Viewpoint on: 5G Key Technologies for Helicopter Aviation Medical Rescue

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Abstract

Background: In the process of medical rescue, the helicopters must quickly and accurately determine the target location, cooperate closely with ground medical personnel, maintain stability during high-speed flight, and achieve real-time data transmission and efficient medical treatment during medical rescue. The highly developed 5G communication technology is essential to achieve the aforementioned objectives.

Objective: This study aimed to explore the application of 5G key technologies in helicopter aviation medical rescue.

Methods: This study used retrospective analysis to statistically analyze 11 aviation medical rescue cases at the Shenzhen University General Hospital from November 2019 to March 2023. To assess the time and efficiency of the rescue, we paid attention to the data such as flight time, distance, disease types, and rescue scenarios. The application of 5G low-altitude network communication technology, body area network disease sensing technology and 5G air-ground collaborative rapid diagnosis and treatment technology in aeromanical rescue was contrasted and explored.

Results: The helicopter rescue flight distance was 60–600 kilometers, and the flight time was 10–136 min. The study used a 5G private network and 5G module vital sign monitoring equipment. The low-altitude 5G network had high communication quality and high-precision localization by the domestically produced Beidou. The air body area network technology used multi-pose mannequins, depth learning estimation algorithm, and encryption algorithm information entropy 7.9993. The encryption time was short. The 5G air-to-ground collaborative rapid diagnosis and treatment technology supported 5G direct connection, with a packet loss rate of 0.2%, and achieved 1080P high-definition multi-party remote consultation.

Conclusions: The combination of helicopter rescue and 5G technology could significantly improve rescue efficiency, shorten response time, and achieve a remote diagnosis. The quality of low-altitude 5G network communication was high, and the domestic Beidou satellite high-precision positioning technology supported precise rescue. The airborne body area network disease perception technology adopted advanced human channel models and encryption algorithms to ensure timely and secure information. The 5G air-to-ground collaborative rapid diagnosis and treatment technology enabled high-quality remote consultation. Applying these innovative technologies might significantly enhance the ability of emergency medical rescue and provide strong support for future rescue operations.

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Viewpoint on 5G Key Technologies for Helicopter Aviation Medical Rescue

Abstract

Rapid global population growth and urbanization have heightened the demand for emergency medical rescue, with helicopter medical rescue emerging as an effective solution. The advent of 5G communication technology, characterized by large bandwidth, low latency, and high reliability, offers substantial promise in enhancing the efficiency and quality of helicopter rescue operations. However, the full integration of 5G technology into helicopter emergency medical services (HEMS) is still in its nascent stages and requires further development. In this viewpoint we present our experience from the Shenzhen University General Hospital of the application of 5G low-altitude network communication technology, body area network disease sensing technology, and 5G air-ground collaborative rapid diagnosis and treatment technology in aeromedical rescue. Where we consider the 5G air-to-ground collaborative rapid diagnosis and treatment technology enabled high-quality remote consultation, enhanced emergency medical rescue, and provides strong support for future rescue operations.

Keywords: low airspace; helicopters; medical aid; 5G technology

Introduction

Helicopter medical rescue has become an effective option for emergency medical assistance as populations and urbanization increase[1]. Such rescues must quickly and accurately determine the target location, cooperate closely with ground medical personnel, maintain stability during high-speed flight, and achieve real-time data transmission and efficient medical treatment[2,3]. To meet these needs, effective communication technology is essential. As one of the most advanced mobile communication technologies at present, 5G technology has advantages such as large bandwidth, low latency, and high reliability. For medical rescue 5G has many advantages[4]. Medical experts can guide on-site medical personnel to provide treatment through remote video and other means, thereby improving the efficiency and quality of medical rescue[5,6].

The development of 5G technology started in 2018, and the first 5G network was put into use in South Korea. Since then, 5G technology has rapidly developed globally. At present, many countries, including the United States, Japan, South Korea, and various countries in Europe, have begun commercial deployment of 5G networks. Applications of 5G technology are also being explored. For example, in the United States, 5G technology has been widely applied in fields such as intelligent transportation and intelligent manufacturing. In Europe, 5G technology is applied in industrial automation and robot control[7]. In Asia, South Korea and Japan are exploring 5G technology in intelligent manufacturing and intelligent health care. China has also led the world in the research and applications of 5G technology[8,9]. Since the end of 2019, China has built the world's largest 5G network and at present, 31 provinces and cities across the country have opened 5G commercial services. China has applied 5G technology to fields such as intelligent manufacturing, intelligent logistics, and smart cities; while in health care it has been used for telemedicine and medical image transmission. Companies such as Huawei and ZTE are leading in the research and development of 5G technology. At the same time, the Chinese government is actively promoting its development and has formulated a series of policy measures to support the promotion and applications of 5G technology.

On August 7, 2022, the aviation rescue drill at Shenzhen University General Hospital

successfully adopted 5G private network access[10]. Through a cooperation agreement with Shenzhen Eastern Navigation Co., Ltd., who provided a guarantee for developing aviation medical rescue programs and services. The work started with four aviation medical rescue drills held from September 2019 to December 2022 in order to lay the technical foundation. The types of diseases considered during these drills included multiple injuries to the whole body and spinal cord, and the scenarios included traffic accidents and tunnel scenes. From November 2019 to March 2023, seven aviation medical rescue operations were conducted covering multiple systemic fractures, spinal injuries, drowning pulmonary edema, multiple organ failure, hemopneumothorax, and other diseases. The types of rescue operations were joint mountain search and rescue, seaside drowning rescue, and traffic accident rescue, with a flight distance of 60–600 km and a flight time of 10–136 min. These operations involved the first aerial pulmonary resuscitation, medical staff delivery, and emergency medical treatment. Among the rescue operations, the joint mountain search and rescue used highly complex technologies such as hovering, winches, and aerial lifting, providing significant support for treating patients[11].

This viewpoint article explores 5G key technologies for helicopter aviation medical rescue to address the shortcomings of traditional air rescue methods in information transmission, positioning accuracy, real-time data transmission, and medical treatment efficiency. We demonstrate the potential of the applications of 5G technology in helicopter medical rescue in terms of improving rescue efficiency, shortening patient treatment time, and enhancing the collaborative combat ability of rescue teams.

Innovative Technology

There are three major problems for medical rescue operations in the air: difficulty in communication, difficulty in disease monitoring, and difficulty in collaborative diagnosis and treatment. To overcome these problems, our team put forward a series of important technological innovations such as developing airborne 5G network communication technology and achieving efficient and stable communication. The body area network disease perception technology provided precise real-time monitoring and 5G air-to-ground collaborative rapid diagnosis and treatment technology, which strengthened the collaborative capacity and efficiency of emergency response teams. Hence, these innovations brought unprecedented breakthroughs to the field of aviation medical rescue, significantly improving rescue effectiveness.

Low airspace medical rescue 5G network technology

Low-altitude 2.6 + 4.9 GHz collaborative networking

The low-altitude medical rescue helicopter provided sidelobe coverage of a 2.6 GHz 5G downtilt base station as a 5G private network access signal during takeoff and landing, with a true height less than 150 m. The main/side lobes of a 4.9 GHz 5G uptilt base station provided 5G private network signal access during takeoff/landing and flight at a true height of 150 m or above. The collaborative coverage of two frequency bands of base stations provided seamless switching of 5G private network access for helicopter vertical takeoff and landing and horizontal flight. The network switching delay was ≤30 ms (Fig. 1).

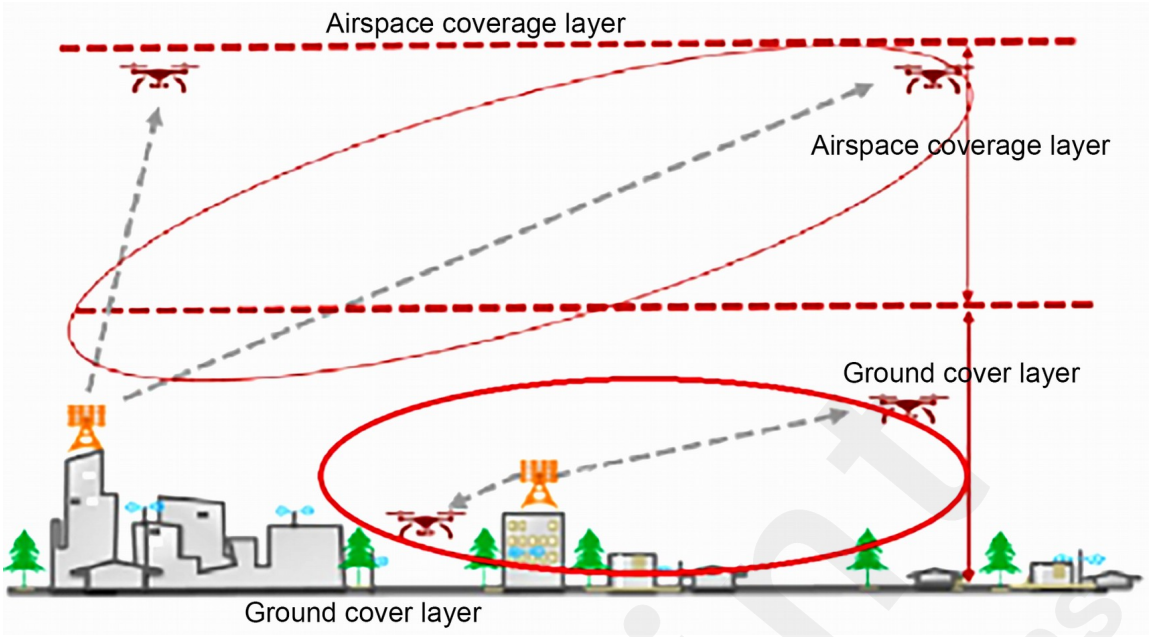

Figure 1. Schematic diagram of 2.6 GHz + 4.9 GHz dual-frequency collaborative 5G networking

Adopting 5G + Global Navigation Satellite System (GNSS) external suction cup antenna

The aircraft body mainly comprises aluminum, significantly attenuating the signal after blocking radio waves. Therefore, we designed an external pull-away suction cup antenna to dock with the onboard 5G router. The external suction cup antenna could be installed on the glass window side of the helicopter (Fig. 2), and directionally received 5G signals from the external airspace of the aircraft body through glass (window) materials with low signal attenuation.

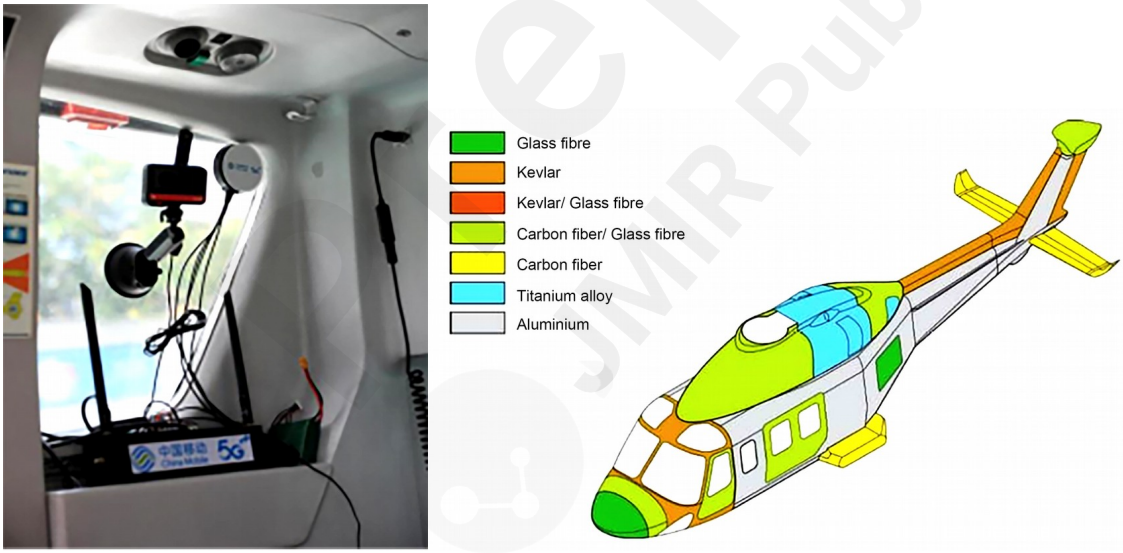

Figure 2. Deployment image of the external 5G + GNSS antenna.
(The antenna was derived from the external suction cup antenna of Guanghetong BGS-910.)

This installation was made on a domestic medical rescue helicopter, with the novel and successful deployment of 5G-CPE equipment. After testing, under this installation method, the attenuation difference of 5G signal inside and outside the body was only 8dB, while 5G-CPE's built-in rubber rod antenna deployed inside the cabin, and the attenuation of 5G signal by the metal material of the aircraft body was 20dB, which is a significant difference.

Collaboration of 5G + Beidou positioning technology

Next, we examined the Beidou positioning capability provided by the 5G-CPE module (Fig. 3). The data were transmitted back to the emergency platform deployed by the hospital via the 5G private network to locate the real-time flight position of the rescue helicopter.

Figure 3. Beidou positioning trajectory map obtained from 5G module.

The traditional positioning scheme for airspace helicopters generally uses a global positioning system (GPS) for the helicopter's built-in flight-positioning module. It does not output positioning data to external systems. It only interfaces with local airspace management departments (regional civil aviation bureaus or air traffic control bureaus) for airspace flight management. For this scheme, we adopted the Guanghetong FM160 model 5G air rescue equipment (Fig. 4) and used the GNSS capability of the 5G module and the antenna to provide GNSS reception, obtaining real-time positioning information for low-altitude medical rescue, and the information output of real-time positioning of low-altitude medical rescue was realized.

Figure 4. 5G module–integrated 5G air rescue equipment with GNSS capability. The module was derived from Guanghetong FM160.

Air body area network disease awareness technology

Construction of a body area network transmission scheme based on body features and channel quality

Communication energy consumption is the key factor that restricts the wider applications of a network with limited energy resources. Human activities drastically affect near-body communication channels, leading to strong time-varying characteristics. This limits the performance of communication energy consumption optimization methods based on wireless sensor networks[12,13]. Therefore, designing an intelligent communication mechanism for body area networks should consider the strong time-varying characteristics of the channel so that the overall transmission energy efficiency can be improved. Our approach was to design a near-body channel estimation algorithm based on deep learning. Treating the time–frequency response of the pilot point as a low-resolution two-dimensional image, using convolutional neural networks and memory networks to generate high-resolution images, and obtaining complete time–frequency response characteristics helped predict and evaluate the current channel quality (Fig. 5). Further, we combined human dynamic channel quality estimation and prediction procedures and studied energy-efficient and adaptive access protocols and resource allocation schemes for improved service quality to achieve stable, flexible, and low-power transmission effects.

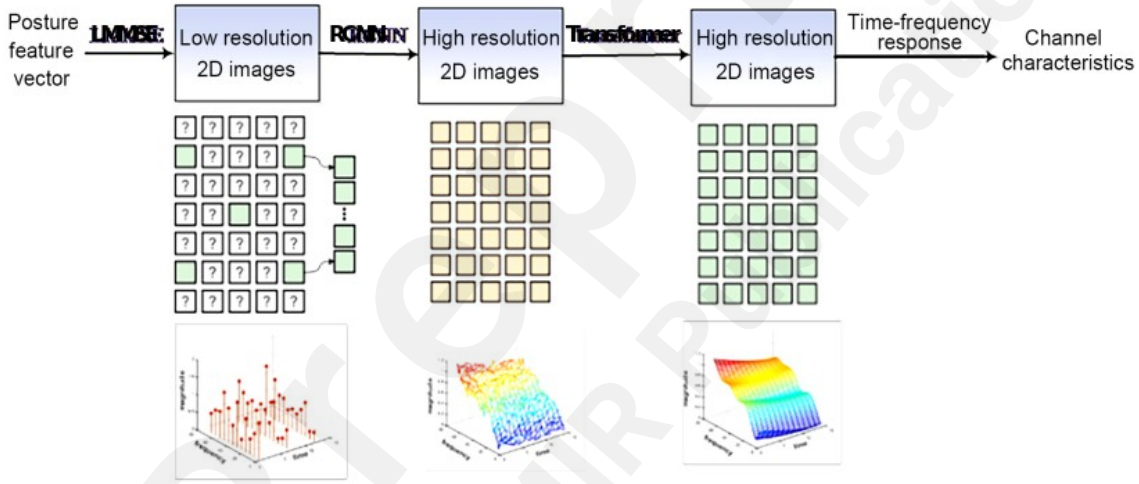

Figure 5. Detection of channel characteristics in body area networks.

Proposing a volume domain network data encryption method based on physical signal features and chaotic mapping

The body area network involves sensitive data and hence requires a high-level security system. The limited sensor resources limit the applicability of traditional encryption schemes. As shown in Figure 6, we used the characteristics of physical signals as the initial chaotic values to design a high-strength and sensitive encryption scheme, providing asymmetric encryption with one key at a time. The main procedures followed in this study were as follows: (1) Calculation of feature vectors for sign signals, precise classification of signal characteristics of physical signs using discrete wavelet transform, and design of multidimensional convolutional neural networks; (2) design and quantification of the algorithm for generating heterogeneous combination chaotic sequences, proposing power spectral entropy as the evaluation criterion, and designing a quantified heterogeneous combination chaotic sequence that met the security requirements of the body area network; (3) implementation and verification of data encryption scheme, proposing a heterogeneous combination chaotic encryption scheme based on sign signal feature vectors and conducting hardware implementation and performance verification based on the field-programmable gate array (FPGA) platform (Fig. 6).

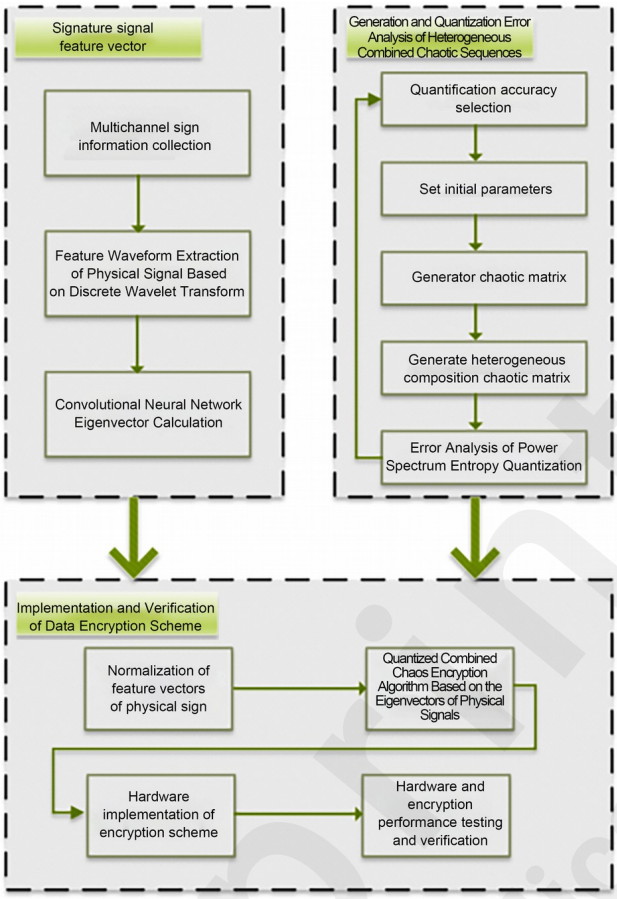

Figure 6. Body area network data encryption method.

5G air-to-ground collaborative rapid diagnosis and treatment technology

Development of a plug-and-play highly reliable 5G emergency equipment

The 5G module has high power consumption, insufficient USB power supply capacity for online medical devices, and unreliable long-term continuous data transmission and communication through a USB-developed 5G single-slot module. (1) We developed a 5G single-slot module using the existing 12-V power supply and direct communication between network ports of online medical equipment. Additionally, we used anti-interference and heat treatment technologies to achieve 5G standardization of devices such as monitors and ventilators. There was no need to change the software and hardware of the online equipment and special installation. This provided us with “plug-and-play” 5G emergency equipment for use in hospitals (Fig. 7). (2) We established highly reliable 5G medical equipment. Our team developed the antenna technology in the form of multiple antennas and coupled devices, anti-power technology and anti-interference technology between equipment, designed switching performance improvement, network disconnection alarm optimization and alarm strategy under high-speed movement, with highly stable software design technology, and wireless parameter tuning. This antenna technology also included switching performance improvement under high-speed movement, network outage alarm optimization, alarm strategy and other designs, with high reliability of 5G monitors, 5G transport monitors, 5G ventilators, 5G defibrillators, and other equipment. The packet loss rate of the data was within 0.5% at high speeds and edge locations with a reference signal received power (RSRP) of –95 dBm for extended periods, which was much higher in reliability compared with other wireless communication consumer products (packet loss rate of 3%–5%). The 5G rescue equipment developed in this study completed the first domestic air rescue and remote intensive care unit

rescue application, playing an essential role in epidemic prevention and control (Fig. 7).

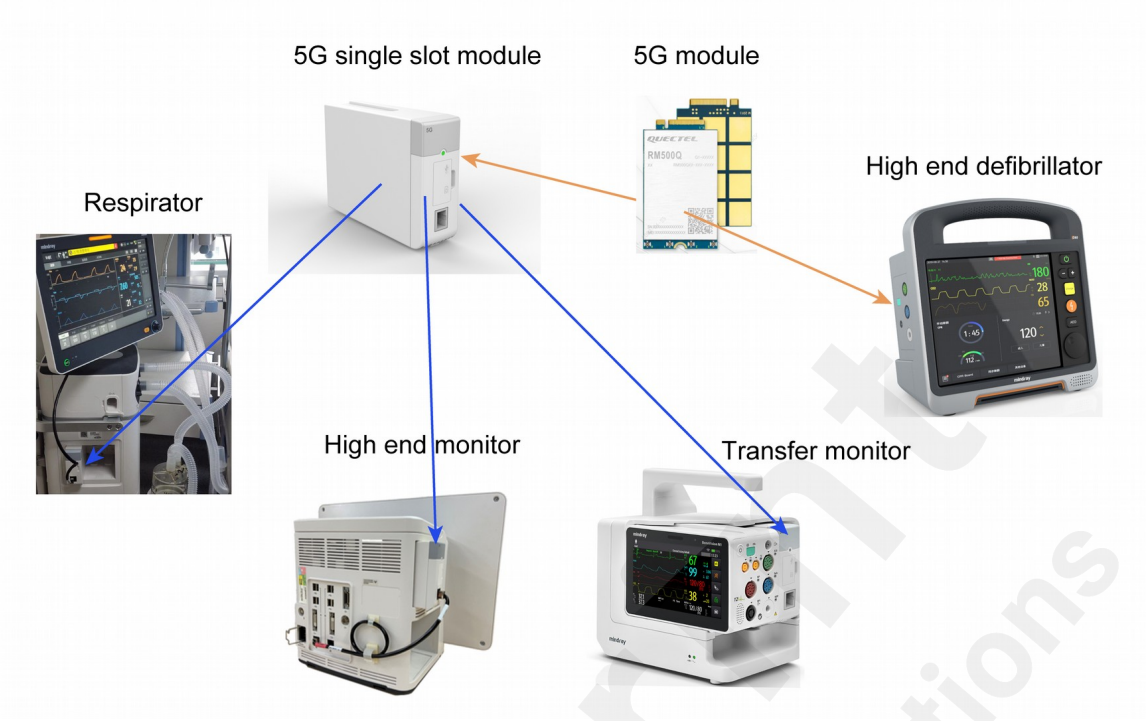

Figure 7. 5G first-aid equipment.

Establishing an air-to-ground collaborative information-sharing platform

We developed a panoramic archive storage and retrieval system for pre-hospital emergency patients. A panoramic archive of pre-hospital emergency patients was formed based on the patient health archive, combined with the vital signs collected by 5G emergency equipment, which helped achieve real-time data exchange with the hospital system. We focused on building a standard for emergency rescue data in open spaces, considering that the panoramic archive of pre-hospital emergency patients included emergency dispatch and diagnosis and treatment information to support comprehensive and complete access and transmission of cross-institutional rescue information. We developed an air-to-ground emergency rescue information exchange and scheduling system. We used microservices, distributed, and message service technologies to develop an application platform relying on the 5G private network and information security infrastructure, achieving information collaboration covering the entire chain of pre-hospital first-aid, inter-hospital transportation, and in-hospital treatment. These technologies supported information exchange and business collaborative applications among cross-regional, cross-institutional, and cross-departmental application systems. Collecting satellite positioning information through the Beidou module and the high-speed and low-latency characteristics of 5G technology supported aviation transportation tracking, injury assessment and disposal, and remote real-time physical sign monitoring and diagnosis. It also opened up an air green channel, significantly improving the overall rescue success rate. We developed a remote and multidisciplinary consultation system for open spaces, established a multi-channel collection and transmission of vital signs, and transmitted the archival information and treatment images of critically ill patients outside the hospital to the hospital's emergency expert group or multidisciplinary consultation on time. This provided technical guidance and full monitoring for the diagnosis and treatment of critically ill patients outside the hospital, and improved the efficiency of diagnosis and treatment (Fig. 8).

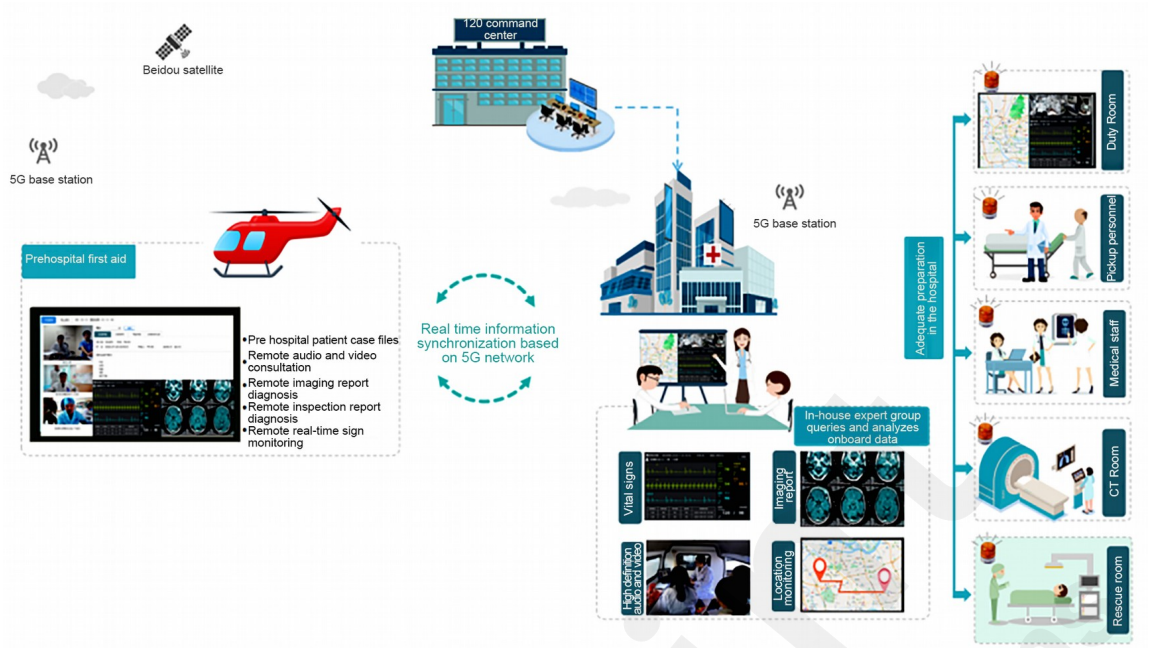

Figure 8. Air-to-ground collaborative information-sharing platform.

Our direct experience of the helicopter aviation medical rescue system

Applications of 5G technologies in two cases

On August 7, 2022, the aviation rescue drill successfully adopted 5G private network access, achieving advanced functions such as remote video consultation, vital sign data transmission, the high-precision positioning of Beidou transmitts the rescue trajectory of the rescue helicopter to the hospital emergency platform in real time through the 5G private network. This drill was novel in testing domestically produced portable ECMO on a helicopter, laying the technical foundation for practical rescue [10]. These achievements were successfully applied in the first international cross-regional long-distance aviation medical rescue case on November 9, 2022. This case further optimized the application of advanced technologies such as remote video consultation, innovative 5G module equipment, vital sign data transmission, and Beidou high-precision positioning; improved rescue time and efficiency; and shortened transit time[11]. The case validated the low airspace medical rescue 5G network technology, air body area network disease perception technology, and 5G air-to-ground collaborative rapid diagnosis and treatment technology. The entire rescue process seamlessly connected the accident scene via the applications of 5G technologies, medical ambulances/helicopters, and hospital emergency departments, achieving " admission as soon as boarding" and "integration of pre-hospital and in-hospital diagnosis and treatment," significantly improving the level of medical rescue.

Clinical rescue effectiveness

Improvement in response time: The helicopter had a flight distance of 60–600 km and a flight time of 10–136 min to cover this distance. In contrast, ambulances typically traveled at speeds of 40–60 km/h depending on road conditions and distance and covered a distance of 60–600 km in 1–15 h. Compared to the traditional ambulance, the flight time was less than a quarter of the traditional ambulance time, significantly reducing the rescue response time.

Innovative 5G medical equipment: On August 7, 2022, the aviation rescue trial first adopted the 5G private network access. On November 9, 2022, the 5G technology assisted the first international cross-regional long-distance aviation medical rescue operation, using the novel airworthy 5G module vital sign monitoring equipment jointly developed with Mindray. The 5G

emergency equipment could improve treatment efficiency[11, 14].

Expanding the rescue scope: The traditional rescue radius is generally 5–10 km. However, in this study, the helicopter rescue radius was 60–600 km. The helicopter rescue could significantly expand the rescue scope and improve rescue efficiency compared with traditional ambulance vehicles expanding the rescue radius to 600 km.

Improving rescue effectiveness: A helicopter using 5G technology can transmit real-time high-definition images and videos through high-speed networks, helping doctors conduct remote diagnosis and treatment in the air. Further, 5G technology can also provide high-precision positioning and map navigation functions, helping rescue personnel locate patients more accurately, shortening search and rescue response time, and improving rescue efficiency.

Technical application effect

Previous study showed an improved model of helicopter air-ground cooperative rescue shortened the rescue time by 7.51% and reduced the rescue cost by 4.18% compared with a previous model[15]. Another study of 36 critical cases transferred between hospitals by emergency helicopters, showed that the average transfer time was (54.95±17.89) minutes, and the average transfer distance was (205.74±74.68) kilometers[16]. Such time for transfer requires airborne medical equipment and rescue techniques. A study that utilized remote mobile medical technology, including Internet of things technology and a cloud computing system, by deploying information sensing devices on traditional vehicles (such as vehicles, helicopters, etc.), and connecting relevant devices with the Internet to realize intelligent identification, positioning, tracking, monitoring and management[17]. This method can realize real-time video monitoring, call and dispatch command of the rescue scene, and remote real-time transmission of information in the car, to improve the efficiency of pre-hospital first aid.

The advancement of 5G low-altitude network communication technology was compared and analyzed in domestic and foreign literatures (Table 1), in order to provide more scientific and effective decision-making basis for future medical rescue.

Table 1. Comparison of similar aviation technological parameters at home and abroad

Technological parameters		Domestic traditional technology	Similar technologies used abroad	Technology used in this study	Comparison results
Low-altitude 5G network technology	Communications technology	≤150 m, –108 dB, 95%[18]	≤80 m, –120 dB, 95%[19]	≤300 m, –100 dB, 100%[11]	Internationally leading
	Positioning technology	Foreign GPS high-precision positioning; dynamic positioning accuracy ≤0.1 m[20]	Foreign GPS high-precision positioning; dynamic positioning accuracy ≤0.1 m[21]	China Beidou satellite high-precision positioning; dynamic positioning accuracy ≤1 m[11]	100% localization of technology
Air body area netw	Human channel model	Multi-pose human model, estimation	Static human body model[23]	A human model of walking and running states	Internationally leading

ork disease awareness technology		algorithm based on deep learning[22]			
	Encryption algorithm information entropy	7.9992[24]	7.99930[25]	7.9993	Similar effect
	Encryption time	0.0834[26]	1.476551[25]	0.0385	Internationally leading
5G air-to-ground collaborative rapid diagnosis and treatment technology	5G emergency equipment	Does not support 5G direct connection; WiFi wireless access; packet loss rate <2%[27]	Does not support 5G direct connection; WiFi wireless access; packet loss rate <2%[28]	Supports 5G direct connection, with a packet loss rate of ≤0.2%[11]	Internationally leading
	Remote real-time audio and video multidisciplinary consultation technology	None, mainly focused on intercom voice communication [29]	One-on-one audio and video communication [30]	Supports multi-party remote consultation under 1080P high-definition video image transmission[11]	Internationally leading

Future directions

Due to the delayed development of domestic aviation rescue, the application of 5G technology in low-altitude scenarios is still in its infancy, resulting in limited use of 5G technology in aviation rescue operations. Proposed solutions include enhancing the aviation rescue system, promoting the development of 5G applications in low-altitude scenarios, researching 5G solutions suitable for various situations, strengthening coordination within the industry chain, and engaging in international cooperation. 5G network coverage is insufficient, although this study adopted ground tilt coverage technology in the 4.9GHz frequency band, low-altitude coverage in some remote areas still needs improvement. The solution includes increasing base stations and optimizing their layout, using high-performance equipment and advanced algorithms, improving low-altitude signal transmission, sharing infrastructure, collaborating with civil aviation and meteorological industries for more information support, and considering satellite communication and ground relay as supplementary methods. 5G network stability: Currently, 5G networks still have certain stability issues in high-speed mobile scenarios, which may affect the real-time communication performance of helicopter aviation

medical rescue. To enhance the stability and communication quality of 5G networks in high-speed mobile scenarios, it is important to explore and implement advanced signal processing technologies and network architectures. Technology popularization and promotion: Although this study made breakthroughs in 5G key technologies, its global popularization and promotion still need strengthening. To strengthen collaboration with governments, enterprises, and research institutions, the focus is on collectively advancing the development of international standards and specifications for 5G technology. We will accelerate the construction and application of 5G networks. At the same time, it is necessary to increase the publicity of the advantages and application scenarios of 5G technology to improve the awareness and acceptance of 5G technology by the public and enterprises.

Improvement of key technologies

The key 5G technologies for helicopter aviation medical rescue need the following improvements: improvement in the 5G communication coverage range and signal stability: Higher frequency band ground tilt coverage technology can be studied to meet a wider range of low-altitude coverage needs, and multi-antenna technology and anti-interference technology can be optimized to improve signal coverage range and stability. Improvement in personal positioning technology: Besides the existing Beidou positioning terminal, hybrid positioning technology that integrates multiple satellite navigation systems (GPS, GLONASS (Global Navigation Satellite System), etc.) can be studied to improve positioning accuracy and reliability. Optimizing the transmission scheme of the body area network: The near-body channel estimation algorithm based on deep learning and human body posture recognition can be further optimized to adapt to more complex human motion states and improve data transmission efficiency. Enhanced body area network data encryption method: More efficient encryption algorithms and protocols can be studied to improve data transmission security based on signal characteristics of physical signs and chaotic mapping. Improving 5G emergency equipment: 5G modular devices with higher transmission rates, lower latency, and lower power consumption can be explored to better adapt to various environments and application scenarios. Improvement in the functions of emergency platforms: Besides real-time audio and video communications, emergency platforms with more intelligent functions can be developed, such as real-time data analysis, intelligent diagnostic advice, and so forth, to improve the effectiveness and efficiency of aerial medical treatment. The key technologies of 5G also include millimeter wave communication, multi-user multiple-input multiple-output (MU-MIMO), network slicing, and edge computing. Millimeter wave communication offers higher data transmission speeds, MU-MIMO technology supports simultaneous connections for more users, network slicing provides tailored network services for various application scenarios, and edge computing reduces data transmission delays while enhancing real-time performance. The 5G key technologies used in helicopter aviation medical rescue can better meet practical application needs through the aforementioned technological improvements and play a significant role in improving medical rescue efficiency and treatment level.

Conclusions

This viewpoint suggests that 5G technology had significant advantages in terms of improvement in response rescue time, innovative medical equipment, expansion of rescue scope, and improvement in rescue effectiveness. Although existing technologies have shortcomings in terms of network coverage, network stability, and other aspects, the 5G technologies for helicopter aviation medical rescue can better meet practical application needs. We believe that 5G technology can make breakthroughs in terms of rapid response, advanced equipment, and expanding rescue coverage, playing a significant role in improving the

efficiency and level of global emergency medical rescue. Furthermore, research and practice on industrial application expansion, intelligent scheduling and management, and data security assurance can be important directions in developing 5G technologies for helicopter aviation medical rescue in the future.

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Ethical Considerations

The study was conducted in accordance with the principles of the Declaration of Helsinki. The study involving human subjects was approved by the Ethics Committee of Shenzhen University General Hospital (No.: KYLL-2023019A). All subjects provided written informed consent before participating in the study.

Statement

Declaration of Interest: No conflict of interest.

Data Availability Statement: Data supporting the findings of this study are available from the corresponding author upon reasonable request.

AI Statement: No AI tools were used in this study.

References

1.Lin X. Current situation and development of helicopter emergency medical rescue. China Science and Technology Information, 2022(4):113-115.. PMID: 32568725

2.Chen Z, Dong B, Luo R. The particularity and existing problems of helicopter emergency medical rescue services. Chinese Disaster Rescue Medicine; 2021,9(8):1184-1188. DOI:10.13919/j.issn.2095-6274.2021.08.011.

3.Shen M. The application of internet of things technology and new emergency rescue systems for telemedicine under 5G communication [J]. Computer Products and Circulation, 2021 (8): 54-56.

4. Berlet M, Vogel T, Gharba M, Eichinger J, Schulz E, Friess H, Wilhelm D, Ostler D, Kranzfelder M. Emergency telemedicine mobile ultrasounds using a 5G-enabled application: Development and usability study. JMIR Form Res. 2022; 6(5):36824. PMID: 35617009.

5.Haleem A, Javaid M, Singh RP, Suman R. Telemedicine for healthcare: Capabilities, features, barriers, and applications. Sens Int. 2021;2:100117.PMID: 34806053

6.Zhai Y, Xu X, Chen B, et al. 5G-network-enabled smart ambulance: architecture, application, and evaluation. IEEE Network, 2021, 35(1): 190-196.

7.Attaran M. The impact of 5G on the evolution of intelligent automation and industry digitization. Ambient Intell Humaniz Comput. 2023;14(5):5977-5993. PMID: 33643481.

8.Ye J. The role of health technology and informatics in a global public health emergency: practices and implications from the COVID-19 pandemic. JMIR Medical Informatics, 2020, 8(7): 19866. PMID: 32568725

9.Naruse K, Yamashita T, Onishi Y, et al. High-quality transmission of cardiotocogram and fetal information using a 5G system: pilot experiment. JMIR Medical Informatics, 2020, 8(9): 19744.PMID: 32897237
10. Li Gang. Aeromedical emergency rescue drill:5G and ECMO join hands in medical rescue helicopter . People's Daily client Guangdong channel. August 10, 2022http://example.com/article-url .
11.Li Gang. Eastern Navigation has completed the first practical application of 5G+aviation medical rescue. People's Daily client Guangdong channel November 10, 2022 http://example.com/article-url.
12.Liu L, Pu H. Efficient on-demand charging planning in large-scale wireless sensor networks. Application Research of Computers, 2022, 39(1):5.
13.Gulati K, Boddu R S K, Kapila D, et al. A review paper on wireless sensor network techniques in Internet of Things (IoT). Materials Today: Proceedings, 2022, 51: 161-165.
14.Zhao H. ECMO team appeared on the rescue scene and 5G+ aeromedical emergency rescue opened the green channel for air life. August 2022. https://baijiahao.baidu.com/s?id=1740685720448154135&wfr=spider&for=pc.
15.Zhang M, Li S, Li B. An air-ground cooperative scheduling model considering traffic environment and helicopter performance. Computers & Industrial Engineering, 2021, 158: 107458.
16.Li Y, Liao X, Zhao H, et al. Thirty-six critical cases of emergency helicopter transferring between hospitals. Zhonghua wei zhong bing ji jiu yi xue, 2021, 33(8): 1003-1006. PMID: 34590572
17.He Z, Ren G, Ning L. Work requirements, process and training of primary health workers in seamless rescue system . Medicine of Chinese Armed Police Force, 2018, 29(10):2.DOI:CNKI:SUN:WJYX.0.2018-10-023.
18.Patzold M. 5G Sets sail around the globe . IEEE Vehicular Technology Magazine, 2019, 14(2): 5-11.
19.Säe J, Wirén R, Kauppi J, et al. Reliability of UAV connectivity in dual-MNO networks: A performance measurement campaign.2020 IEEE International Conference on Communications Workshops (ICC Workshops). IEEE, 2020: 1-5.PMID: 35898026
20.Dong Y, Zhang L, Wang D, et al. Low-latency, high-rate, high-precision relative positioning with moving base in real time. GPS Solutions, 2020, 24: 1-13.
21.Walko C, Maibach M J. Flying a helicopter with the HoloLens as head-mounted display. Optical Engineering, 2021, 60(10): 103103-103103.
22.Lei Y, He S, Khamis M, et al. An end-to-end review of gaze estimation and its interactive applications on handheld mobile devices. ACM Computing Surveys, 2023, 56(2): 1-38.
23.Gupta S, Kakkar V, Ahmed S, et al. Modeling of on-Chip biosensor for the in vivo diagnosis of hypertension in wireless body area networks. IEEE Access, 2021, 9: 95072-95082.
24.Wang J, Huang D, Fan S, et al. PSDCE: Physiological signal-based double chaotic encryption for instantaneous E-healthcare services[J]. Future Generation Computer Systems, 2023, 141: 116-128.
25. Zhang Y. A chaotic system based image encryption scheme with identical encryption and decryption algorithm. Chinese Journal of Electronics, 2017, 26(5): 1022-1031.
25.Wang X, Li Y, Jin J. A new one-dimensional chaotic system with applications in image encryption. Chaos, Solitons & Fractals, 2020, 139: 110102.

27.Yuan H, Xiao N, Cheng M, et al. A Teleoperation Control Method for Vascular Interventional Surgery Robot.2021 IEEE International Conference on Mechatronics and Automation (ICMA). IEEE, 2021: 1027-1032.
28.Pervez F, Qadir J, Khalil M, et al. Wireless technologies for emergency response: A comprehensive review and some guidelines[J]. Ieee Access, 2018, 6: 71814-71838.
29.Wei S. Effectiveness and feasibility of helicopter rescue in trauma treatment. Fire Protection Today, 2023, 8(9):24-26.
30.Johnsen A S. Helicopter emergency medical services in sudden-onset major incidents: Patterns of use.University of Stavanger. 2021.

Supplementary Files