

Research Article

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Aeromedical Transportation of Patients with Acute Trauma in a Metropolis: Follow-up on the Issue and Own Experience of Moscow Territorial Scientific and Practical Center for Disaster Medicine Department of the Moscow Health Department

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ABSTRACT In connection with the expansion of the administrative boundaries of the city of Moscow, the number of trauma cases, including those associated with road traffic accidents, man-made accidents, and industrial accidents, remains at a high level. The provision of emergency medical care and transportation of patients with acute trauma is one of the important tasks of the territorial center of disaster medicine in Moscow. Aeromedical evacuation of victims to hospitals of the metropolis allows adhering to the rule of the "golden hour", which certainly affects the reduction of disability and mortality in road traffic incidents and accidents.

Keywords: disaster medicine, emergency, aeromedical brigades, metropolis

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AMT – aeromedical team

BP - blood pressure

CI - confidence interval

GCS – Glasgow Coma Scale

HEMS – helicopter emergency medical service

HR – heart rate

RTA – road-traffic accident

OR – odds ratio

SPCEMC – Scientific and Practical Center for Emergency Medical Care

The provision of emergency medical care and transportation of patients with acute injuries is one of the priorities of disaster medicine, the head institution of the territorial service of which is the State Budgetary Healthcare Institution "Scientific and Practical Center for Emergency Medical Care of the Moscow City Health Department" (SPCEMC). Trauma is the second most important pathology in the statistics of urgent mortality.

In 2016, 4.9 million people worldwide died as a result of injuries, 29% (1.4 million) of them as a result of road traffic accidents (RTAs) [1]. Trauma is the leading cause of death in Americans under 40 years of age, with prehospital mortality in patients with penetrating trauma reaching 22.6% [2]. The consequences of severe injuries are a common cause of primary disability – 6th place in 2019, and account for 4.3% in the structure of the total accumulated contingent of disabled people among the adult population of the Russian Federation [3].

At the same time, modern means of providing medical care to patients with injuries, the use of high-tech methods and a wide range of medical rehabilitation measures enable the patient to partially or completely restore lost functions, even with a significant initial impairment. One of the most important conditions for this is the timely and full provision of primary emergency medical care, as well as the rapid and immediate evacuation of the victim to a specialized hospital - a decrease in transportation time directly affects survival in acute trauma [4].

On July 1, 2012, the Troitsky and Novomoskovsky administrative districts joined Moscow, which have a large territory with settlements at a considerable distance from multidisciplinary hospitals, as well as the frequent traffic congestion of the city's highways, create prerequisites for the use of air medical transport to provide emergency medical care and transport patients with severe concomitant injury.

Medical evacuation of patients with acute trauma is one of the main reasons for the use of helicopter emergency medical service (Helicopter Emergency Medical Service, HEMS) in most countries of the world, both in urban and rural areas. In Europe, as of 2011, more than 300 helicopters from 77 HEMS organizations provided emergency care to trauma patients in 22 countries [5]. The most common reasons for using helicopters for trauma evacuation in Europe are falls from a height, penetrating trauma, severe trauma requiring prolonged transport, and multiple injuries. A systematic review of studies by D.P. Butler (UK) et al. in 2010, was devoted to comparing two methods of medical transportation of patients with injuries - helicopter and ground, in terms of their impact on mortality; the results of the review did not give unambiguous answers, but they outlined the key positions of the problem under study. According to the authors of the review, HEMS is effective and preferable to ground rescue under certain circumstances: the frequency of injuries in a particular region, the geographical location of hospitals, the length of the helicopter's stay on the road, the professional capabilities of the aeromedical team (AMT) and the presence of strictly defined tasks and protocols must be taken into account [6].

Of the 40 910 sorties by medical helicopters in Poland between 2011 and 2016, 13% were due to acute trauma, while the authors conclude that the air evacuation of victims is safe based on the absence of deaths over the entire studied time period [7]. According to a study conducted in 2019, trauma was one of the two main reasons for calling a medical helicopter in rural areas of Poland (51.04%), along with cardiovascular diseases, while the most typical cohort of victims were men under the age of 64 [8].

In Japan, HEMS has been used to evacuate injured patients since 2001; approximately one third of flights (35%) in the country are due to injury, and the average activation time for a medical helicopter (from receiving an emergency call to requesting a helicopter) in case of an acute injury is 14.3 ± 11.5 minutes [9]. An analysis of the work of the helicopter emergency medical service in Fukushima Prefecture (Japan) showed that in 62.2% of cases the reason for the call was an injury [10].

In 2010, 69 700 trauma patients were flown by helicopter to US Level 1 and Level 2 trauma centers; 44,700 of them (64%) were evacuated directly from the place of injury [11]. ML Moront et al. indicate the effectiveness of helicopters in pediatric trauma in the United States, while the highly specific and sensitive criteria for calling an ambulance helicopter are the state of consciousness on the Glasgow Coma Scale (GCS) and heart rate (HR) [12]. Successful experience of using HEMS for the evacuation of patients with acute trauma from winter resorts in the United States was noted, in this case, the most accurate criteria for the need to use a helicopter were the GCS consciousness assessment and pulse oximetry [13]. Also in the United States, the University of Texas Trauma Center, based on a 5-year analysis of the work of the HEMS service, concluded that the time spent by the medical helicopter team on the scene was of the utmost importance - its increase was closely correlated with an increase in the death rate of patients with injuries. Acute trauma has been found to be highly time-sensitive, especially in its earliest moments, and HEMS provides a faster way to reach severely injured patients and provide them with the care they need. The authors of the study noted the importance of using HEMS ambulance helicopters in severe concomitant injury and in rural areas. Limiting factors for the operation of the service were also identified - the risk of accidents, the small size of the cabin, the high cost of operation, the need to take into account the weight of the crew and the patient, the schedule of other aircraft, weather

conditions, fuel supply. Of 288 airlifted patients, 91.6% had blunt trauma and 8.4% had penetrating trauma, and mortality during evacuation over 5 years was 7.6% (22 people) [14].

Another large study (61 909 patients) conducted in the United States found an increased chance of survival of adult patients with serious injury when they were hospitalized using the HEMS service. The statistics of deaths during the evacuation of patients with injuries by a medical helicopter was 12.6% [15]. This highlights the high financial cost of this type of medical evacuation: in Maryland, the average estimated cost of helicopter transportation is \$5 000, and the annual cost of helicopter transportation to a trauma center ranges from \$114 777 to \$4.5 million per facility.

An earlier study of HEMS in Massachusetts also found a significant reduction in mortality during medical evacuation of patients with trauma by an ambulance helicopter (odds ratio - odds ratio (OR) 0.76; 95% confidence interval (CI) 0.59–0.98; $p = 0.031$) [16]. Multivariate logistic regression analysis of the effect of prehospital helicopter transportation on survival of patients with traumatic brain injury in the United States revealed its association with increased survival of patients as if they were hospitalized in trauma centers of the 1st level (OR 1.95; 95%, CI 1.81– 2.10; absolute risk reduction 6.37%) and level 2 (OR 1.81; 95%, CI 1.64–2.00; absolute risk reduction 5.17%). At the same time, mortality during transportation by a medical helicopter was 12% and 10.6% for the centers of the 1st and 2nd levels, respectively [17].

Considering the difficult to predict outcome and the long period of hospitalization and rehabilitation in case of untimely specialized treatment of patients with spinal cord injury, the HEMS service is actively used in the USA for their transportation to centers; 6,929 such patients were transported in 34 states from 2004 to 2011, with an average transport time of 63 minutes; the duration of none of the cases of transportation did not exceed 2 hours [18].

Trauma care for the population of remote and rural areas of Scotland is based on the use of 3 HEMS helicopters [19]. In the structure of the national trauma system used in Scotland for 2013–2014. medical helicopters evacuated 192 patients with injuries (0.2% of the total number of injuries), mainly from island and mountainous areas [20]. About 30% of cases of a medical helicopter call in Norway in 2015 were also due to traumatological incidents [21].

Evacuation of patients with trauma by medical helicopters is widely used in rural regions of Japan, with a large proportion of severe (41%) and combined (22%) injuries, often (39%) requiring resuscitation [22]. A cohort retrospective study by Asuka Tsuchiya et al. compared the performance of Japan's helicopter and ground emergency medical services in transporting severely injured patients between 2004 and 2014. The authors found a significantly lower mortality rate in severely injured adult patients evacuated by HEMS compared with ground service after statistical adjustment for confounding factors [23]. A significant increase in the survival of patients with trauma during evacuation by helicopter from remote rural areas of Australia was noted [24].

In Germany, helicopters have been used as part of a nationwide emergency medical network since 2004, including for the evacuation of injured patients. According to the results of a comparative study with the ground rescue service, H. Andruszkow et al., which included 52,281 trauma patients, of which 31.2% were hospitalized with HEMS, found a clear positive effect of helicopter evacuation in reducing post-traumatic in-hospital mortality in all age groups (OR 0.81, 95% CI 0.75– 0.87, $p < 0.001$), with the greatest severity in the subgroup of older patients with "low energy" injuries. Among the possible reasons for such results are "aggressive" treatment at the scene, as well as early and direct hospitalization of victims in level 1 trauma centers [25].

In Denmark, HEMS teams have been in place since May 2010 and have resulted in reduced time to referral, fewer secondary transfers, and reduced 30-day mortality in severely injured patients [26]. Similar data (decrease in mortality in adults with blunt trauma) for medical evacuation by medical helicopter teams were obtained by Kyoungwon Jung et al. in South Korea [27].

In reviewing the literature on HEMS performance in 12 European countries, Siobhán Masterson et al. It has been noted that helicopter ambulances are usually staffed with highly qualified medical personnel with a wider range of competencies and experience compared to the ground emergency service, which can also be reflected in the statistics of outcomes in evacuated patients with acute trauma [28]. The need for a doctor in the helicopter AMT is indicated by the results of a large retrospective observational study conducted in the Netherlands [29]: for 100 HEMS calls staffed by doctors, there are an additional 5.33 saved lives of patients with severe injuries. In contrast, prehospital intubation of patients with traumatic brain injury by paramedics or other healthcare professionals with limited professional experience was associated with an approximately two-fold increase in the odds of mortality (OR 2.33, 95% CI 1.61–3.38, $p < 0.001$) [30].

Injuries are a frequent reason for calling AMT SPCEMC in Moscow. Since 1995, when air ambulance began operating in Moscow, SPCEMC helicopters have been actively used in the medical evacuation of victims of road accidents with combined types of injuries. The dynamics of aeromedical helicopter departures in Moscow due to car accidents from 1997 to 2017 clearly shows the relevance of CEMC air ambulance transport in relation to this category of patients (Fig. 1).

Since 2005, in addition to calling an aeromedical helicopter “directly” in case of an accident, the method of “call a helicopter ambulance on yourself” has been actively used, based on close cooperation between the SPCEMC and the A.S. Puchkov Ambulance Station of the Moscow Health Department.

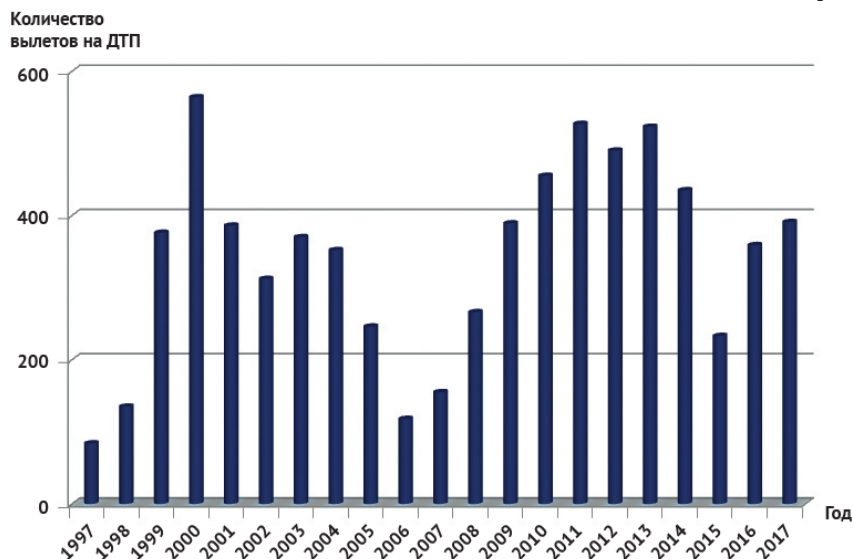


Fig. 1. Statistics of departures of aeromedical teams of the Scientific and Practical Center of Emergency Medical Care in cases of road traffic accidents (RTA) in Moscow, 1997–2017

Since 2017, after the opening and improvement in Moscow, first of the “infarction” and then “stroke” network of invasive centers, there has been a significant increase in the proportion of “acute” somatic patients with vascular accidents transported by AMT SPCEMC. However, the importance of the service in the evacuation of patients with severe injuries has not decreased (Fig. 2).

Thus, in 2017 and 2018, the proportion of cases of medical care provided by AMT specialists to patients with acute injury was about half of all departures (47% and 53%, respectively). In 2019, the proportion of evacuated patients with trauma decreased to 37% due to the expansion of the activity of Moscow’s ambulance transport in relation to somatic patients, however, 58 sorties of medical helicopters were made due to injury, which is only 11 sorties less than in 2018, and 4 departures less than in 2017.

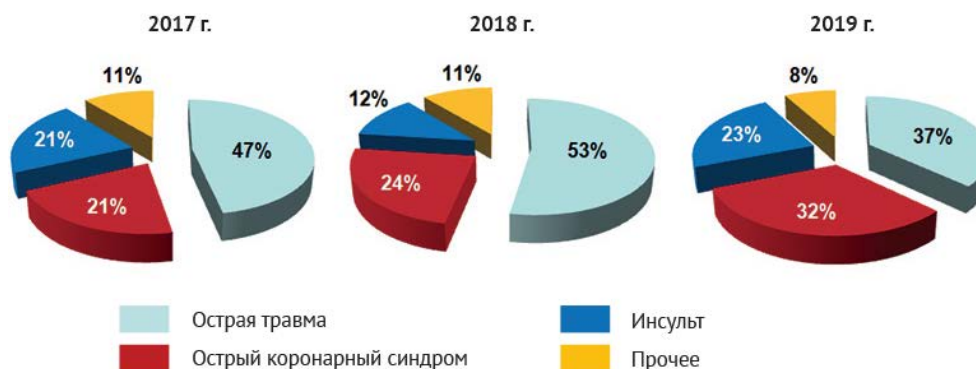


Fig. 2. Statistics of cases of medical care and transportation by aviation medical teams of the Scientific and Practical Center of Emergency Medical Care according to nosological units in Moscow, 2017–2019

Until 2018, the provision of medical care by AMT SPCEMC specialists was possible only during daylight hours; since June 2018, 3 ambulance helicopters have been on duty around the clock, 2 more helicopters are additionally involved in the presence of a large number of victims [30].

Transportation of the injured is carried out by light ambulance helicopters EC-145, equipped with a full range of medical equipment for resuscitation and anesthesia, which may be required by patients with severe concomitant injury [31]. The presence of an automatic compression device and an apparatus for extracorporeal membrane oxygenation in the configuration of a medical helicopter practically eliminates the concept of “non-transportability”, allowing transportation of patients with polytrauma even in critical condition [32, 33].

Clinical example

August 15, 2020 at 13:35 - call of the AMT SPCEMC to the Golyanovo district (Eastern administrative district of Moscow) to the scene of an accident. Helicopter takeoff from the base at 1:40 p.m. At 2:00 p.m. the team arrived.

A 28-year-old male patient M., a bus driver who was injured in an accident, is on the shield after deblocking. No active complaints. No chronic diseases in the anamnesis.

Upon examination: the general condition is severe. Consciousness is clear. The skin is pale. During auscultation, vesicular breathing is heard over the lungs, it is weakened over the left half of the chest, there are no wheezing. The respiratory rate is 16 per minute. The pulse is rhythmic, weak filling. Auscultation: the heart rhythm is regular, the tones are clear. Heart rate - 110 beats/min. Blood pressure (BP) - 90/60 mm Hg. The abdomen is soft and painless. There are no focal neurological symptoms. Horizontal small-scale nystagmus.

Local status:

1. There are traces of blood in the nasal passages.
2. The left thigh is deformed, dramatically enlarged, with intense edema in the middle third, the left lower limb is shortened to 20 cm, rotated outwards; distal to the hip deformity, pulsation of the main arteries and sensitivity are not determined.
3. On the left half of the chest along the axillary line in the projection of the 8th, 9th and 10th ribs - bruising and crepitus upon palpation.
4. Bleeding laceration about 4x4 cm on the anterior surface of the left knee joint.
5. Soft tissues of the lower third of the left forearm with tense edema, local pain upon palpation and limitation of movements of the left hand are noted.

Pulse oximetry (SpO₂): 93%.

Diagnosis: Severe multisystem trauma. Closed craniocerebral injury. Brain concussion. Complicated closed fracture of the left femur. A lacerated wound in the area of the left knee joint. Closed chest trauma. Fracture of the 8th, 9th and 10th ribs on the left. Traumatic shock.

Emergency Therapy: Fentanyl 100 mcg intravenously.

Take-off from a place at 2:24 p.m.

Therapy:

1. Immobilization of the cervical spine with a Shants collar.
2. Immobilization of the patient using a vacuum mattress.
3. Isotonic sodium chloride solution 500 ml intravenously.
4. Voluven solution 6% - 500 ml intravenously.
5. Treatment of the wound of the left knee with 3% hydrogen peroxide solution, aseptic dressing.
6. Oxygen inhalation 100%, 10 l/min.

At 2:34 p.m., the patient was taken to the City Clinical Hospital. S.S. Yudina, the condition is stable, severe, without negative dynamics, heart rate – 100 bpm, blood pressure – 120/80 mm Hg, SpO₂ – 97% against the background of oxygen therapy.

At 3:38 p.m. the helicopter returned to base.

The time from receiving a call to arriving at the place is 25 minutes.

The duration of patient transportation is 10 minutes.

The transportation distance is 22 kilometers.

CONCLUSION

In conclusion, we can once again emphasize the relevance of the use of ambulance helicopters in providing medical care to patients with severe injuries in a metropolis. The dynamic development of the infrastructure of the city of Moscow, the presence of new large territories predetermine the need for the targeted use of aeromedical teams of the Scientific and Practical Center for Emergency Medical Care of the Moscow Health Department in case of acute injury; reduction of the period from injury to the provision of fast qualified medical assistance, as well as rapid transportation of the victim to a hospital with the possibility of high-tech intervention, are often decisive in relation to both the prognosis of life and the severity of the consequences of a multisystem injury.

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