

## RESULTS OF OPTIMIZATION OF SANITARY AVIATION EVACUATION IN THE CONDITIONS OF A METROPOLIS

S.A.Gumenyuk

State Budgetary Health Institution of Moscow "Scientific and Practical Center of Emergency Medical Care of the Moscow City Health Department". Moscow, Russian Federation

**Abstract.** The aim of the study is to analyze the main results of optimization of the work of aviation medical brigades in a metropolis and the dynamics of typical reasons for refusal to use an ambulance helicopter.

**Materials and research methods.** The article presents the characteristics of the BK-117C-2 (EC-145) helicopter used to deliver patients to a specialized medical organization.

A retrospective analysis of all aviation medical brigades flights of the Scientific and Practical Center for Emergency Medical Aid of the Moscow Department of Health in 2017–2019, as well as a comparative analysis of aviation medical brigades performance indicators for 2005–2007 and 2017–2019, was carried out. The main compared indicators: time from the call to the departure of an ambulance helicopter to a patient; time of aviation medical brigade arrival to the place of call; total time before the patient is admitted to a specialized hospital; typical reasons for a refusal to use a helicopter when there is a call for it.

**Research results and their analysis.** The analysis of the research results led to the following conclusions:

- use of helicopters to provide emergency medical care and to carry out air ambulance evacuation of patients in a metropolis makes it possible to successfully solve a number of complex problems. With the start of optimization and the introduction of algorithms for the operation of ambulance helicopters, flight time to a patient decreased by 2019, compared to 2007, by 1.9 times – from  $(33.2 \pm 1.07)$  to  $(17.8 \pm 0, 72)$  min;
- when evaluating the results of optimizing the aviation medical brigades work in Moscow, it should be borne in mind that there are objective limitations when using an ambulance helicopter. If you do not take into account reasons such as a patient's refusal or a lack of indications for helicopter evacuation, impossibility of using an ambulance helicopter in the metropolis was on average: in 2017–2019 – 6.51% (210 cases per 3227 applications); in 2005–2007 – 10.23%. For about 10 years, impossibility of evacuating a patient to a specialized hospital has decreased for objective reasons by 3.72%, which emphasizes the effectiveness of the developed algorithms for air ambulance evacuation of urgent patients in a metropolis.

**Key words:** ambulance brigades, aviation medical brigades, BK-117C-2 (EC-145) helicopters, emergency medical assistance, helicopter use algorithms, medical organization, metropolis, optimization, sanitary aviation evacuation, Scientific and Practical Center for Emergency Medical Aid of the Moscow Department of Health

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

**For citation:** Gumenyuk S.A. Results of Optimization of Sanitary Aviation Evacuation in the Conditions of a Metropolis. *Meditsina katastrof = Disaster Medicine*. 2021;2:77-80 (In Russ.). <https://doi.org/10.33266/2070-1004-2021-2-77-80>

## РЕЗУЛЬТАТЫ ОПТИМИЗАЦИИ ПРОВЕДЕНИЯ САНИТАРНО-АВИАЦИОННОЙ ЭВАКУАЦИИ В УСЛОВИЯХ МЕГАПОЛИСА

С.А.Гуменюк

ГБУЗ «Научно-практический центр экстренной медицинской помощи Департамента здравоохранения города Москвы», Москва, Россия

**Резюме.** Цель исследования – проанализировать основные результаты оптимизации работы авиамедицинских бригад (АМБр) в мегаполисе и динамику типичных причин отказа в вылете санитарного вертолета.

**Материалы и методы исследования.** Представлена характеристика вертолета БК-117С-2 (EC-145), используемого для доставки пациентов в профильные лечебные медицинские организации (ЛМО).

Выполнен ретроспективный анализ всех вылетов АМБр Научно-практического центра экстренной медицинской помощи Департамента здравоохранения г. Москвы (ЦЭМП) в 2017–2019 гг., а также сравнительный анализ показателей работы АМБр за 2005–2007 и 2017–2019 гг. Основные сравниваемые показатели: время от поступления вызова до вылета санитарного вертолета к пациенту; время прибытия АМБр на место вызова; общее время до поступления пациента в профильный стационар; типичные причины отказа в вылете вертолета при наличии вызова.

**Результаты исследования и их анализ.** Анализ результатов исследования позволил сделать следующие выводы:

- использование вертолетов для оказания экстренной медицинской помощи и проведения санитарно-авиационной эвакуации пациентов в мегаполисе позволяет успешно решать ряд сложных задач. С началом оптимизации и введением алгоритмов работы санитарных вертолетов время полета до пациента уменьшилось к 2019 г., по сравнению с 2007 г., в 1,9 раза – с  $(33,2 \pm 1,07)$  до  $(17,8 \pm 0,72)$  мин;
- при оценке результатов оптимизации работы АМБр в Москве следует иметь в виду, что в столице существуют и объективные ограничения при использовании санитарного вертолета. Если не учитывать такие причины, как отказ пациента или отсутствие показаний к вертолетной эвакуации, то невозможность использования санитарного вертолета в мегаполисе

составляла в среднем: в 2017–2019 гг. – 6,51% (210 случаев на 3227 заявок); в 2005–2007 гг. – 10,23%. В течение примерно 10 лет невозможность эвакуации пациента в профильный стационар снизилась по объективным причинам на 3,72%, что подчеркивает эффективность разработанных алгоритмов санитарно-авиационной эвакуации urgentных пациентов в мегаполисе.

**Ключевые слова:** авиамедицинские бригады, алгоритмы использования вертолета, бригады скорой медицинской помощи, вертолеты BK-117C-2 (EC-145), лечебные медицинские организации, мегаполис, Научно-практический центр экстренной медицинской помощи Департамента здравоохранения г. Москвы, оптимизация, санитарно-авиационная эвакуация, экстренная медицинская помощь

**Для цитирования:** Гуменюк С.А. Результаты оптимизации проведения санитарно-авиационной эвакуации в условиях мегаполиса // Медицина катастроф. 2021. №2. С. 77-80. <https://doi.org/10.33266/2070-1004-2021-2-77-80>

#### Contact information:

**Sergey A. Gumenuk** – Cand. Sci. (Med.), Deputy Director of Medical Unit of Scientific and Practical Centre of Emergency Medical Care

**Address:** 5/1 bldg. 1, Bolshaya Sukharevskaya square, Moscow, 129010, Russia

**Phone:** +7 (495) 608-75-55

**E-mail:** npcemp@zdrav.ru

#### Контактная информация:

**Гуменюк Сергей Андреевич** – кандидат медицинских наук, заместитель директора по медицинской части НПЦ ЭМП ДЗМ

**Адрес:** Россия, 129010, Москва, Большая Сухаревская пл., д. 5/1, стр. 1

**Тел.:** +7 (495) 608-75-55

**E-mail:** npcemp@zdrav.ru

In large cities of the Russian Federation, the share of diseases of cardiovascular system in the structure of requests for emergency medical care is 47–52%; of central and peripheral nervous system – 14–17%; of acute surgical pathology of abdominal organs – 9–12%; of respiratory diseases – 8–10%. In 2018, more than 3.9 million people were provided with emergency and urgent medical care in Moscow. [1–4].

According to the World Health Organization – WHO (2015), in the structure of prehospital mortality the first place is occupied by coronary heart disease. The causes of coronary death were: acute myocardial infarction (35.8%); acute coronary (36.6%) and cardiovascular (27.6%) insufficiency. Among people aged 45–75 years, in 52% of cases the death was sudden and occurred within first 1–2 hours after the onset of symptoms, while in 25.6% of cases prehospital resuscitation measures were successful [5].

The reason for optimizing the previously existing approaches to air ambulance evacuation with the use of helicopters was the assessment of prehospital measures for the main urgent diseases requiring special treatment: acute coronary syndrome; acute cerebrovascular accident – stroke; traumatic brain injury; bleeding [6–8]. In patients with the above diseases, an increased likelihood of developing an early lethal outcome was perceived. In a number of cases, there were long intervals between the call to ambulance and the delivery of the patient to a specialized hospital. At the same time, it should be emphasized that the time from the onset of the disease until the arrival of an urgent patient to a specialist doctor is an extremely important factor.

**The aim of the study** is to analyze the main results of optimization of the work of aviation medical brigades in megacities and the dynamics of main reasons for the refusal for ambulance helicopter usage.

**Materials and research methods.** In Moscow, BK-117C-2 (EC-145) helicopters are used to deliver patients to specialized medical organizations – Figure 1.

In everyday use of helicopter, its transformable cabin is equipped with a stretcher. If necessary, the helicopter can be retrofitted with a second stretcher or with an incubator for transporting newborns. The equipped medical wall contains: depending on the helicopter board – either 2 Dräger Oxylog 3000 Plus artificial lung ventilation devices (IVL), or Dräger Oxylog 1000 and LTV 1200 Pulmonic ventilators; Corpuls 3 combined device with a built-in GSM satellite mo-

dem, including a monitor, defibrillator, pacemaker; at least two B. Braun Perfusor Space syringe pumps. Each board is equipped with a dielectric floor, which makes it possible to perform electro-pulse therapy in flight. All equipment used to operate these helicopters is certified for use on aircraft.

A retrospective analysis of all aviation medical brigades flights of the Scientific and Practical Center for Emergency Medical Aid of the Moscow Department of Health in 2017–2019, as well as a comparative analysis of aviation medical brigades performance indicators for 2005–2007 and for 2017–2019 was carried out. The main compared indicators: time from the call to the departure of an ambulance helicopter to a patient; time of aviation medical brigade arrival at the place of call; total time before the patient is admitted to a specialized hospital; main reasons for the refusal to use a helicopter in case of a call for it.

**Research results and their analysis.** Currently, in Moscow, in all cases, except for cases of interhospital medical evacuation, an ambulance team is sent to the patient's location. Its specialists decide: whether an ambulance helicopter is needed for hospitalization of the patient or not; whether the helicopter will be able to land at the scene of the event, or it is possible to transfer the patient to an intercepting platform, which reduces overall hospitalization time.

To optimize aviation medical brigades operation, the following algorithms were developed for using the helicop-



**Рис. 1.** Вертолет санитарной авиации, используемый при госпитализации пациентов  
**Fig. 1.** Ambulance helicopter used for hospitalization of patients

ter to provide medical care to the population of Moscow: "Arrival of the helicopter before the arrival of an ambulance brigade"; "Arrival of the helicopter after the arrival of an ambulance brigade"; "Medical evacuation from medical institutions"; "Work of aviation medical brigades in an emergency situation"; "Transfer of the patient from an aviation medical brigade to an ambulance team if it is impossible to use a helicopter."

In each specific case, we tried to determine the most optimal indications, to minimise the time and to adapt approaches to hospitalization of patients in specialized medical facilities using a medical helicopter for the conditions of Moscow.

Time of arrival of an aviation medical team to a patient in Moscow, an average annual number of aviation medical brigades departures was: in 2017–2019. — (752.3 ± 2.33) cases; in 2005–2007 — (194.0 ± 5.17) cases, which highlights the rapid pace of development of air ambulance in the capital.

An important criterion for the provision of urgent medical care is the time of arrival of a doctor to a patient. Results of the optimisation of aviation medical brigades operation in 2017–2019 are presented in Tables 1, 2.

Thus, an overwhelming majority (78.6%) of flights within Moscow were prepared for departure within 15 minutes from the moment of a call. An average time spent on preparing

an ambulance helicopter for departure was: in 2017–2019. (10.97 ± 1.34) min; in 2005–2007 — (26.48 ± 1.91) min.

The time of flight and evacuation of a patient from the place of his localization to a respective medical organisation was no more than 10 minutes, an average time was (6.83 ± 0.67) minutes both in 2007 and 2019.

Thus, in 2017–2019, the total time from the call to the arrival to the patient in 91.8% of cases was up to 40 minutes, while in 2005–2007 the share of departures within this time frame was 88.3%.

In general, creation of algorithms and their optimization resulted in the fact that by 2019 an average time of arrival to a patient from the moment of a call was reduced from (33.2 ± 1.07) min to (17.8 ± 0.72) min (Figure 2).

"Ideal" — from the point of view of feasibility and validity — can be considered the hospitalization of urgent patients in hospitals from remote areas of the metropolis.

If we compare the delivery of patients to medical organisations by an ambulance helicopter with their hospitalization by ambulance vehicles, the difference was almost 20 minutes. During the evacuation by aviation medical brigades, the total time from the moment of a call till the patient's delivery to

Таблица 1/ Table No 1

**Среднее время готовности АМБр к вылету в 2017–2019 гг.**

Average time span from call to aviation medical brigade readiness for departure 2017–2019

Время от вызова до вылета, мин Time span from call to departure, min	Кол-во вылетов, абс./% Number of departures, abs. / %			Среднее значение, % Average, %
	2017 n=795	2018 n=752	2019 n=710	
До 5 /Up to 5	88/11,2	54/7,2	34/4,8	7,73
5–10	295/37,1	274/36,4	199/28,0	33,83
10–15	255/32,1	275/36,6	301/42,4	37,03
15–20	116/14,6	102/13,6	131/18,5	15,57
20–25	24/3,0	24/3,2	22/3,1	3,1
Свыше 25/Over 25	17/2,1	21/2,8	23/3,2	2,7

Таблица 2/ Table No 2

**Среднее время от поступления вызова до прибытия АМБр на место события в 2017–2019 гг.**

Average time span from call to arrival of aviation medical brigade at the site 2017–2019

Время от вызова до прибытия на место события, мин /Time span from call to arrival at the place, min	Кол-во вылетов, абс./% Number of departures, abs. / %			Среднее значение, % Average, %
	2017 n=783	2018 n=742	2019 n=703	
До 15 /Up to 15	79/10,1	79/10,7	26/3,7	8,17
15–20	164/20,9	143/19,3	40/5,7	15,33
20–25	185/23,6	159/21,4	76/10,8	18,60
25–30	175/22,4	177/23,9	169/24,0	23,43
30–35	103/13,2	95/12,8	184/26,2	17,40
35–40	43/5,5	46/6,2	105/14,9	8,87
40–45	16/2,1	18/2,4	41/5,8	3,43
45–60	10/1,3	12/1,6	37/5,3	2,73
Свыше 1ч/Over 1h	8/1,0	13/1,8	25/3,6	2,13

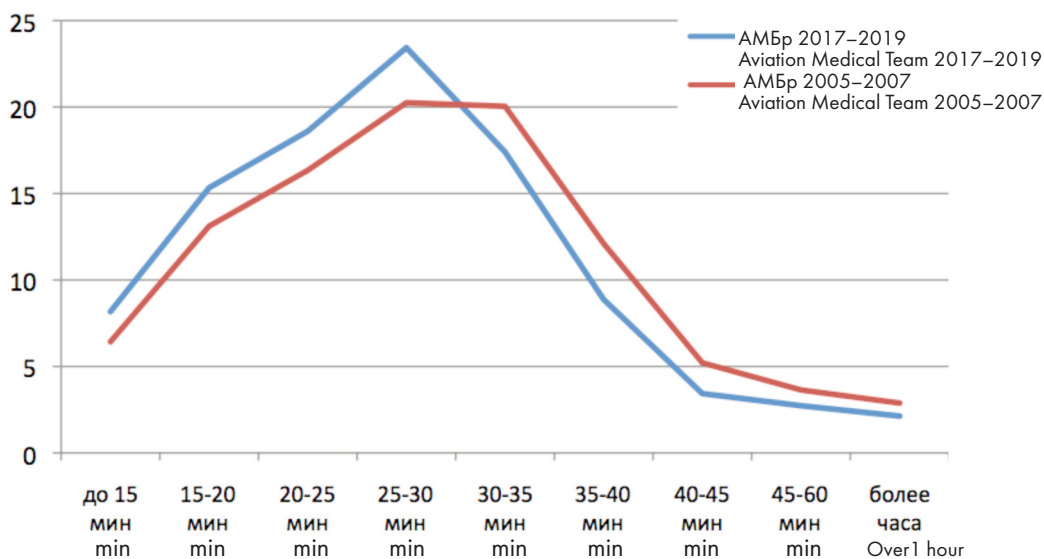


Рис. 2. Временные интервалы от момента поступления вызова до прилета АМБр к пациенту в 2017–2019 гг., %  
Fig. 2. Time intervals from call to arrival of aviation medical brigade in 2017–2019, %

a hospital — when comparing cases with approximately same distance to the hospital — averaged ( $48.8 \pm 9.1$ ) minutes. This is almost 2 times faster, if we do not take into account evacuation from remote areas of the metropolis, when the total hospitalization time using a helicopter and an ambulance car was 90.7 and ( $69.7 \pm 2.44$ ) minutes, respectively. This supports the performance of created algorithms for aviation medical brigades operation.

The main reasons for non-fulfillment of applications for sanitary aviation evacuation

During hospitalization of patients by aviation medical teams in the hospitals of the capital, there were cases when the helicopter, for one reason or another, could not fly to the place of the patient's localization. Reasons for non-fulfillment of requests for the departure of aviation medical brigades in 2017–2019 are presented in Table 3.

The reasons specified in paragraphs 7 and 8 of Table 3 were relevant in 2017, but completely eliminated by 2019. Clause 7 ("No equipped site"), as a rule, meant either a snow-covered area, or inability for ambulance vehicles to approach it for any other reason that prevents landing of a medical helicopter. The issue was resolved through constant checking and snow removal. Clause 8 ("Refueling / crew exchange") — the issue was solved by agreements with the administration of the Moscow Aviation Center — the flight personnel began to take over duty not all at the same time, but at different times. For example, the first helicopter is on duty from 8: 00 to 18:00, the second — from 10:00 to 20:00, the third helicopter — from 12:00 to 22:00.

The above reasons for non-fulfillment of requests for aviation medical teams departure should be taken into account in any megalopolis when creating an emergency medical service in general and air ambulance in particular.

### Conclusion

1. The use of helicopters for the provision of emergency medical care and for the medical and aviation evacuation of patients in a metropolis allows to successfully solve a number of complex problems. With the start of optimization and with the introduction of algorithms for operation of ambulance helicopters, the flight time to the patient decreased in 2019, compared to 2007, by 1.9 times — from ( $33.2 \pm 1.07$ ) to ( $17.8 \pm 0, 72$ ) min.

### REFERENCES

1. Vechorko V.I. The New Standard for Admissions. The Experience of a Moscow Hospital. *Healthcare*. 2019;9:84-94 (In Russ.).
2. Bockeria L.A., Revishvili A.Sh., Neminuschiy N.M. *Vnezapnaya Serdechnaya Smert* = Sudden cardiac death. Moscow, GEOTAR-Media Publ., 2011. 272 p. (In Russ.).
3. Kovaleva N.N. Comparative Analysis of Cases of Sudden Death at the Prehospital and Hospital Stages. Materials of the First All-Russian Congress of Emergency Physicians. Moscow Publ., 2005. P. 39-42 (In Russ.).
4. Petrikov S.S., Parfenov V.E., Mitish V.A. Scientific Achievements in the Field of Emergency Medical Care in the Russian Federation for 2017. Issue 7. Moscow, Research Institute of Emergency Medicine named after N.V. Sklifosovsky Publ., 2018. 126 p. (In Russ.).
5. Potapov V.I., Buk T.E., Kuznetsova N.V. Mortality of the Population from External Causes (according to the literature). *TSEMINFORM*. 2014;5; 125:3-7 (In Russ.).
6. Tulupov A.N., Sinenchenko G.I. *Torakoabdominalnaya Travma* = Thoracoabdominal Trauma. St. Petersburg, Foliant Publ., 2016. 312 p. (In Russ.).
7. Shabunin A.V., Shlyakhovskiy I.A., Maer I.A., et al. Analysis of the Work of the Surgical Service of the Moscow Department of Health in 2016. *Endoscopic Surgery*. 2017;23;4:3-7 (In Russ.).
8. Haasensritter J, Biroga T, Keunecke C, et al. Causes of Chest Pain in Primary Care - a Systematic Review and Meta-Analysis. *Croat Med J*. 2015;56(5):422-430.

Таблица 3/ Table No 3

### Основные причины невыполнения заявок на вылет АМБр в 2017–2019 гг.

Main reasons for the non-fulfillment by aviation medical team of applications for departure 2017–2019

Причины невыполнения заявок Reasons of non-fulfillment of applications	Кол-во заявок, абс./% Number of applications, abs./%			Итого, % Total, %
	2017 n=916	2018 n=873	2019 n=1438	
1. Отмена/запрет по метео-условиям / Cancellation/prohibition due to weather conditions	7	5	10/75	97/3
2. Запрет Федеральной службы охраны / Prohibition of the Federal Guard Service	18	6	54	78/2,4
3. По техническим причинам / For technical reasons	4	4	10	18/0,6
4. Посадка невозможна / Landing is not possible	5	5	7	17/0,5
5. Отсутствие показаний или наличие противопоказаний / Absence of indications or presence of contraindications	5	7	22	34/1,1
6. Отказ пациента/отмена вызова / Patient refusal/call cancellation	82	94	40/16	232/7,2
7. Нет оборудованной площадки / No equipped site	8	-	-	8/0,25
8. Дозаправка/обмен экипажа / Refueling/crew exchange	259/186	-	-	445/13,78

2. When evaluating the results of optimizing the aviation medical brigades work in Moscow, it should be borne in mind that there are objective limitations for an ambulance helicopter usage in the capital. If not taking into account reasons such as the patient's refusal or the lack of indications for helicopter evacuation, the impossibility of using an ambulance helicopter in the megalopolis was on average: in 2017–2019 — 6.51% (210 cases per 3227 applications); in 2005–2007 — 10.23%.

3. Thus, within about 10 years, the impossibility of evacuating a patient to a specialized hospital has decreased for objective reasons by 3.72%, which emphasizes the effectiveness of the developed algorithms for medical aviation evacuation of urgent patients in a metropolis.

### СПИСОК ИСТОЧНИКОВ

1. Вечорко В.И. Новый стандарт приемных отделений. Опыт московской больницы // *Здравоохранение*. 2019. №9. С. 84-94.
2. Бокерия Л.А., Ревихвили А.Ш., Неминущий Н.М. *Внезапная сердечная смерть*. М.: ГЭОТАР-Медиа, 2011. 272 с.
3. Ковалева Н.Н. Сравнительный анализ случаев внезапной смерти на догоспитальном и госпитальном этапах // *Материалы Первого Всероссийского съезда врачей скорой медицинской помощи*. М., 2005. С. 39-42.
4. Петриков С.С., Парфенов В.Е., Митиш В.А. Научные достижения в области скорой медицинской помощи в Российской Федерации за 2017 год. Выпуск 7. М.: НИИ скорой помощи им. Н.В.Склифосовского, 2018. 126 с.
5. Поталов В.И., Бук Т.Е., Кузнецова Н.В. Смертность населения от внешних причин (по данным литературы) // *ЦЭМИНФОРМ*. 2014. №5. С. 3-7.
6. Тулулов А.Н., Сinenchenko Г.И. *Торакoабдоминальная травма*. СПб.: Фолиант, 2016. 312 с.
7. Шабунин А.В., Шляховский И.А., Маер И.А. и др. Анализ работы хирургической службы Департамента здравоохранения Москвы в 2016 г. // *Эндоскопическая хирургия*. 2017. Т.23. №4. С. 3-7.
8. Haasensritter J, Biroga T, Keunecke C, et al. Causes of Chest Pain in Primary Care -- a Systematic Review and Meta-Analysis // *Croat Med J*. 2015. V.56, No.5. P. 422-430.

The material was received 06.04.21; the article after peer review procedure 24.04.21; the Editorial Board accepted the article for publication 15.06.21  
Материал поступил в редакцию 06.04.21; статья принята после рецензирования 24.04.21; статья принята к публикации 15.06.21