.*

***Ethics statement:*** *This work was conducted with human subjects. This study was approved by the local bioethics committee of the State Institution "Filatov Institute of Eye Diseases and Tissue Therapy of the National Academy of Medical Sciences of Ukraine", protocol No. 3 of 04/14/2022. All patients gave informed consent to participate in the study. The study was conducted in accordance with the Declaration of Helsinki. Animals were not included in this study.*

***Data availability statement:*** *Data obtained during and/or analyzed during this study can be obtained from the corresponding author upon reasonable request.*

***Abbreviations:*** *HADS, Hospital Anxiety and Depression Scale; MINI, Mini-International Neuropsychiatric Interview; NAB, neuropsychological assessment battery; PROMIS, Patient-Reported Outcomes Measurement Information System; PSP, Personal and Social Performance; PTSD, post-traumatic stress disorder; RBANS, Repeatable Battery for the Assessment of Neuropsychological Status; TBI, traumatic brain injury*