

ОПЫТ ВЫПОЛНЕНИЯ РЕСПИРАТОРНОЙ ПОДДЕРЖКИ У ПОСТРАДАВШИХ С ТЯЖЕЛЫМИ ТРАВМАМИ В ХОДЕ ПРОВЕДЕНИЯ САНИТАРНО-АВИАЦИОННОЙ ЭВАКУАЦИИ ВЕРТОЛЕТАМИ ЛЕГКОГО КЛАССА

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Резюме. Цель исследования – определить оптимальные виды респираторной поддержки при острой дыхательной недостаточности (ОДН) у пострадавших с тяжелыми травмами при проведении медицинской эвакуации вертолетами легкого класса.

Материалы и методы исследования. Материалы исследования – данные о выполнении респираторной поддержки у пациентов с различными видами травм и ОДН за 2016–2021 гг., содержащиеся в автоматизированной информационно-аналитической системе «Медицина катастроф города Москвы» ГБУЗ г.Москвы особого типа «Московский территориальный научно-практический центр медицины катастроф (ЦЭМП) Департамента здравоохранения города Москвы» (далее – ЦЭМП).

При выполнении исследования применялись исторический, статистический и аналитический методы.

Результаты исследования и их анализ. Результаты анализа показали:

- доля пострадавших с различными травмами, полученными в чрезвычайных ситуациях (ЧС) на территории г.Москвы, составляет 31,9% всех санитарных потерь в ЧС. Из них 12,9% находились в крайне тяжелом и тяжелом состоянии, в том числе 1,1% нуждались в выполнении искусственной вентиляции легких (ИВЛ) и интубации трахеи;

- тяжелая форма ОДН, требующая выполнения ИВЛ и интубации трахеи, была вызвана: в 49,7% случаев – политравмой; в 38,4 – изолированной травмой; в 8,7 – термической травмой и в 3,2% случаев – комбинированной травмой.

Определены показания и особенности проведения ИВЛ с интубацией трахеи у пострадавших с различными травмами, подлежащих медицинской эвакуации санитарным вертолетом легкого класса.

Ключевые слова: авиамедицинские бригады, вертолеты легкого класса, искусственная вентиляция легких, пострадавшие с тяжелыми травмами, респираторная поддержка, санитарно-авиационная эвакуация

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EXPERIENCE PERFORMING RESPIRATORY SUPPORT IN VICTIMS WITH SEVERE INJURIES DURING AIR AMBULANCE EVACUATIONS BY LIGHT-CLASS HELICOPTER

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Summary. The aim of the study was to determine the optimal types of respiratory support for acute respiratory failure in patients with severe trauma during medical evacuation by light-class helicopters.

Materials and research methods. The materials of the study are the data on the performance of respiratory support in patients with various types of trauma and acute respiratory failure for 2016-2021, contained in the automated information-analytical system "Disaster Medicine of Moscow" of the State Budget Institution "Moscow Territorial Scientific and Practical Center for Disaster Medicine of the Moscow City Health Department".

When performing the study, historical, statistical and analytical methods were used.

Study results and their analysis. The results of the analysis showed:

- proportion of victims with various traumas received in the emergency situations in Moscow constitutes 31,9% of all sanitary losses in emergencies. Of them 12.9% were in an extremely severe and serious condition, including 1.1% who needed artificial lung ventilation and tracheal intubation;

- severe acute respiratory distress requiring ventilation and tracheal intubation was caused in 49.7% of cases by polytrauma, in 38.4 cases – by isolated trauma, in 8.7 cases – by thermal trauma, and in 3.2% of cases – by combined trauma.

The indications and peculiarities of artificial ventilation with tracheal intubation in patients with various traumas to be medically evacuated by a light-class ambulance helicopter have been determined.

Key words: *air ambulance evacuation, artificial lung ventilation, aviation medical teams, light class helicopters, respiratory support, victims with severe injuries*

Conflict of interest. *The authors declare no conflict of interest*

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Introduction

Respiratory support (RS) in pre-hospital period is an important element of the complex treatment of patients with severe acute respiratory failure (ARF) of various etiologies including those caused by trauma [1-3].

Management of external respiratory function is the most important component of out-of-hospital resuscitation [4, 5]. However, the topic of RS as one of the components of intensive care carried out at the scene and during medical evacuation has not been sufficiently studied yet and many issues remain debatable.

The role of the doctor at this stage is extremely important, but often due to a number of unfavorable circumstances he has to act in extremely difficult conditions [6, 7].

In severe forms of ARF, tracheal intubation is the "gold standard" in emergency airway prosthetics, providing a reliable achievement of positive effect — alternative methods are shown mainly when intubation is impossible [8, 9].

Tracheal intubation provides airway patency and prevention of aspiration complications [10, 11].

It has been noted in many studies that high quality medical care should be provided to patients and injured people without delay. Its early start, adequate assessment of the severity of the patient's condition and reduction of the time of primary medical care can improve the prognosis [12-14].

Domestic and foreign experience in the use of air ambulance indicates a number of its advantages: rapid delivery of qualified specialists to patients, timely air ambulance evacuation of patients and injured people, provision of medical assistance en route [15-19].

The results of the work of the aviation medical teams (AMT) of the Moscow Territorial Scientific-Practical Center for Disaster Medicine (Emergency Medical Care Center) of the Moscow City Health Department (hereinafter referred to as EMCC) testify to the advantage of using a light-class ambulance helicopter in megalopolitan conditions [20, 21].

An air ambulance helicopter has a qualified doctor and a paramedic on board; it is equipped with modern medical equipment, which makes it possible to deliver an anesthesiology and intensive care unit to the scene, to begin providing primary medical and sanitary care in the pre-hospital pe-

riod, and to successfully perform emergency medical evacuation of patients [22, 23].

These advantages of the use of air ambulance reduce the vital signs for medical evacuation to the nearest hospital to cases of massive, as a rule — intracavitary, bleeding that cannot be stopped outside the operating room, increase the profile of medical evacuation and, ultimately, the quality of medical care in the hospital period.

At the same time successful performance of artificial lung ventilation (ALV) in patients with various traumas accompanied by severe ARF required a differentiated approach to the choice of the method of airway patency and respiratory support regime taking into account the type and nature of injury, and that was the reason for presenting the results of the present study.

The aim of the study was to determine the optimal types of respiratory support for acute respiratory failure in patients with various traumas during medical evacuation by light class helicopters.

Materials and Methods. The study used data on the performance in 2016-2021. ALV and tracheal intubation by AMT specialists of light class helicopter during their provision of emergency medical care (EMC) to victims with severe acute respiratory failure as a result of various traumas.

Historical, statistical, and analytical methods were used in performing the study.

Results of the study and their analysis. Analysis of the specified data contained in the automated information-analytical system "Disaster Medicine of Moscow" showed that over the past 6 years (2016-2021) sanitary losses in emergency (ES) and non-emergency (non-standard) situations amounted to 70,217 people. The proportion of injured victims with injuries was 31.9%, of whom 12.9% were in extremely severe and severe condition; 1.1% needed ventilation and tracheal intubation.

The data on the severity of the condition of trauma victims in 2016-2021 are presented in the table.

They show that over the past 6 years there has been an increasing trend in the number of victims who were in an extremely severe and serious condition as a result of severe trauma, including those in need of ALV and tracheal intubation: if in 2016 there were 390 such victims, then in 2021 their number was 617 people, i.e. increased by 1.6 times.

Таблица / Table

Структура тяжести состояния у пострадавших, получивших различные травмы в 2016–2021 гг., чел./ %
 Structure of condition severity in victims of various injuries in 2016-2021, pers./ %

Тяжесть состояния Severity of condition	2016	2017	2018	2019	2020	2021	Итого Total
Всего в крайне тяжелом состоянии Total in extremely serious condition	79/2,0	58/1,5	61/1,5	67/1,6	65/2,4	63/1,8	393/1,7
в том числе на ИВЛ including ventilated	27/0,7	30/0,8	30/0,8	32/0,8	21/0,8	17/0,5	157/0,7
Всего в тяжелом состоянии / Total in serious condition	311/7,9	288/7,3	287/7,2	511/11,9	545/19,8	554/16,2	2496/11,2
в том числе на ИВЛ including ventilated	12/0,3	16/0,4	13/0,3	18/0,4	8/0,3	12/0,3	79/0,4
Всего в крайне тяжелом и тяжелом состоянии / Total in extremely severe and serious condition	390/9,9	346/8,8	348/8,7	578/13,4	610/22,2	617/18,0	2889/12,9
в том числе на ИВЛ including ventilated	39/1,0	46/1,2	43/1,1	50/1,2	29/1,1	29/0,8	236/1,1
Средней тяжести Moderate severity	1976/50,2	2068/52,3	2151/53,8	2143/49,7	1290/47,0	1699/49,7	11327/50,7
Удовлетворительное Satisfactory	1491/37,8	1461/37,0	1419/35,5	1495/34,7	772/28,1	993/29,1	7631/34,1
Биол. смерть Biological death	84/2,1	76/1,9	81/2,0	96/2,2	74/2,7	109/3,2	520/2,3
Общее число пострадавших с травмой Total number of victims with trauma	3941/100,0	3951/100,0	3999/100,0	4312/100,0	2746/100,0	3418/100,0	22367/100,0

The results of treatment of severe trauma largely depend on the effectiveness of emergency medical care in the pre-hospital period. As it follows from domestic and foreign studies, the duration of transportation also affects the outcome of treatment of patients with severe traumatic brain injury (TBI), penetrating chest or abdomen wounds, and unstable hemodynamics and should not exceed 20-30 min. Domestic and foreign authors note that helicopter ambulance services have advantages over ground transportation in severe trauma, but air ambulance evacuation should be performed taking into account local conditions and specifics of trauma system resource distribution.

The use of AMTs makes it possible to start providing primary medical care in the pre-hospital period, increasing the profile of hospitalization and, as a result, optimizing the provision of medical care in the pre-hospital period.

The long-term experience of the work of the aeromedical teams of the Center for Emergency Medical Care shows that in the conditions of a megalopolis with the unforeseen course of an emergency, traffic congestion on the roads and obstructed traffic, the use of an ambulance helicopter with qualified specialists of AMT on board, equipped with modern medical equipment, allows to successfully perform emergency medical evacuations of the injured [20].

It is extremely difficult to perform intubation in the cabin of a light-class air ambulance helicopter. However, the performance of ALV with tracheal intubation is a life-saving manipulation, which cannot be delayed.

The distribution by type of injury to victims who were given ventilation during medical evacuation by light-class ambulance helicopter in 2016-2021 is shown in the figure.

All light-class ambulance helicopter AMTs are equipped with the following ventilators: "Medumat Standard A",

"Medumat Transport" ("Weinmann Emergency", Germany); "Oxylog 2000", "Oxylog 3000+" ("Draeger", Germany); "Rulmonetic LTV-1200" (Sage Fusion, USA); Ambu bags for manual ventilations. In one case, AMT specialists used "Stephan 120 Mobil", which allows adequate invasive respiratory support for newborns with body weight <5 kg.

In addition, AMT physicians had at their disposal the tools necessary to perform tracheal intubation and noninvasive ventilatory support (nALV). The oxygen supply in 2 and 5 L cylinders was sufficient to provide respiratory support.

Discussion

One of the peculiarities, which influenced the determination of tactics in trauma patients, is the necessity to take into account the general medical situation in mass admissions. In these cases, the provision of medical assistance began with medical triage of the injured, which for AMT specialists was mainly to determine the indications for medical helicopter evacuation and identify victims in need of emergency medical care and medical evacuation in the first place — a light-class helicopter can take on board not more than two heavy victims

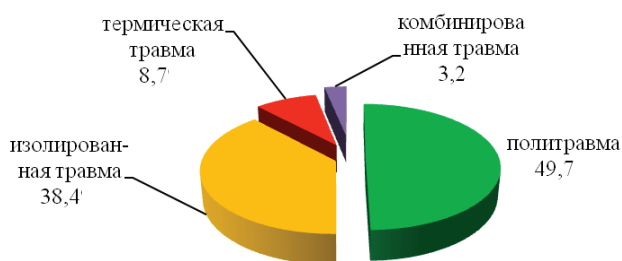


Рисунок. Распределение по видам травм пострадавших, эвакуированных санитарным вертолетом легкого класса, %
Figure. Types of injuries in victims evacuated by a light-class ambulance helicopter, %

at a time. This took into account not only the severity of the patient's condition at the time of the initial examination, but also the predicted tendency for deterioration even against a background of relative apparent well-being.

No invasive methods were used at the triage stage. All therapeutic measures involving complex manipulations and individual approach to the patient were performed after transferring him to the ambulance/emergency medical care team, emergency response team or AMT.

The duration of this phase should not exceed a few minutes, except in cases of widening of the lesion and prolonged evacuation of victims from the lesion, for example, in a collapse.

At the next stage of emergency medical aid, when the victims were handed over to the medical teams, the help was rendered, if possible, taking into account the individual features of the victim and — necessarily — taking into account the conditions of further transportation. In the practice of AMT we mainly followed the tactics of preparing the victims for transportation in the maximum volume and in the shortest possible time before their delivery on board. The preference for such tactics was due to the limited space in the aircraft cabin, making it difficult to safely perform such manipulations as reliable venous access, tracheal intubation and pleural puncture. For the same reason, we adhered to the concept of expanding the indications for early initiation of respiratory support, including invasive one.

In case of moderate or stably severe condition without consciousness impairment, with stable systemic hemodynamics, without pronounced ALS and a tendency to deterioration in the near future, noninvasive method was preferred.

All trauma victims without unconsciousness at the time of examination and with multiple skeletal injuries received oxygen insufflation up to 10 L/min; if the effect of oxygen therapy was insufficient, the next step was continuous positive airway pressure (CPAP) or tracheal intubation and transfer to invasive ALV.

Indications for invasive respiratory support in the prehospital period were:

- progressive depression of consciousness;
- progressive bradypnoea, tachypnoea, or obstructive breathing disorders;
- psychomotor agitation not controlled by analgesia and subhypnotic doses of benzodiazepines;
- seizure syndrome;
- instability of hemodynamics — in this case, attention was paid not only to the figures of arterial pressure (BP), but also to the increase of tachycardia or, on the contrary, to the tendency to bradycardia;
- dynamic desaturation, resistant to oxygen insufflation.

The following were considered as absolute indications for invasive ALV: depression of consciousness to coma; tachypnea from 35/min; bradypnea up to 10/min; systolic BP <70 mm Hg with no effect from infusion therapy; SpO₂ <90% against O₂ insufflation.

Due to the aforementioned expansion of indications for preventive transfer to invasive ventilatory ventilation, our experience with the use of nALV in AMTs practice in trauma — in contrast to the similar experience of EMCC emergency response teams in somatic pathology, especially during the Covid-19 pandemic — is small — 2 cases of thoracic injury with chest contusion and suspected cardiac contusion from a traffic accident (RTA) with a favorable outcome. In both cases, a sparing regimen was used: P_{insp} = 6-8 cm H₂O; PEEP = 5-6 cm H₂O, FiO₂ = 40%. The condition of the victims at the time of admission to the hospital was considered to be stably severe; no disorders of consciousness and systemic hemodynamics, gross respiratory disorders, cardiac rhythm and conduction disorders, desaturation below 93% — were noted.

During invasive ALV preference was given to sparing modes with preservation of spontaneous breathing; SIMV, P-SIMV; respiratory volume (RV) — 7-9 ml/kg of patient body weight; respiratory rate (RR) — 14-16/min in adult victims; PEEP — 5-6 cm H₂O; FiO₂=40-60%. For skeletal trauma, cervical spine trauma, volume-controlled ALV was generally sufficient to safely transport the casualty to the hospital; while patients with cervical trauma were better able to tolerate higher, up to 10-12 ml/kg, PEEP at lower (up to 12/min) respiratory rate. For patients with TBI and severe thoracic trauma, pressure-controlled ventilation was preferable; at the same time, we aimed for PEEP not to exceed 6-7 mm H₂O, P_{peak} — 30 cm H₂O. Due to time deficit in the prehospital period, patient synchronization with the machine required deep sedation and analgesia. In case of insufficient effect of ALV in a given mode the ventilator parameters were selected individually; in addition, if necessary, additional measures were taken — drainage of pleural cavity in tension pneumothorax, deepening of sedation, muscle relaxation with transfer to forced modes of ALV. In all cases of invasive ALV saturation of the upper airway was carried out.

Conclusion

1. In patients with various types of trauma and acute respiratory failure, polytrauma predominated among nosological forms.

2. The choice of type and mode of respiratory support and of method of ensuring airway patency in patients with acute respiratory failure evacuated by a light-class ambulance helicopter requires a differentiated approach to the choice of method from the AMT doctors.

3. In AMT practice, when providing emergency medical care to critically injured patients using light class helicopters, the tactics of preventive transfer of patients to invasive ventilation is justified. At the same time, it is preferable to perform ventilation with preservation of spontaneous breathing and pressure control, which requires adequate analgesia and prevention of cardiodepressive and arrhythmogenic effects of tracheal intubation.

4. The use of non-invasive ventilation in the practice of AMT requires further study and development.

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