ISSN 0030-5987. Orthopaedics, traumatology and prosthetics. 2025. No 2

УДК 616.747+616.717.1+616.727.1]-001.45-089(045)

DOI: http://dx.doi.org/10.15674/0030-59872025217-23

Predictor scale of upper extremity function recovery in military trauma of the upper arm (offer to use)

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Objective. To determine the prognostic value of the extent of damage in military trauma to the upper arm for surgical intervention to improve the results of restoring upper limb function. Methods. A retrospective analysis of 30 cases of military trauma of the upper arm in combatants of the Armed Forces of Ukraine was conducted from the stage of admission to our hospital for treatment until 4 months after surgery. Functional outcomes were assessed using the Oxford Shoulder Score (OSS) scale 4 months after surgery. A previously developed scale was used to predict the recovery of upper limb function after military trauma of the upper arm to predict the consequences of surgery. Results. All 30 patients had a gunshot injury to the upper arm as a result of a shrapnel or bullet wound received during combat missions in the war on the territory of Ukraine. All 30 combatants received qualified medical care, underwent staged surgical interventions and a course of rehabilitation recovery. Based on the data of a retrospective analysis of patients, the correlation of rehabilitation results according to the OSS scale and the results of the assessment according to the scale-predictor of recovery of upper limb function in case of gunshot injury to the upper arm is traced. Conclusions. The results obtained after the assessment using the predictor scale serve as an aid in deciding on the feasibility and scope of surgical intervention. The decisive factor is the professionalism of the doctor and the patient's willingness to take risks to restore limb function in severe injuries of the upper arm in a large scope of trauma.

Мета. Визначити прогностичне значення обсягу ушкоджень у разі вогнепальної травми надпліччя для проведення хірургічного втручання з метою покращення результатів відновлення функції верхньої кінцівки. Методи. Виконано ретроспективний аналіз 30 випадків вогнепального ураження надпліччя військовослужбовців ЗСУ починаючи з госпіталізації та через 4 міс. після операції. Оцінювання функціональних результатів проводили за шкалою Oxford Shoulder Score (OSS) через 4 міс. після хірургічного втручання. Використовували попередньо розроблену шкалу-предиктор відновлення функції верхньої кінцівки в разі вогнепального ушкодження надпліччя для прогнозування наслідків втручання. Результати. Усі пацієнти мали вогнепальну травму надпліччя внаслідок осколкового або кульового поранення отриманого під час виконання бойових завдань у війні на території України. Комбатантам надано кваліфіковану лікарську допомогу, здійснено етапні хірургічні втручання та курс реабілітаційного відновлення. Відповідно до показників ретроспективного аналізу, прослідковано кореляцію результатів реабілітації щодо значень за шкалою OSS і оцінюванням за шкалою-предиктором відновлення функції верхньої кінцівки за вогнепальної травми надпліччя. Висновки. Проаналізовано існуючі шкали оцінювання функції верхньої кінцівки, сфери їхнього використання та питання, за якими визначають ефективність застосування цих класифікацій під час лікування та реабілітації пацієнтів. Запропонована нами шкала слугує допоміжним елементом для прийняття рішення про доцільність та обсяг хірургічного втручання в разі вогнепальної травми надпліччя, бо прогнозує його ефективність та можливі наслідки, також може використовуватись для інформування пацієнта про результативність відновлення. Вирішальним фактором є професіоналізм лікаря та готовність хворого ризикувати за для відновлення функції кінцівки за умов важких поранень надпліччя та значного травмування. Ключові слова. Надпліччя, шкала оцінювання, шкала-предиктор, бойова травма, війна, хірургічне втручання, військовослужбовці.

Keywords. Upper arm, assessment scale, predictor scale, combat injury, war, gunshot wound, surgical intervention, military personnel

Introduction

The relevance of the use of upper limb function assessment scales is due to the need to have a detailed tool for determining the disorder due to the growing number of people with injuries to the upper arm area, therefore it is an integral part of the work of a modern orthopedic traumatologist. They help assess structural damage and pain levels in patients. In a gunshot injury to the upper arm, several anatomical structures are affected: bones, joints, muscles, tendons, nerves [1]. Ukrainian scientists assess the functional state of the shoulder joint using the Oxford Shoulder Score (OSS) and Visual Analog Scale (VAS) 6 and 12 months after surgery [2]. However, in significant pain syndrome, it is sometimes impossible to adequately determine the degree of upper limb dysfunction using existing scales, such as OSS [3], Disabilities of the Arm, Shoulder and Hand (DASH) [4], American Shoulder and Elbow Surgeons Standardized Assessment Form (ASES) [5], University of California Los Angeles Shoulder Score (UCLASS) [6], etc. The question arises of the need to create an adapted scale, that is, a completely new tool for assessing or forming a rehabilitation prognosis for the upper limb in such individuals, the number of whom is constantly increasing during the continuation and intensification of hostilities in Ukraine.

Purpose: to determine the prognostic value of the extent of damage in case of gunshot injury to the upper arm for surgical intervention to improve the results of restoring upper limb function.

Material and Methods

The study materials were reviewed and approved by the Bioethics Committee at the Institute of Traumatology and Orthopedics of the NAMSU (protocol No. 2 dated 07.02.2025). All patients involved in the study were familiarized with the surgical intervention plan and signed an informed consent.

During almost 3 years of the war, we surgically treated 52 male individuals, aged 32 to 53, with gunshot injuries to the upper arm.

However, when analyzing the structure of gunshot injuries to the upper arm, data on age, gender, and concomitant injuries are not decisive for making a decision on the appropriateness of treatment. The vast majority of wounded underwent complex reconstructive surgeries to restore limb function. They included replacement of bone defects using autograft bone tissue from the iliac wing in 43 patients, transplantation of non-free flaps such as: thoracodorsal on the neurovascular pedicle in 14 wounded, local rotational flap in 8. Implantation of an articulating spacer of the humeral head was performed in 19 patients with subsequent replacement with a shoulder joint endoprosthesis. Metal osteosynthesis of various categories of complexity was performed in 52 patients. All these surgical interventions took quite a long time and required significant physical and psychological efforts of the surgeon and the patient at the subsequent stages of postoperative rehabilitation. Gunshot injury to the upper arm requires special attention, since the effectiveness of the operation in this area is a prerequisite for further rehabilitation and restoration of the function of the entire upper limb. Complications that developed in the postoperative period significantly influenced or prevented a satisfactory rehabilitation outcome. Their analysis in the case of gunshot injury to the upper limb was given by G. B. Kolov et al. [7]. When studying such fractures of the humerus bones, the following well-known classifications were used:

1. Craig — clavicle fractures (clavicle and clavicular-coracoid ligaments) [8];
2. Goss-Ideberg — fractures of the articular surface of the scapula in combination with the body and processes [9];
3. Ogawa — fractures of the coracoid process [10];
4. Gustilo Classification — soft tissue defects [11];
5. Oxford Shoulder Score (OSS) — assessment of functional outcomes.

We also used a previously developed scale-predictor of the restoration of upper limb function in gunshot injuries of the upper arm to predict the consequences of surgical intervention and determine the degree of rehabilitation potential of the patient.

The distribution of points is based on a subjective assessment of the rehabilitation potential of such patients. In our opinion, damage to the underlying muscles or nerves that innervate them and bone defects require more time and effort for recovery. Therefore, they received 10 points each (min — 0, max — 65) (Table 1).

We identified 3 groups of patients with a distribution by the number of points scored according to the structure of injuries in the area of the upper arm and shoulder joint at the time of hospitalization in our department (1 — 35+; 2 — 20–30; 3 — up to 20).

To analyze the results of assessing the effectiveness of this scale, 30 subjects out of 52 were selected, their observation was long-term and long-term results are available [12]. These combatants had a score of more than 5.

Table 1

Scoring system for the structure of upper arm injuries

Damage	Score
Deltoid muscle or *n. axillaris*	10
Bone defects requiring plastic surgery	10
Thoracodorsal bundle	10
Rotator cuff of the shoulder — more than 5 months*	5
Soft tissue defect in the upper arm area	5
N. subscapularis	5

Note. * — the degree of fatty degeneration and/or hypertrophy after 5 months is problematic for treatment.

Results

All 30 patients had a gunshot injury to the upper arm as a result of a shrapnel or bullet wound received during combat missions in the war on the territory of Ukraine. They received qualified medical care, underwent staged surgical interventions and a course of rehabilitation recovery. The structure of injuries is given in Table 2.

The OSS scale is a subjective scale for assessing the functional state of the shoulder joint: the patient answered twelve questions, the answer to each of them was rated from 0 to 4 points. Their maximum number was 48, the minimum was 0. The number of points from 0 to 19 was rated as an unsatisfactory

Table 2

Structure of upper arm injuries

Patient	Scapula	Clavicle	Shoulder	Deltoid / *n. axillaris*	Thoracodorsal bundle	Rotator cuff of the shoulder	Soft tissue defect	*n. subscapularis*	Score
1	+	–	+	+	–	–	–	–	30
2	+	–	+	+	–	–	+	–	35
3	+	–	–	–	–	+	–	–	15
4	+	–	–	–	–	+	–	–	15
5	+	–	–	–	–	–	–	–	10
6	+	–	–	–	–	+	+	–	20
7	+	–	+	+	–	+	+	–	40
8	+	–	–	+	–	–	+	–	25
9	+	–	–	–	–	+	+	–	20
10	+	–	–	+	–	+	–	–	25
11	+	–	+	–	+	–	–	+	35
12	–	+	+	+	–	+	–	–	35
13	+	–	–	+	–	+	+	–	30
14	+	–	+	+	–	–	–	+	35
15	+	–	+	–	–	–	–	–	20
16	+	–	–	–	+	–	–	+	25
17	–	+	+	–	–	–	+	–	25
18	–	–	+	–	–	–	+	–	15
19	–	+	–	+	–	–	–	–	20
20	+	–	–	–	–	–	–	+	15
21	–	–	+	–	+	–	–	–	20
22	–	–	+	–	–	+	+	–	20
23	+	–	–	–	–	+	–	–	15
24	+	–	–	–	–	–	–	+	15
25	+	–	+	–	–	–	–	–	20
26	+	–	–	–	–	–	–	–	10
27	–	–	–	–	–	+	+	+	15
28	+	–	–	–	–	–	+	–	15
29	–	–	+	–	–	–	+	–	15
30	+	+	+	+	–	+	+	–	50

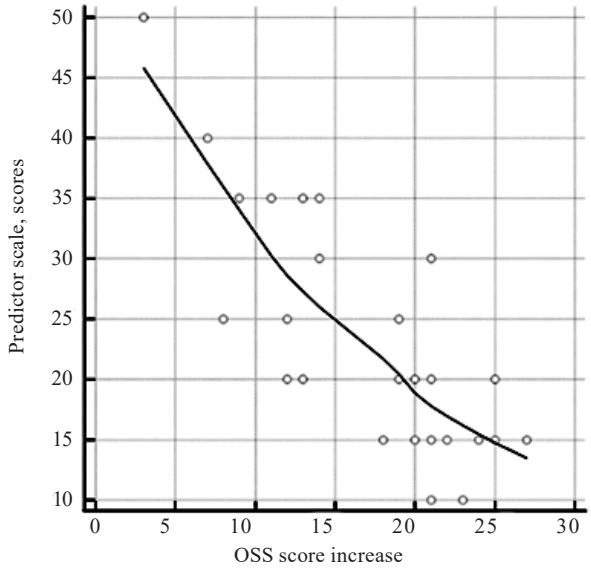
Table 3

Oxford Shoulder Score survey results

Patient	Before intervention	After intervention	Score increase
1	19	33	14
2	13	26	13
3	29	47	18
4	20	40	20
5	22	43	21
6	20	33	13
7	15	22	7
8	23	31	8
9	22	35	13
10	19	31	12
11	12	23	11
12	15	29	14
13	11	32	21
14	14	25	9
15	19	38	19
16	15	34	19
17	13	32	19
18	20	42	22
19	19	39	20
20	24	46	22
21	17	38	21
22	22	37	25
23	19	44	25
24	21	45	24
25	19	31	12
26	25	48	23
27	21	42	21
28	20	47	27
29	23	44	21
30	18	21	3

result, 20–29 as a satisfactory result, 30–39 as good, 40–48 as excellent. The results of the OSS scale survey are presented in Table 3.

According to the retrospective analysis of patients, the correlation of rehabilitation results according to the OSS scale assessment and the results of the scale-predictor of recovery of upper limb function in case of gunshot injury to the upper arm is observed: 6 patients (No. 2, 7, 11, 12, 14, 30) — 35+ points, 4 months for OSS — 22, 26, 23, 29, 25, 21 points respectively; 13 patients (No. 1, 6, 8, 9, 10, 13, 15, 16, 17, 19, 21, 22, 25) — 20–30 points, 4 months for OSS — 33, 33, 31, 35, 31, 32, 38, 34, 32, 39, 38, 37, 31 points respectively; 11 combatants



Sample size	30
Spearman's coefficient of rank correlation (rho)	–0,752
Significance level	p < 0,0001
95 % Confidence interval for rho	–0,875 to –0,538

Fig. 1. Spearman's rank correlation coefficient R = –0.752; statistical significance level p < 0.0001

(No. 3, 4, 5, 18, 20, 23, 24, 26, 27, 28, 29) — up to 20 points, 4 months for OSS — 47, 40, 43, 42, 46, 44, 45, 48, 42, 47, 44 points, respectively. A 4-month period was considered sufficient for postoperative healing and initial rehabilitation, so the preoperative OSS score, surgical intervention extent, and functional outcomes at 4 months were evaluated.

Inverse proportional relationship between the score on the predictor scale and the increase in OSS points has been statistically proven.

With a large number of patients injured as a result of military operations, as well as at the stage of the triage point in combat conditions, it is necessary to understand and try to predict the outcome of treatment and care for the wounded based on the volume of injury. We developed and conducted an internal assessment of the effectiveness of the predictor scale for gunshot injuries of the upper arm based on retrospective data from 30 patients who were operated on by one team of surgeons. The scale-predictor proposed by us is an auxiliary tool for making a decision on the feasibility and scope of intervention in case of gunshot injury of the upper arm. After all, using the "disposable" reserves of the body such as: bone grafting from the wing of one iliac bone or from both at once, *n. suralis*, tendon of *m. palmaris* (if available) or *m. semitendinosus*, various rotational and non-free

flaps, we reduce the depot for further reconstructive surgical interventions and the possibility of treating the patient with autografts in the future. The prospect of restoring the function of the limb is, if not the determining one, then one of the most important factors in the feasibility of performing the operation. The apparent severity of the injury of 35+ points on the scale-predictor of restoring the function of the upper limb in case of gunshot injury of the upper arm is shown in a clinical case.

Clinical case

A complex gunshot injury of the upper arm with damage to almost all structures (Fig. 1, 2). 10 points each — bone defect of the acromial end of the clavicle; proximal part of the humerus; spine and acromial process of the scapula with fracture of the body of the scapula, damage to the deltoid muscle and *n. Axillaris*; 5 points each — injury to the rotator cuff of the shoulder, soft tissue defect in the area of the humerus.

The patient underwent a long-term surgical intervention, more than 8 hours. A bone graft was used to replace the defect of the spine and acromial process of the scapula 11 cm. An articulating spacer of the humeral head was implanted. Metal osteosynthesis was performed with four overlay plates (Fig. 3).

A non-free active thoracodorsal flap was transplanted to replace the defect of the deltoid muscle and skin (Fig. 4).

The use of the thoracodorsal flap is not due to vascular damage, but to a musculocutaneous defect in the area of the shoulder blade, or a non-functioning deltoid muscle.

Three months after surgery, the increase on the OSS scale was 3 points, from 18 to 21.

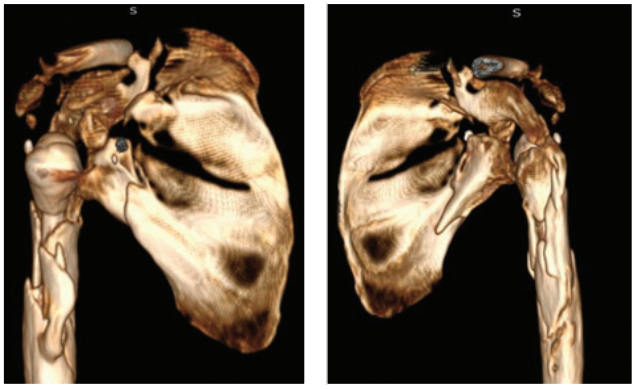


Fig. 1. CT scan of a serviceman with a complex gunshot wound to the upper arm (50 points on the predictor scale, included in the group of 35+ points)

Fig. 2. Skin of the same patient at the time of surgery

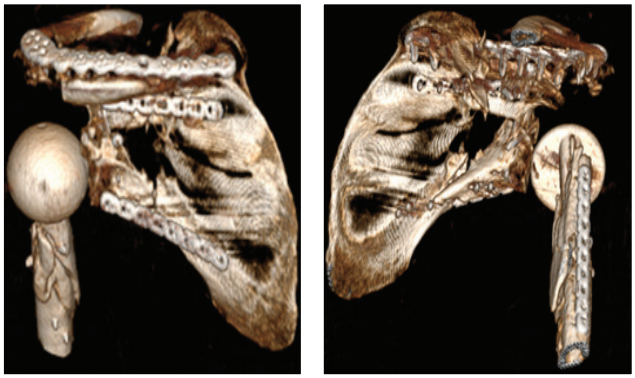


Fig. 3. Postoperative CT scan of the same patient

Fig. 4. Involuntary active thoracodorsal flap

Discussion

Existing scales for assessing upper limb function, their areas of use, and questions that determine the effectiveness of these classifications in the treatment and rehabilitation of patients were analyzed.

G. Hohenberger et al. found the DASH score to be positively correlated with the corresponding severity score of deformed limbs. However, the authors note that there is a need for further studies with a larger number of patients to verify the results obtained to draw conclusions about accurate predictors [13].

Meta-analysis by H. M. Kim et al. assessed 252 studies (32,072 patients; mean age 59.6 years; mean body mass index 28.7; mean follow-up time 27.8 months). The authors noted that the most frequently used were the American Shoulder and Elbow Surgeon (ASES) (n = 183; 73 %) and the Visual Analog Scale (VAS) (n = 163; 65 %). They recommend the widespread implementation of the ASES and UCLA scores for clinical and scientific standardization; however, the UCLA PROM requires in-person testing of range of motion and strength, which is a practical limitation and an obstacle to long-term follow-up [14]. Summarizing the available information, we concluded that it is inappropriate to compare these classifications with our proposed predictor scale for the recovery of upper limb function in gunshot injuries of the upper arm. Since they assess upper limb functionality only before and after surgery. However, using our predictor scale, it becomes possible to assess and predict the outcome of surgical treatment and subsequent rehabilitation.

The literature describes the use of predictor scales for predicting the duration of surgical intervention [15], assessing and predicting risks during surgical intervention [16], predicting the level of pain syndrome in patients in the postoperative period [17], but the use of classifications for predicting the level of recovery of upper limb function at the stage of preoperative examination is not defined and requires further development in modern medical practice. Our predictor scale may be one of the first steps towards popularizing and promoting this prediction method.

Conclusions

The scale we have proposed serves as an auxiliary element for planning on the feasibility and scope of surgical intervention in case of gunshot injury of the upper arm, because it predicts the effectiveness of treatment and possible consequences, and can also be used to inform the patient about the effectiveness of recovery. Score ranges on the predictor scale are as follows: 35 points or higher indicates that surgery is considered high risk or technically infeasible, with an unfavorable or minimal expected prognosis; 20–30 points suggests surgical intervention is technically possible, with a likely improvement in quality of life; up to 20 points indicates that intervention and reconstruction are recommended, with patients in this group having a favorable prognosis for rehabilitation and near-complete restoration of limb function.

The decisive factor is the professionalism of the doctor and the patient's willingness to go through a difficult path to restore limb function in case of severe injuries of the upper arm and a large volume of trauma.

Conflict of interest. The authors declare the absence of a conflict of interest.

Prospects for further research. In-depth study of the long-term consequences of injuries and the results of treatment of these patients.

Information on funding. This study is not commercial and has no external funding.

Authors' contribution. Strafun S. S. — idea and concept of the study, evaluation of the findings, drawing conclusions; Gayovych V. V. — literature search, evaluation and discussion of the findings; Telepenko G. V. — structuring and drafting the article, choosing research methods, data summarization of the findings, statistical processing of the findings, compiling the reference list, patient sampling, processing of medical documentation, data summarization in an Excel spreadsheet.

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The article has been sent to the editors	Received after review	Accepted for printing
07.01.2025	18.03.2025	21.03.2025

PREDICTOR SCALE OF UPPER EXTREMITY FUNCTION RECOVERY IN MILITARY TRAUMA OF THE UPPER ARM (OFFER TO USE)

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