

Predicting lethal outcome risks in patients with craniomaxillofacial trauma and polytrauma by the ISS and NISS

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Multiple papers reveal no reliable difference between early and delayed maxillofacial injuries treatment in postoperative complications in patients with craniomaxillofacial trauma and polytrauma. A choice factor of the treatment tactics is the lethal outcome risk, as well as the lethal outcome prognosis. In order to objectivize the severity of trauma authors suggested the assessment scores which represent patient's condition severity in points and provide lethal outcome risk estimation, — Injury Severity Score (ISS) and New Injury Severity Score (NISS), each with advantages and disadvantages of prognosing the lethal outcome. Though, the data on its preciseness and informativeness regarding patients with combined craniomaxillofacial trauma are limited, and the results, obtained from various authors, seem to be controversial.

OBJECTIVE — to identify and compare the threshold (critical) values of the ISS and NISS assessment scales which predict the lethal outcome risks in patients with craniomaxillofacial trauma and polytrauma.

MATERIALS AND METHODS. During 2016—2019 years 503 patients were treated due to maxillofacial traumas and associated injuries. Patients age ranged from 18 till 91 years, (average age — 30.5 years). There was a male predominance in the sample (84.3%). Facial bone fractures occurred in 70% of cases (352 patients). Mainly after assaults (44%), falls (20%) and motor-vehicle accidents (16%). The other etiological factors included occupational traumas (0.5%), sport traumas (1%) and unknown aetiology traumas. The study evaluated patients with facial and concomitant injuries, who received multidisciplinary treatment in a specialized trauma hospital. Values of Injury Severity Score and New Injury Severity Score were statistically analyzed to evaluate effectiveness in prognosing lethal outcome risks.

RESULTS. Mortality in the sample was 3% (15 patients). With the optimum cut-off value of ISS > 24, lethal outcome prognosis model sensitivity yields 93.3%, specificity — 91.4%. With the optimum cut-off value NISS > 36, the lethal outcome prognosis sensitivity yields 86.7%, its specificity 92.4%.

CONCLUSIONS. ISS and NISS demonstrate similar effectiveness in prognosing lethal outcome risks. The difference of area under the curve of both trauma severity estimation methods is not statistically significant ($p=0.651$). Both indicators could be used in daily practice in specialized hospitals to assess the patient's condition and determine priority of treatment steps.

KEYWORDS

mortality, craniomaxillofacial trauma, ISS, NISS, Le Fort.

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Traumatic injuries represent one of the most common causes of mortality and disability in the world. In the end of previous century it was considered that early and, if possible, complete, multidisciplinary-based treatment of combined injuries of various

organs and organ systems provides for the best integral outcomes, being associated with the least risk of postoperative complications. This approach, called «Early total care» (ETC), was thoroughly described and recommended for treatment of complex traumas

and polytraumas by Riska et al., 1977; and Bone et al., 1989 [1, 2]. The other authors supported expectant tactics in certain complicated cases, in order to decrease the risk of mortality and life-threatening conditions in the postoperative period. The surgery called «Damage control» was founded in early 90ies (DC). The term was first used by Rotondo, who proved advantages of delayed treatment of certain penetrating abdominal injuries, compared to early operative intervention [3]. The delayed treatment of some extremity injuries showed the same results and was called «Damage control orthopedics» (Scalea et al., 2000) [4]. Significant achievements in the polytrauma pathophysiology studies during last decades define modern approach to the treatment of combined trauma and polytrauma, thus, developing into new treatment methods. Nowadays, both methods: ETC and DC — are used in the treatment of patients with polytrauma, according to the patient's condition and medical indications (Klüter et al., 2013) [5]. This completely applies to the combined traumas of the maxillofacial region. A prevailing approach since the 1990ies includes early open reposition and osteosynthesis of the injured bones (during first hospitalization days, under the absence of significant edema and posttraumatic changes of the splinter bone tissues), which was aimed at maximum recovery of function and esthetical appearance of the injured regions (Manson et al., 1988, Gruss et al., 1990) [6, 7]. Though, perfection of the surgical technique and instruments for osteosynthesis provides for acceptable results even in case of delayed operations, particularly, in patients with severe open craniocerebral injuries, after stabilizing life functions and decreasing the neurosurgical risks. Nowadays, multiple papers comparing clinical effectiveness of early and delayed maxillofacial injuries treatment by the postoperative inflammatory complications reveal no reliable difference between these two approaches [8]. A choice factor of the treatment tactics is the lethal outcome risk, as well as the lethal outcome prognosis during operation and/or anesthesia. The mortality of patients with the craniocerebral injury and polytrauma makes up 2.2 %, but for some injury types it is about 2.4 % [9]. So, a distinct criterion is required for differential treatment of the maxillofacial injuries, regarding general condition of the patient and injuries severity, for determining the best terms of treatment and reducing the postoperative complications and/or lethal treatment outcomes risks.

In order to objectivize the severity of trauma in patients with combined trauma and polytrauma, the authors suggested the assessment scores which represent patient's condition severity in points, thus allowing to define the order of treatment measures to be taken,

among which two basic widely used assessment scales provide for precise lethal outcome risk estimation for the patients with severe injuries. These are the Injury Severity Score (ISS) and New Injury Severity Score (NISS), each with advantages and disadvantages of prognosing the lethal outcome [10–13]. Both scales are based on the «Abbreviate Injury Severity Scale» (AIS), which is an anatomic coding system, used for classification and description of traumas severity [14]. Noteworthy, both ISS and NISS are easy and quick in use, with broad spectrum of scores, which may be easily applied for detecting the threshold (critical) value for predicting lethal outcomes. It may become a reliable tool in daily practice of the maxillofacial surgeon, aimed at choosing the treatment tactics according to the patient's severity, though, the data on its preciseness and informativeness regarding patients with combined craniomaxillofacial trauma are limited, and the results, obtained from various authors, seem to be controversial.

OBJECTIVE — to identify and compare the threshold (critical) values of the ISS and NISS assessment scales which predict the lethal outcome risks in patients with craniomaxillofacial trauma and polytrauma.

Materials and methods

The study represents retrospective review of the patients admitted by the «Kyiv City Clinical Emergency Hospital» from 2016 till 2019. The inclusion criteria were as follows: in-patients with contusions, soft facial tissue traumas, facial bone fractures and concomitant injuries of other, non-facial regions; complete documentation and definite treatment outcome in the chosen patients. The exclusion criteria were: pediatric trauma (the patients aged under 18 years old), patients who primarily received medical and emergency care in other medical institutions and were later transferred to the «Kyiv city Clinical Emergency Hospital» for treatment of complications.

The following parameters were collected and reviewed retrospectively: sex, age, etiology and mechanism of the trauma, location and mechanism of the facial bone fractures, other facial and oral injuries, concomitant traumas of other body parts, accompanying somatic diseases, drug and alcohol abuse, date of hospitalization vs injury date, length of hospital stay, date and type of surgical intervention, treatment outcome, date and cause of death. The patients were examined at the time of hospital admission according to the Advanced Trauma Life Support [16, 17]. The trauma severity was assessed by the following scales: Abbreviated Injury Scale (AIS), Injury Severity Score (ISS) and New Injury

Severity Score (NISS). The AIS-90 was used to encode and determine the polytrauma severity according to the existing recommendations [18, 19]. The trauma assessment was based on diagnosis, supported by clinical and radiological data, surgery data or autopsy data. The AIS-90 score was assessed, to be further used for detecting polytrauma severity by both ISS and NISS. In the NISS method, squares of three most severe injuries by AIS-90 are regarded, but, comparing it to the well-known ISS, the NISS considers two scores from one anatomical region, for example, from the head [20]. At the same time, ISS uses three most severe injury points from different anatomical regions, which results in numerous drawbacks. The concomitant traumas of the patients were of various severity, divided into 5 relative groups (head traumas, extremities traumas, abdominal traumas, thoracic traumas, spinal traumas). Patient data were collected and organized using the Microsoft Excel database [21]. The trauma severity parameters were divided into two groups, according to the ISS and NISS, to be statistically analyzed for detecting the threshold (critical) values of lethal outcome prognosis.

The relation between the parameters was detected by correlation test. The threshold/critical values for lethal outcome risks were determined using ROC curve analysis and the Youden index. The area under the curve (AUC) and 95 % CI were assessed. A probability value <0.05 was considered statistically significant [22]. Statistical analyses were performed using the software EZR v.1.54 (graphical user interface for R statistical software version 4.0.3, R Foundation for Statistical Computing, Vienna, Austria) [23].

Results and discussion

According to the retrospective analysis of the 2016–2019 case histories, a total of 503 in-patients were treated in the «Kyiv City Clinical Emergency Hospital» due to maxillofacial traumas and associated injuries. Facial bone fractures occurred in 70 %

of cases (352 patients). The other cases were characterized by injuries and/or multiple contusions of soft facial tissues. The age of the patients with maxillofacial traumas ranged from 18 till 91 years, with average age – 30.5 years (25 ± 37 years). There was a male predominance in the sample (84.3 %).

The main causes of traumas were assaults (44 %), falls (20 %) and motor-vehicle accidents (16 %). The other etiological factors included occupational traumas (0.5 %), sport traumas (1 %) and unknown etiology traumas (18.5 %) (Fig. 1). Twenty-eight percent of patients were under alcohol or drug action at the time of trauma.

A more thorough analysis of fracture zones revealed the following: the zygomatic bone traumas prevailed (27.4 %), followed by the nasal bone with nasal-ethmoid complex traumas (25.1 %) and mandibular traumas (24 %). The maxillary fractures by Le Fort I, II, III were established in 9 % of cases.

The first group (head traumas) related to the craniocerebral traumas. Severe traumas, such as intracranial hemorrhage and open craniocerebral trauma were reported in 31 % of cases. The second group (extremities traumas) included contusions, injuries, fractures, dislocations and vascular damage – 22 %. The third group (abdominal traumas) included contusion of anterior abdominal wall, internal organ ruptures and penetrating wounds – 13 %. The fourth group (thoracic traumas) included contusions, injuries and fractures of the ribs, hemothorax, pneumothorax, contusion of the heart and lungs – 28 %. The vertebral fractures, composing 6 % of cases, were related to the vertebral traumas of the fifth group (Fig. 2).

Estimation of the trauma severity by the ISS and NISS methods revealed that the trauma severity scores range from 1 and 57 according to the ISS and from 1 to 66 according to the NISS. Fifteen lethal cases (3 %) were registered among the patients group, with main death causes represented by the cerebral edema (73.3 %), multiple organ dysfunction syndrome (13.3 %), posttraumatic *pneumonia* (6.7 %) and acute heart failure (6.7 %), caused

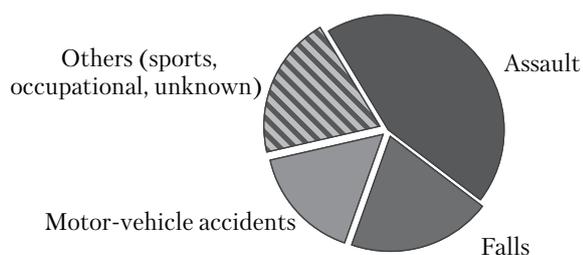


Figure 1. **Main causes of maxillofacial traumas**

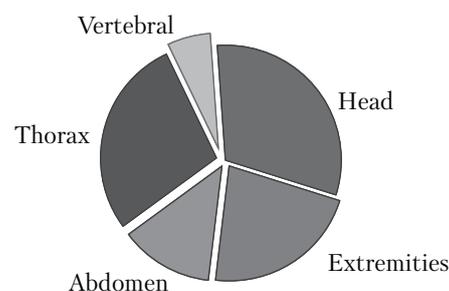


Figure 2. **Basic concomitant traumas in patients with the maxillofacial trauma and polytrauma**

Table. Median, first and third quantile of the ISS and NISS scores

Parameter	ISS	NISS
Overall patient group (n = 503)	4 (2–16)	6 (3–22)
Lethal cases (n = 15)	34 (25–41.5)	48 (43–57)

presumably by concomitant traumas. Their severity ranged within 11–57, according to the ISS method and within 11–64, according to the NISS. Further statistical analysis showed that the non-normal distribution of the identified factors, with the median, the first and third quantiles of the ISS and NISS regarded (Table).

The optimum cut-off value of ISS > 24, the lethal outcome prognosis model sensitivity yields 93.3 % (95 % CI 68.1–99.8 %), specificity – 91.4 % (95 % CI 88.5–93.7 %). The prognostic significance of the positive test (+PV) is 25 % (95 % CI 19.5–31.4 %). The prognostic significance of the negative test (–PV) is 99.8 % (95 % CI 98.5–100 %) (Fig. 3).

The optimum cut-off value NISS > 36, the lethal outcome prognosis sensitivity was 86.7 % (95 % CI 59.5–98.3 %), its specificity 92.4 % (95 % CI 89.7–94.6 %). The prognostic significance of positive test (+PV) is 26 % (95 % CI 19.6–33.7 %). The prognostic significance of negative test (–PV) is 99.6 % (95 % CI 98.4–99.9 %) (Fig. 4).

Considering that the mortality in the sample was 3 % (15 patients), the suggested mortality prognosis system allows to detect the patients with lethal

outcome risks 9 times more often than in the control group (+PV 25 % and 26 % respectively). The prognostic significance of the negative test (–PV) in both cases is close to 100 %, which lets us assume that the negative test is with high accuracy related to positive outcome, in 99.8 % according to the ISS and in 99.6 % according to the NISS.

The Spearman's correlation test analysis defined strong positive correlation between the ISS and NISS values ($r = 0.963$, $p < 0.05$).

Using the ROC-curve analysis and comparing areas under the ROC curves, the prognostic ability of both methods to predict lethal outcome was found to be quite high, without statistically significant difference (Fig. 5).

Early surgical treatment, which includes open reposition and internal fixation of the injured facial bones, improves maximum recovery of function and esthetical appearance of the injured regions (Manson et al., 1988, Gruss et al., 1990) [6, 7]. But results, obtained from various authors, seem to be controversial. There is no reliable difference between early and delayed treatment approaches [8]. So, a criterion is required to objectivize the postoperative complications and/or lethal treatment outcomes risks prognosis, especially in patients with craniocerebral trauma and polytrauma.

The method of the Injury Severity Score ISS was suggested by Baker et al. (1974), based on the contracted injury scale AIS, with three most severe injury scores obtained from different anatomical areas squared. This makes the most severe injuries significant [24]. Numerous scientists noted strong

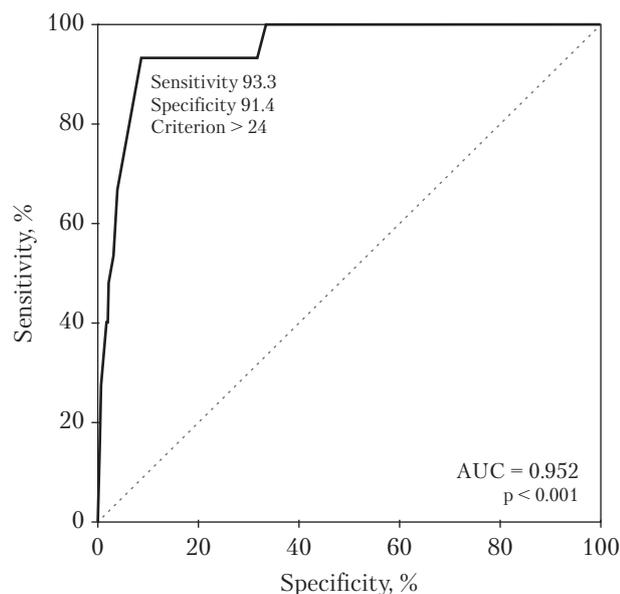


Figure 3. Characteristics of the ROC-curve analysis. Cut-off value of the ISS

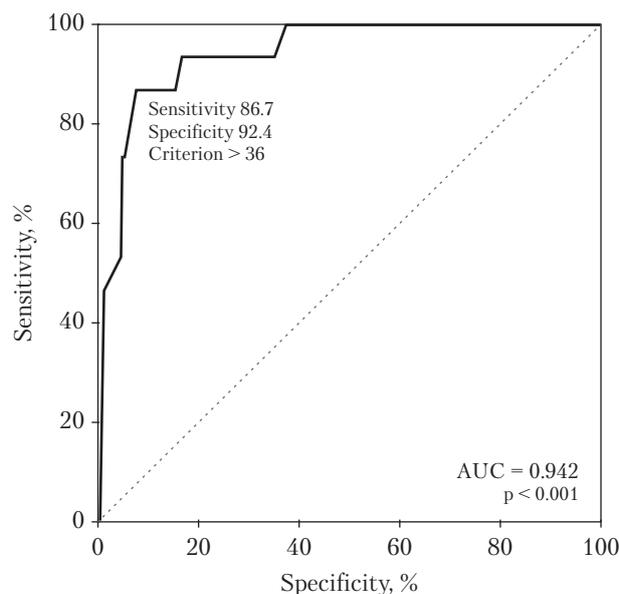


Figure 4. Characteristics of the ROC-curve analysis. Cut-off value of the NISS

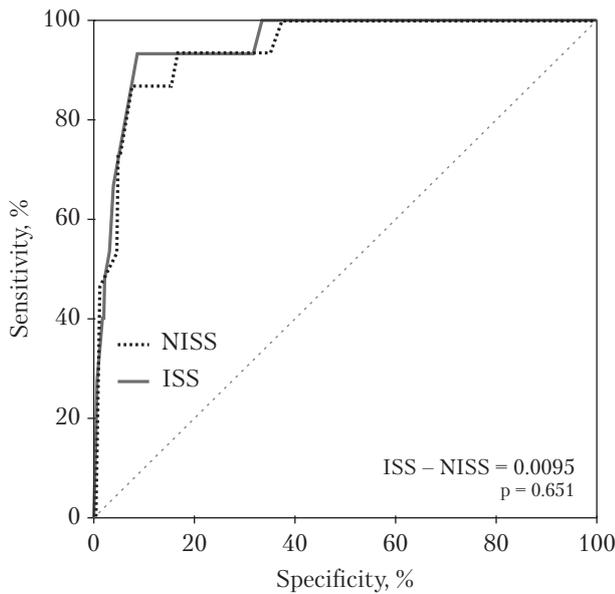


Figure 5. Comparison of areas under the curve of the ISS and NISS

correlation between increased ISS score and mortality of the patients with gunshot wounds, those after road accidents and hospital stay period length [25–27], which were widely used in scientific studies. Though, most authors state about the ISS method imperfection, compared to a more modern method NISS [18, 19]. This was mainly explained by decreased significance of the cranio-cerebral trauma for mortality prognosis, as, the most severe score of only one anatomical area was considered, which means that the cranio-cerebral trauma effect was underestimated. According to Wong et al., 2016, the ISS proved to be more informative for the patients with polytraumas and traumas of various areas of the body, while the NISS was more informative for the cranio-cerebral trauma patients [28]. This was confirmed by the studies of Lavoie et al., 2004, stating that in case of the severe cranio-cerebral trauma the NISS better predicts lethal outcome risks [18]. The number of studies of the combined facial bone traumas is quite limited. Though mortality from the maxillofacial traumas is insignificant in this group, i.e., 2.4%, asphyxiation due to upper respiratory airways impassability and head and neck vascular hemorrhage cause 87% of immediate lethal outcomes, with 97.6% of deaths occur during first 24 hours after the road accident [29].

The study was limited, as during assessing the trauma severity and prognosis of the lethal outcome the patients treated in the poly-specialized hospital «Kyiv city clinical emergency hospital» were not divided into separate groups of cranio-cerebral trauma and polytrauma.

The study result evidence that both methods are highly precise in prognosis of the lethal outcome risk (ISS – AUC 0.952 (95% CI 0.929–0.969); NISS – AUC 0.942 (95% CI 0.918–0.961)). With the optimum cut-off value of ISS > 24, the lethal outcome prognosis model sensitivity yields 93.3% (95% CI 68.1–99.8%), specificity – 91.4% (95% CI 88.5–93.7%).

The optimum cut-off value NISS > 36, the lethal outcome prognosis sensitivity was 86.7% (95% CI 59.5–98.3%), its specificity 92.4% (95% CI 89.7–94.6%). The suggested mortality prognosis system allows to detect risk group patients, with lethal outcome risks detected 9 times more often than in the general population (+PV 25% and 26% respectively, lethal outcome risk – 3%). Using the ROC – curve analysis and comparing the areas under the ROC curves, the prognostic ability of both methods to predict lethal outcome was found to be quite high, without statistically significant difference ($p = 0.651$), which means that both methods of the trauma severity assessment are quite informative in characterizing the trauma details, and the high prognostic ability of each permits to assess the lethal outcome risks in patients with combined cranio-cerebral trauma and polytrauma. The data of this study are confirmed by meta-analysis by Deng et al., 2016 [13].

Conclusions

Mortality in patients with combined maxillofacial trauma and polytrauma is 3%.

Methods ISS and NISS predict the lethal outcome risk with high precision (ISS – AUC 0.952 (95% CI 0.929–0.969); NISS – AUC 0.942 (95% CI 0.918–0.961)).

With the optimum cut-off value of ISS > 24, lethal outcome prognosis model sensitivity yields 93.3%, specificity – 91.4%. With the optimum cut-off value NISS > 36, the lethal outcome prognosis sensitivity yields 86.7%, its specificity 92.4%.

ISS and NISS demonstrate similar effectiveness in prognosing lethal outcome risks. The difference of area under the curve of both trauma severity estimation methods is not statistically significant ($p = 0.651$).

DECLARATION OF INTERESTS

The authors declare that they have no conflicts of interest.

AUTHORS CONTRIBUTIONS

I. Shumynskyi: conceptualization, methodology, writing review and editing; M. Sabadosh: formal analysis, investigation, writing, original draft preparation; V. Gurianov: statistical analysis; A. Kopchak: supervision.

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Застосування показників ISS та NISS у прогнозуванні ймовірності летального наслідку у пацієнтів з черепно-щелепно-лицевою травмою та політравмою

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У багатьох наукових дослідженнях не виявлено статистично значущої різниці між раннім і відстроченим лікуванням щелепно-лицевих травм за кількістю післяопераційних ускладнень у пацієнтів з черепно-щелепно-лицевою травмою та політравмою. Чинниками для вибору тактики лікування є ризик виникнення летального наслідку, а також прогноз летального наслідку. Для об'єктивізації тяжкості травми запропоновано оціночні шкали, які відображують тяжкість стану пацієнта в балах та дають змогу про-

гнозувати летальний наслідок, — шкалу тяжкості травми (Injury Severity Score (ISS)) і нову шкалу тяжкості травми (New Injury Severity Score (NISS)), кожна з яких має переваги та недоліки щодо прогнозу летального наслідку. Однак дані щодо їх точності та інформативності у пацієнтів із поєднаною черепно-щелепно-лищевою травмою обмежені, а результати, отримані різними авторами, суперечливі.

Мета — визначити та порівняти порогові значення шкал ISS і NISS, які прогнозують летальний наслідок у пацієнтів із черепно-щелепно-лищевою травмою та політравмою.

Матеріали та методи. У 2016—2019 рр. з приводу щелепно-лищевої травми та пов'язаних з нею травм проліковано 503 пацієнти. Вік пацієнтів — від 18 до 91 року (середній вік — 30,5 року). Серед пацієнтів переважали чоловіки (84,3%). У 70% випадків (352 пацієнти) мали місце переломи кісток обличчя. Основними причинами отримання травм були побиття (44,0%), падіння з висоти (20,0%) та дорожньо-транспортна пригода (16,0%). Інші етіологічні чинники — травма (0,5%), спортивна травма (1,0%) і травма невідомої етіології. У дослідження залучили пацієнтів з травмами обличчя та супутніми травмами, у яких застосували мультидисциплінарний підхід до лікування в спеціалізованій травматологічній лікарні. Для оцінки ефективності прогнозу летального наслідку проаналізовано значення показників шкал ISS та NISS.

Результати. Летальність у вибірці становила 3% (15 пацієнтів). При пороговому значенні ISS 24 бала чутливість моделі прогнозу летального наслідку становила 93,3%, специфічність — 91,4%, при пороговому значенні NISS — 36 балів — відповідно 86,7 та 92,4%.

Висновки. Шкали ISS і NISS мають схожу ефективність щодо прогнозу летального наслідку. Різниця за площею під ROC-кривою між методами оцінки тяжкості травми є статистично незначущою ($p = 0,651$). Обидва показники можна використовувати у спеціалізованих лікарнях для оцінки стану пацієнта та визначення етапності лікувальних заходів.

Ключові слова: смертність, черепно-щелепно-лищева травма, ISS, NISS, Le Fort.

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