

SPECIAL ARTICLE

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## Research on the functions of developing telemedicine service and establishing regional medical conjoined system

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### Summary

*This article introduces the technical requirements, standards, operation models, the domestic development status and problems of developing telemedicine technology, the necessity of establishing regional medical system, and the conception of cloud model, respectively. Based on the analysis of cardiovascular treatment cases in our hospital, this*

*article suggests that developing telemedicine service and establishing regional medical conjoint system is the necessary direction of the domestic medical development. As with all kinds of difficulties, one can learn from the success cases and formulate practical and feasible measures according to the practical reality of different areas in China.*

### Developing telemedicine service

#### *The conception and technical requirements*

Telemedicine refers to the comprehensive utilization of the latest achievements in the field of modern network communication technology, computer information processing technology, multimedia technology, medical imaging technology, high definition (HD) audio and video interactive technology etc. Through a remote way, telemedicine carries out a number of medical activities such as remote diagnosis, remote consultation, remote rounds, remote surgery teaching and guiding, remote multi parameter monitoring etc [1]. Its two core issues are interoperability and interoperability of resources [2].

Telemedicine is embodied in the following aspects: 1: Remote medical resources integration platform. This should achieve the integration of expert resource, education resource and some other medical service resources and should high-

light the release management, indexing and query function of various information to meet the requirements of all types of users, such as providing access to web pages, information management, information inquiry and sharing and other comprehensive services. 2: Remote medical service management platform. This should achieve the centralized management function of all kinds of information and statistical analysis function of all kinds of applications, so as to meet the requirements of providing business management and decision support for competent department of health and hospital registering on the internet. 3: Remote medical service support platform. This should achieve some business functions such as remote consultation, remote specialist diagnosis, medical records data acquisition, remote monitoring, remote pathological diagnosis, remote rounds and remote visits, remote guidance of pre-hospital care, remote education, surgical teaching etc., to meet the requirements of all kinds of institutions

to take various remote medical business activities. 4: Telemedicine information exchange platform. This should achieve exchange functions of data, image, video, audio and other information to meet the requirements of HD audio and video interaction, instant communication, data exchange, data sharing and other information exchanges between medical management at all levels and hospital. This information exchange has crossed brand, network (private and public), hardware and software. 5: Telemedicine system management platform. This should achieve the functions of systemic user registration and permissions management, data standard management, node management, monitoring and management, service management (management of each function system), log management, security audit, configuration management, resource directory and so on to meet the requirements of operation and maintenance personnel to take system management.

#### *Standard and operation model*

At present, the international standard formats for telemedicine services mainly include DICOM, CEN/TC 251, HL7, ISO/TC 215, ISO/IEEE 11073, ITU-T etc [3]. DICOM medical digital imaging and communication is applied to medical image exchange; CEN/TC 251 (European standard) is mainly used for the coordination and development of electronic health care; HL7 is developed for hospital information system; ISO/TC 215 mainly concentrates in health archives including the medical record data structure, information and communications, security, pharmacy and medicine, equipment, business needs etc. It is more suitable for developing countries; ISO/IEEE 11073 is mainly used in medical equipment interoperability; ITU-T focuses to developing telecommunications infrastructures that are required by virtual multimedia delivery. Also the telecommunications infrastructures support medical monitoring, remote diagnosis service and electronic medical records.

The development of telemedicine inevitably included two equally important elements: technological innovation and operational model innovation [4]. The continuous operation model is the key to the investment, construction, development and innovation of telemedicine system. United States is the most developed country in Internet issues and it has built one of the most developed medical network in the world. The main features of the telemedicine service include [5]: Internet technology, covering a wide range, becomes the foundation of telemedicine service, the research

and development that is cored on a university is the technical support of telemedicine service, regional integration of medical resources is the core of telemedicine service management, and increasingly perfect payment mechanism is the guarantee of the rapid development of telemedicine service. The development and application of telemedicine in European countries maintain a trend of advancing side by side with that in United States. Affected by geographical location, traffic and Internet coverage scope, the level of medical technology and other factors (cross national, medical technology sharing that crosses region) have become a prominent feature of European telemedicine services [6], e.g. remote frozen section of medical service has been developed between Switzerland and Germany to transfer static image, while Spain has built static image transmission system to connect with the European continent. In order to improve the overall level of telemedicine services in Europe, some telemedicine system cooperation projects on the level of countries have developed in Europe, thus the cooperation between countries is closer.

#### *Current situation and difficulties of China's development*

1: The informatization level of most of the domestic medical institutions is still in its primary stage. The informatization development of Chinese hospital experiences three stages: the stage of hospital management informatization (HIS system), the stage of clinical management informatization (CIS system), and the stage of local medical and health services (GMIS system) [7]. The majority of medical institutions, especially the hospital information system constructions of county-level hospitals, community hospitals and township health clinics are in their first stage. The laggard hospital informatization easily caused the phenomenon of information islet, which seriously affects the cooperation and communication between regional medical institutions and hinders the development of telemedicine services. 2: Some patients lack the existence of the telemedicine service model. A big part of Chinese people prefer the traditional face-to-face medical model much more. The propaganda of telemedicine in our country is limited to medical therapy unit but ignores to propagate and spread the superiority and reliability of telemedicine to patients. Thus patients do not know the great benefits that telemedicine can bring to them, which gives much apprehension to patients when they apply

for telemedicine service, so they are reluctant to try this new way of service. 3: The standardization and standardization of telemedicine service system are not enough. Currently, government departments have not yet established a relatively perfect standardization system of telemedicine services. Some aspects have shortcomings, such as software system, industry regulation, charging standards etc. Among them, the software system includes three aspects: patient information record standardization, medical institution information sharing standardization and all kinds of service interface standardization. The medical information system of all institutions is not compatible with each other, which leads to that the medical information can not be shared, and the openness and information exchange of regional telemedicine unit can not be realized in a short time. There is no uniform payment standard and service compensation for a telemedicine project in China, and the lack of uniform payment standard is an important factor to hinder the long-term development of telemedicine services. 4: The laws and regulations of telemedicine services are not regular in the following aspects: misdiagnosis and missed diagnosis due to fault, missing data and error in electronic information system transmission; telemedicine accident due to the uncertainty of network will be more difficult to deal with than traditional medical disputes. Because responsibility acts in both sides and multi-party in the telemedicine service don't have a clear regulation, if there is a medical accident in the process of telemedicine services, the respective responsibilities of telemedicine services unit need to be clear to not cause the phenomenon that both sides of the responsibility shirk their responsibilities and make the problem to expand further.

## Establishing a regional medical system

### *Necessity*

A regional medical conjoint system integrates the medical resources of the same region together. It consists of a tertiary hospital, some secondary hospitals and community health service centers to guide the patients to receive medical treatment hierarchically and orderly, which solves the problem that "to see a doctor is difficult and expensive" [8]. A medical conjoint system is the exploration model of the implementation of health policy to force a new system, the formation of a new mechanism and the achievement of regional medical collaboration. It can be said that the pur-

pose of the medical system is a sharp "sword" that government and the medical and health industry have carry on once again to orienting the health reforming problem. The target of promoting the construction of the medical conjoint system is to develop the advantages of a tertiary hospital professional technical advantages better and the lead role of a regional medical center, which can build treatment models of graded medical treatment, e.g. for acute and chronic treatments and two-way referral diagnosis. Based on different functions, medical institutions of the medical conjoint system can be divided into: 1: The tertiary medical institution is a diagnostic center of a regional emergency critical and difficult disease to provide inpatient emergency and referral services; and 2) The secondary medical institutions are mainly responsible for the basic medical services within the jurisdiction and emergency treatment of critically ill patients. The main duty of the primary medical institutions is to maintain and promote the health of the residents [9]. The construction of medical conjoint system emphasizes the important role of basic level medical and health institutions in the aspects of patients' rehabilitation and residents' health, which highlights the contents of public health and health management.

From the exploration model of medical conjoint system in various regions, there are two kinds of medical conjoint system construction models at present: loose coupling medical conjoint system and tight coupling medical conjoint system [10]. The so-called loose coupling medical conjoint system refers that each hospital in the medical conjoint system operates in complete independence and through the informatization platform. All of the hospitals in the medical conjoint system can achieve remote reservation registration, remote consultation, remote preengaging medical examination, two-way referral etc. This is the mutual extension of medical business in big hospitals and small and medium-sized hospitals. The so-called tight coupling medical conjoint system demands that all hospitals in the medical conjoint system implement unified management and realize the unified deployment of medical resources based on informatization platform which intends to extend and apply the medical and management level of big hospitals into small and medium-sized hospitals as much as possible. These two models have their own characteristics e.g. loose coupling is constructed on the core of medical business, while the tight coupling is based on the overall management idea of the hospital, but

their core ideas are to achieve the correct diagnosis and treatment of patients. Through the rational allocation and utilization of medical resources, the problem “to see a doctor is difficult and expensive” can be solved. Under such an original intention, the medical informatization construction must develop top-level design and step-by-step construction under the premise of ensuring the patient as the focus.

#### *Relationship between telemedicine and regional medical conjoint system*

Independent telemedicine could just share the resources, but as a technical means, its ultimate aim is to serve the medicine development and solving the difficulty in seeing a doctor. The regional medical conjoint system is the software power to build coordinated development. Through its integration of uneven medical resources, the majority of patients can enjoy the same medical treatment. Perfect telemedicine network and thorough regional medical conjoint services will be the mainstream of medical development in the future [11].

Our hospital has gradually summed up a set of practical experience in the development of nearly 5 years, including:

#### *(1) Doing a good job in special contra-aperture aid*

According to the operational characteristics and specific needs of every member units, the hospital selects some departments to forming one-to-one counterpart helping relationship and raises the business level of the member units through some measures such as visits of experts, rounds and case discussions, teaching, training etc.

#### *(2) Promoting the smooth development of two-way referral*

Under the principle of patients with voluntary, health insurance policy permission, rational allocation of medical resources, continuous service and health management, the hospital builds a green channel for reasonable referral and transfer of patients in the medical conjoint system.

#### *(3) Carrying out remote consultation*

The hospital establishes medical conjoint system diagnostic imaging centers and carries out the radiological examination of remote consultation through remote medical education training platform.

#### *(4) Strengthening personnel training*

The hospital needs to formulate personnel training plan for member units of the medical conjoint system and to develop various training courses, such as general practitioner training, special skills (special technology), three bases and three rigours (of nursing etc). In addition, the hospital needs to carry out the work that Chinese and Western medicine expert tutors teach a primary physician.

#### *(5) Increasing the information support*

The hospital can use remote medical education and training platform to establish a sharing mechanism of network information. The residential health database and remote consultation medical platform are built on the basis of ensuring the independence, stability and security of the information system of member units, and in this way all hospitals within the group can share medical information. Experience: (1) The measure that does not break the original hospital management system is easy to implement. (2) On the basis of disease, the hospital unifies the diagnostic standards and norms to ensure that patients can enjoy the same level of medical service in different medical institutions. This data can be integrated and used in every hospital, and the hospital should unify the quality standards of examination and laboratory test data. (3) Providing patients with continuous tracking services from hospital to family through cloud platform technology; on the basis of advantages and disadvantages in different hospitals, it guides the rational treatment for patients to avoid blind flow and reducing unreasonable medical expenses.

#### *The idea of cloud model*

Regional health information platform is a data exchange and sharing platform which connects basic business information system of every institution (medical and health institutions, administration business management unit and relevant health institutions) in the planning area, and it is the basis and a carrier of every informatization system in the region to take effective information integration. In addition, it is a comprehensive business platform of diversified subsystems. Cloud computing technology has better solved the data sharing problems among the system flexibility, expansion, reliability and system efficiency, video equipment compatibility and medical institution, which can provide system support for



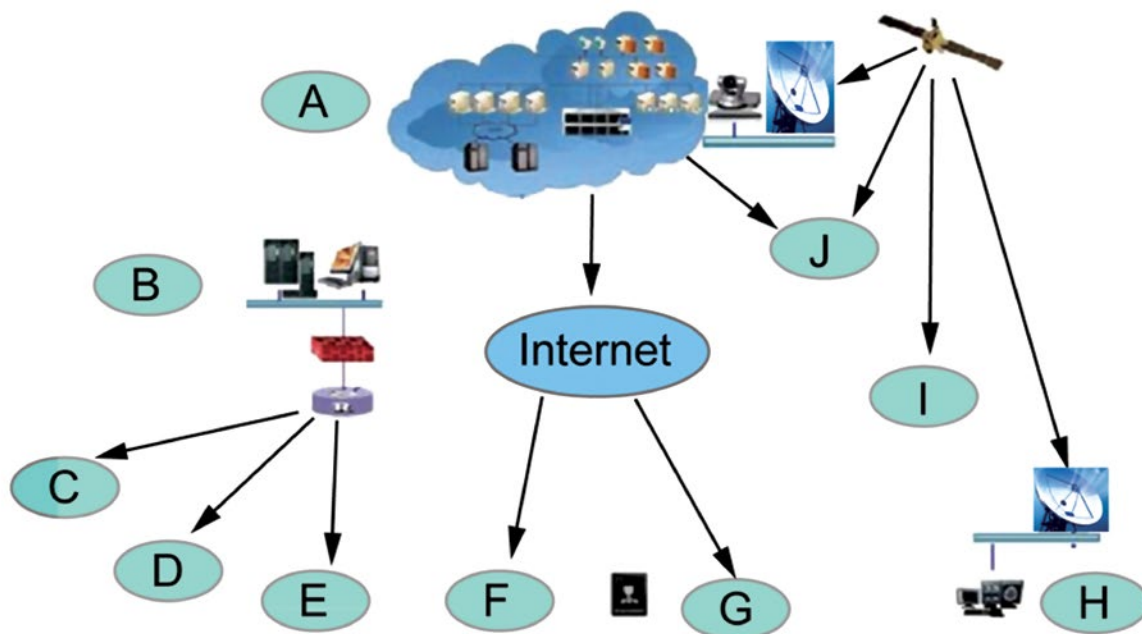
all kinds of medical institutions to carry out cross regional telemedicine services [12] (Figure 1).

### Analysis of chronic disease management case

In the past 5 years, our hospital has regarded regional medical collaboration as a basic way of hospital management through the integrated application of network, cloud computing, telemedicine, mobile health information technology and cardiovascular disease emergency process management, and we have achieved the object perception, first aid process standardization management and the standardization management of the whole process. We have extended the integration of the hospital information system to pre-hospital first aid, and provided remote expert consultation and guidance of diagnosis and treatment in order to extend the hospital first aid to the pre-hospital period. On the foundation of the remote first aid and health management cloud platform, we have built a closed management circle-“high risk early warning→pre-hospital first aid→hospital treatment→intensive care”.

In addition, we have created the data link of monitoring and standardizing the business process. This has formed a regional technology tie

and advantage. Through the combination of central hospital - secondary hospital - community hospital, we have developed “mobile ICU” and “remote ICU” and combined their operation mechanism with aid agencies cooperation mechanism, service convergence mechanism and information flow mechanism organically. This has formed a regional cooperative network of cardiovascular emergency which is on the foundation of community medical service, on the center of the strength of specialized treatment in large hospitals. This thesis has analyzed the patients with acute and chronic cardiovascular diseases in our hospital. Those patients were treated by the routine treatment model and telemedicine+regional medical conjoint system (new model). The new model has significantly expanded the treatment group. The conventional model can only cover about 60% of the population of our hospital in the city within a radius of 5 km, while other areas of our city and other nonlocal patients come to our hospital after other people are treated so the influence of the hospital is very limited. The new model will extend our hospital’ coverage to the whole province, as approximately 10% of patients are from remote countrysides. The number of hospitals that established close cooperation with our hospital is up to twenty, and we have built perfect and harmonious



**Figure 1.** The network topology map of telemedicine service platform based on cloud model.

**A:** telemedicine service platform, **B:** regional telemedicine service platform, **C:** special network, **D:** regional specialist hospital, **E:** city/county/township primary hospital, **F:** independent network registered hospital, **G:** mobile medical treatment/pre-hospital care, **H:** military hospital, **I:** telemedicine emergency rescue vehicle, **J:** the main web of the military telemedicine information network.

cooperation forms in the cardiovascular, traffic trauma, tumor and other discipline fields, which not only enhance the influence of our hospital but they also play a great role in developing the advantageous disciplines of our hospital, making up weak disciplines, and improving the strength of the primary hospital. As a result, the treatment time of cardiovascular diseases is shortened.

During treatment of acute coronary syndrome, "time is life". In the new model, the average time of D-to-B (Door-to-Balloon) was 68.7+15.6 min, and for about 85% of the patients, D-to-B time was less than 90 min; in the normal model, the average D-to-B time was 93.6+17.2 min, and for about 60% of the patients, it was less than 90 min. At the same time, due to the higher proportion of patients endorsed by the new model, the time that the new model spends in treating cardiovascular diseases is greatly reduced. After the implementation, the new model passes around the emergency departments and directly goes into the catheter room of the department of cardiology and pre-hospital real time transmission. ECG is the independent predictive factor of D-to-B time < 90 min (OR/ odds ratio=1.865, 95% CI: 1.123-3.549, p value=0.025; OR=1.344; 95% CI of OR: 1.007-4.158, p=0.029). Additionally, the new model has improved the success rate of treatment. Concerning patients who cannot be timely transferred, the hospital can give timely and correct treatment advice and strategy through remote guidance, which can greatly reduce the incidence of severe complications, such as cardiac death, malignant arrhythmia, heart failure and so on; the new model can carry out percutaneous coronary intervention (PCI) treatment and remote technical guidance for the primary hospital, and this plays

an important role in improving the success rate of emergency intervention and reducing the complications. Finally, the average length of hospital stay is shortened and the cost of hospitalization is reduced. For maximizing the use of limited medical resources and improving the treatment efficiency and also increasing the patient satisfaction, the new model is an important factor.

According to the above, developing telemedicine service and establishing regional medical conjoint system is the necessary direction of the domestic medical development. As in all kinds of difficulties, we can learn from the successful cases and formulate practical and feasible measures according to the practical reality in different areas of China. In addition, we need to constantly sum up and modify these measures in order to write a fresh chapter of China's medical and health service!

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## Conflict of interests

The author declares no conflict of interests.

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