

Rehabilitation of Cardiovascular Diseases in China

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ABSTRACT

The Annual Report on Cardiovascular Health and Diseases in China (2022) intricate landscape of cardiovascular health in China. In connection with the previous section, this 12th section of the report offers a comprehensive analysis of rehabilitation of cardiovascular diseases. In recent years, China's cardiac rehabilitation has developed vigorously, and its clinical benefits have been proven by more and more evidences. More cardiac rehabilitation centers are built and standards are constantly being promoted. Despite the rapid development and progress, there are still major shortcomings in the current situation, such as lack of awareness among patients and families about the significance and importance of cardiac rehabilitation, and under participation in cardiac rehabilitation; the development of cardiac rehabilitation is uneven, with the majority concentrated in tertiary hospitals in economically developed areas; lack of high-level evidence-based evidences, quality control and safety standards need to be improved; the medical payment system is not thorough; lack of a systematic training and admission system, hindering the development of cardiac rehabilitation in China. Therefore, continuous efforts are needed to strengthen the construction of cardiac rehabilitation centers, which should sink from tertiary hospitals to secondary and primary medical service centers; encourage clinical research on cardiac rehabilitation; introduce consensus on quality control and safety standards; explore more on phase III cardiac rehabilitation; increase investment in integrating high-tech, artificial intelligence, etc. With the unique advantages of traditional Chinese medicine, exploring a Chinese characteristic cardiac rehabilitation model that is in line with China's national conditions. Evidence-based medicine has confirmed that rehabilitation is the most effective method to reduce the disability rate of stroke, and it is also an indispensable key sector in the organized management model of stroke. Rehabilitation should span the entire process of stroke treatment. Perfecting the rehabilitation medical management system, steadily improving the rehabilitation medical service capacity, expanding diversified service methods, and emphasizing early and whole-range rehabilitation treatment have important clinical value and social significance for stroke rehabilitation.

CARDIAC REHABILITATION

Since the concept of cardiac rehabilitation was introduced into China in the 1980s, after nearly 40 years of exploration and practice, China's cardiac rehabilitation work has been continuously advancing and has gained remarkable achievements.

Development of Cardiac Rehabilitation in China

Type of hospital

In 2016, a cross-sectional survey on the current status of cardiac rehabilitation in Chinese hospitals included 124 tertiary hospitals in 7 geographical regions of China.^[1] The results showed that only 30 hospitals (24%) practiced cardiac rehabilitation, including 0 military hospital, 18 state-owned hospitals (29% of all surveyed state-owned hospitals), 12 university affiliated hospitals (22%

of all surveyed university affiliated hospitals). It is revealed that cardiac rehabilitation work is mainly carried out in state-owned hospitals and university affiliated hospitals (Figure 1).

Coverage rate

The result of the survey on the current status of cardiac rehabilitation in Chinese hospitals in 2016 showed that only 2.2 hospitals per 100 million population could carry out cardiac rehabilitation.^[1] In terms of the distribution density in 7 geographical regions (number of cardiac rehabilitation centers/100 million population), developed regions such as North China, East China and South China are the most distributed, followed by the Northeast, Central and Southwest, while the Northwest has none, indicating that the development of cardiac rehabilitation in China is extremely uneven (Table 1).

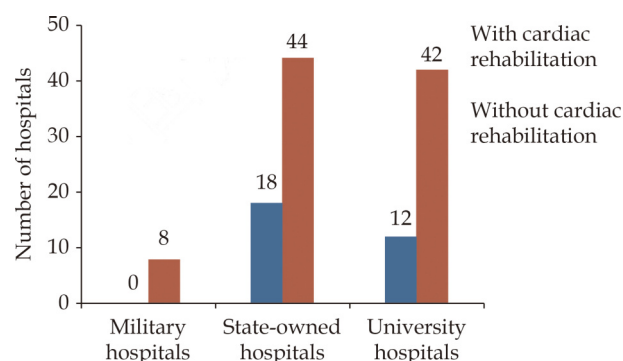


Figure 1 Type and number of hospitals in China that carry out cardiac rehabilitation.

Phases of cardiac rehabilitation

Cardiac rehabilitation (CR) is divided into three phases: phase I (inpatient CR), phase II (early outpatient CR) and phase III (long-term outpatient CR). According to the survey on the current status of cardiac rehabilitation in Chinese hospitals in 2016, among the 13 hospitals that finished the complete 36-item survey and reported having a CR program, 3 hospitals (23%) offered phase I rehabilitation, 3 hospitals (23%) offered phase II rehabilitation, and 7 (54%) offered phase I + II rehabilitation (Figure 2).^[1]

Status of characteristic rehabilitation with traditional medicine

(1) Effect of Chinese traditional Taijiquan exercise on prognosis of patients with coronary artery disease (CAD) after percutaneous coronary intervention (PCI)

A study investigated the effect of Taijiquan on the prognosis of patients with CAD after PCI.^[2] 326 patients with CAD aged 57–71 years from March 2014 to March 2016 were randomly divided into control group and Tai Chi group. The control group was only given routine treatment, and the Tai Chi group was added with 24-style

Yang Taijiquan besides routine treatment. The results of 6-month intervention showed that the scores of Exercise of Self-care Agency Scale (ESCA), Activities of Daily Living (ADL), SF-36 Questionnaire and left ventricular ejection fraction (LVEF) in the Tai Chi group were higher than those in the control group ($P < 0.05$). The arrhythmia incidence, recovery time of atrioventricular block, hospital stay and the scores of Self-rating Anxiety Scale (SAS) and Self-rating Depression Scale (SDS) were lower than those in the control group ($P < 0.05$). It is suggested that Taijiquan exercise could improve the prognosis of CAD patients after PCI (Table 2).

(2) Effect of Chinese traditional Baduanjin exercise on left ventricular (LV) remodeling and cardiac function in patients after acute myocardial infarction (AMI)

A randomized controlled study enrolled 110 clinically stable ST-segment elevation myocardial infarction (STEMI) patients who received coronary intervention treatment from January 2015 to October 2017, of whom 56 received 12 weeks of Baduanjin exercise cardiac rehabilitation (BE group), and the remaining 54 received 12 weeks of general exercise rehabilitation (control group).^[3] The results showed that compared with the control group, the BE group showed significantly lower left ventricular end-diastolic volume index (ΔLVEDVi) (change from baseline to 6 months in the echocardiographic LV end-diastolic volume index) (-5.1 ± 1.1 vs. $0.3 \pm 1.2 \text{ mL/m}^2$, $P < 0.01$), and there was a greater increase in left ventricular ejection fraction (ΔLVEF) ($4.2\% \pm 1.5\%$ vs. $0.1\% \pm 1.2\%$, $P < 0.05$), suggesting that Baduanjin exercise (BE) could attenuate the adverse left ventricular (LV) remodeling, reduce ventricular dilation and improve ejection function in STEMI patients (Figure 3).

Status of Cardiac Rehabilitation Safety

The safety of cardiac rehabilitation is the focus of at-

Table 1 Distribution of hospitals carrying out cardiac rehabilitation in seven geographical regions of China.

Region	Numbers of people/million	Numbers of cardiac rehabilitation centers	Density of cardiac rehabilitation centers/ (number/100 million population)
Northeast	108	1	0.9
North	155	9	5.8
East	382	13	3.4
Central	240	2	0.8
South	147	4	2.7
Southwest	213	1	0.5
Northwest	99	0	0
Total	1,344	30	2.2



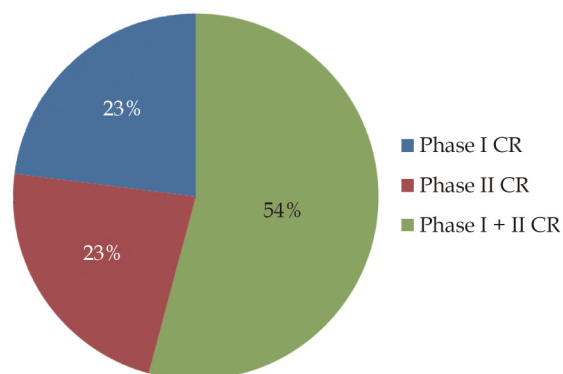


Figure 2 Work carried out by CR centers of Chinese hospitals. CR: cardiac rehabilitation.

tention. A prospective cohort study on the safety and efficacy of home-based cardiac rehabilitation included 335 patients with CAD after PCI from July 2015 to March 2018, they were divided into control group and home-based rehabilitation group.^[4] Among them, the home-based rehabilitation group were remotely monitored through smartphones and corresponding software, and the longest follow-up was 42 months. Through propen-

sity matching analysis, it was found that the incidence of major adverse cardiovascular event (MACE) in the home-based rehabilitation group was lower than that in the control group, and rehospitalization due to deteriorated angina pectoris was significantly decreased. The exercise ability, quality of life and control of CAD risk factors were better than those in the control group, which proved that the smartphone assisted home-based cardiac rehabilitation model was a safe and effective method to reduce cardiovascular risk and improve the health of patients with CAD (Table 3).

Cutting-edge advances of cardiac rehabilitation in China

Cardiac rehabilitation in China is gradually extending from center-based to home-based. However, as a novel thing, home-based cardiac rehabilitation is facing challenges. How to monitor to ensure safety and how to set, adjust and intervene are urgent problems to be solved.

A single-center, prospective, assessment-blinded, randomized controlled study included a total of 100

Table 2 Comparison of activities of daily living, cardiac function, mood and other related indicators between Taijiquan and control group.

Indicator	Taijiquan group (n = 128)	Control group (n = 121)	P-value
ESCA score	122.5 ± 13.4	105.4 ± 12.5	0
ADL score	45.7 ± 6.5	39.6 ± 4.8	0.007
SF-36 score	61.5 ± 7.4	40.0 ± 5.3	0.001
LVEF	47.3% ± 3.4%	42.6% ± 3.1%	0.043
Arrhythmia recovery time, day	4.5 ± 1.2	6.3 ± 1.3	0.015
Recovery time of atrioventricular block, day	3.3 ± 1.6	5.5 ± 1.4	0.006
Hospital stay, day	16.4 ± 2.5	20.5 ± 4.8	0.032
SAS/score	32.3 ± 4.5	43.9 ± 5.6	0.001
SDS/score	39.2 ± 9.3	53.6 ± 8.7	0.003

Data are presented as mean ± SD. LVEF: left ventricular ejection fraction; SAS: self-rating anxiety scale; SDS: self-rating depression scale.

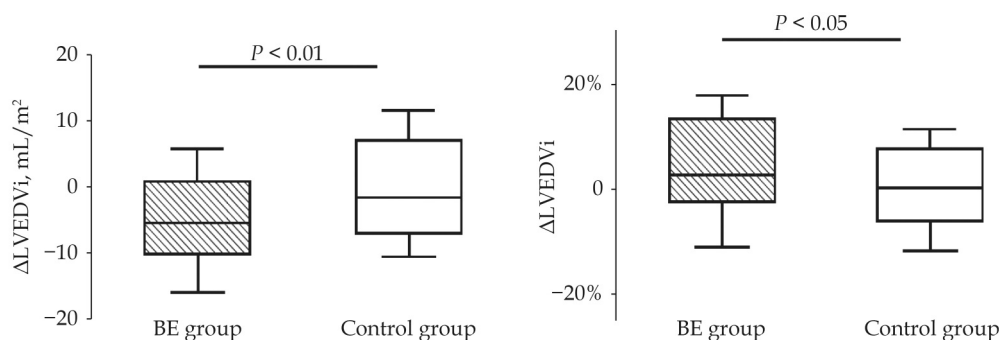


Figure 3 Changes in the echocardiographic LVEDVi and LVEF from baseline to 6 months. LVEDVi: left ventricular end-diastolic volume index; LVEF: left ventricular ejection fraction.

Table 3 Comparison of MACE, exercise endurance and control of CAD risk factors between the two groups.

Indicators	Control group (n = 135)	Home-based rehabilitation group (n = 135)	P-value
MACE	12 (8.9%)	2 (1.5%)	0.002
AMI incidence	0	0	-
Unplanned revascularization	12 (8.9%)	2 (1.5%)	0.002
Stroke	0	0	
Cardiac death	1 (0.6%)	0	0.493
Rehospitalization due to deteriorated angina pectoris	31 (23%)	13 (9.7%)	0.002
Max MET	5.1 ± 1.4	6.2 ± 1.3	0.001
VO _{2peak} at anaerobic threshold, mL/kg per minute	13.7 ± 4.1	16.2 ± 4.3	< 0.001
Systolic pressure, mmHg	130.1 ± 13.9	122.2 ± 13.7	< 0.001
LDL-C, mmol/L	2.2 ± 0.8	1.5 ± 0.6	< 0.001

Data are presented as mean ± SD or n (%). CAD: coronary artery disease; LDL-C: low-density lipoprotein cholesterol; MACE: major adverse cardiovascular event.

patients with atrial fibrillation after radiofrequency catheter ablation from February 2019 to July 2019.^[5] They were randomized to a 12-week standard rehabilitation group (control group) or a comprehensive, domiciliary, mobile application-guided and telemonitored cardiac rehabilitation group (intervention group). Ninety seven patients completed follow-up. The results showed that the increase in VO_{2peak}, the beliefs related to CVD and exercise self-efficacy scores in the intervention group was significantly higher than in the control group. It is suggested that remote home-based cardiac rehabilitation is necessary for atrial fibrillation patients after radiofrequency catheter ablation, and provides a promising alternative to conventional cardiac rehabilitation models (Table 4).

Another prospective randomized controlled study included 96 patients with stable CAD, divided into control group and telemonitored group. Among them, the telemonitored group carried out remote monitoring through smartphones and corresponding software. After 6 months of follow-up, it was found that the cardiopulmonary and physical parameters and indexes and patients' adherence in the telemonitored group were better than in the control group, which proved that the telemonitored

cardiac rehabilitation model was effective for Chinese patients with CAD.^[6]

Evaluation of Important Clinical Indicators of Cardiac Rehabilitation in China

Effects of cardiac rehabilitation on all-cause mortality and MACE in patients with Myocardial Infarction in the Absence of Obstructive CAD (MINOCA)

A single-center prospective controlled study included 534 patients with MINOCA from August 2014 to October 2016 and randomized into a control group (CR-) and a cardiac rehabilitation group (CR+) to observe the impact of exercise-based cardiac rehabilitation on all-cause mortality and MACE in MINOCA patients.^[7] The 3-year follow-up survival curve showed that compared with the CR-group, the all-cause mortality (log-rank $P < 0.05$) and MACE (log-rank $P < 0.01$) in the CR+ group were significantly reduced. It is suggested that exercise-based cardiac rehabilitation could significantly improve the prognosis of MINOCA patients (Figure 4).

Effect of early rehabilitation exercise on prognosis of patients after cardiac surgery

A study, from January 2016 to January 2018, investig-

Table 4 Comparison of changes in main functional outcomes between the intervention group and the control group.

Outcomes	Control group (n = 48)	Intervention group (n = 49)	P-value
VO _{2peak} , mL/kg per minute	4.9 ± 6.6	9.3 ± 8.0	0.003
Beliefs related to CVD	2.5 ± 15.2	11.1 ± 10.5	0.002
Exercise self-efficacy	4.2 ± 5.3	8.3 ± 4.8	< 0.001

CVD: cardiovascular diseases.



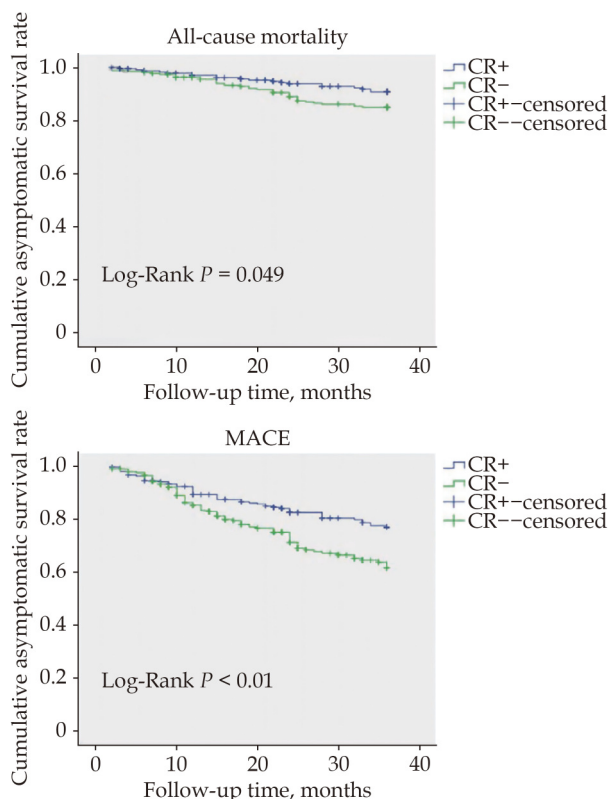


Figure 4 Comparison of all-cause mortality (A) and MACE (B) between patients in the CR+ group and the CR- group. CR: cardiac rehabilitation; MACE: major adverse cardiovascular event.

ated the effect of early rehabilitation exercise on the prognosis of patients after cardiac surgery.^[8] Eight hundred and ninety three patients after cardiac surgery and stayed in the ICU for more than 48 h were included. They were grouped in early rehabilitation group (239 patients) and conventional treatment group (654 patients) according to whether or not early rehabilitation was carried out. One hundred and ninety two cases from each group were matched by 1: 1 propensity score. The results showed that the mechanical ventilation duration was significantly shortened, the sedative drug use was reduced, the incidences of delirium and intestinal dys-

function were decreased, and the risk of malnutrition was reduced in the early rehabilitation group as compared to the conventional treatment group, suggesting that prognosis could be improved with early rehabilitation exercise after cardiac surgery (Table 5).

Health Economic Evaluation of Cardiac Rehabilitation in China

Cardiac rehabilitation shortens hospitalization days of CVD patients

A single-center, randomized controlled study analyzed the impact of precision implementation of early ambulation on the prognosis of elderly patients undergoing off-pump coronary artery bypass grafting (CABG).^[9] A total of 178 patients aged ≥ 60 years who underwent off-pump CABG were enrolled in this study. The patients were randomized to either the precision implementation of early ambulation group (PEA group) or the conventional ambulation group (control group). A precision early ambulation plan, based on the age projected maximum heart rate and maximum oxygen uptake (VO_{2max}), was developed for the PEA group. The results showed that in the intention-to-treat analysis, the post-operative hospital stay of the PEA group (9.04 ± 3.08 days) was significantly shorter than that of the control group (10.09 ± 3.32 days).

Cardiac rehabilitation saves hospitalization cost of CVD patients

A study of evaluation on the effect of early comprehensive rehabilitation in children with congenital heart disease after surgery analyzed length of hospital stay, hospitalization cost of 400 children with congenital heart disease (aged between 6 months and 3 years old) undergoing heart surgery from January 2007 to December 2018.^[10] The patients were randomly divided into rehabilitation group and control group. The rehabilitation group was given comprehensive rehabilitation inter-

Table 5 Comparison of prognostic indicators between the two groups of patients after matching analysis.

Indicator	Early rehabilitation group (n = 192)	Conventional treatment group (n = 192)	P-value
Mechanical ventilation duration, h	36.0 $\pm$ 14.9	43.0 $\pm$ 12.5	0.016
Duration of sedative use, h	39.0 $\pm$ 16.8	47.0 $\pm$ 21.3	0.001
Delirium	15 (7.81%)	33 (17.19%)	0.006
Intestinal dysfunction	51 (26.56%)	82 (42.71%)	0.001
Triceps skinfold thickness, mm	15.0 $\pm$ 2.8	12.0 $\pm$ 3.3	0.021

Data are presented as mean $\pm$ SD or n (%).

vention measures, and the control group was given conventional intervention measures. The results showed that the length of hospital stay of rehabilitation group was obviously shortened ($P < 0.001$) and hospitalization cost lowered ($P < 0.001$), suggesting that comprehensive rehabilitation could significantly reduce the hospitalization time and cost of children with congenital heart disease (Table 6).

Guidelines for Cardiac Rehabilitation

In recent years, cardiac rehabilitation has developed rapidly in China, and relevant institutes have issued rehabilitation guidelines successively (Table 7). These pro-

grammatic documents systematically elaborated the definition and benefit evidence of cardiac rehabilitation, clarified the standardized process, risk control and quality control measures, and formulated the basic norms for the construction of cardiac rehabilitation departments.

STROKE REHABILITATION

Current Situation of Stroke Rehabilitation in China

Rehabilitation beds and personnel structure

The number of rehabilitation beds in Chinese medical institutions continues to increase (Figure 5), and it was

Table 6 Comparison of hospitalization time and cost between rehabilitation group and control group.

Group	Hospitalization time/d	Hospitalization cost/CNY
Rehabilitation group ($n = 200$)	4.2 ± 2.1	$38,132 \pm 9,502$
Control group ($n = 200$)	6.6 ± 3.2	$42,867 \pm 13,516$
<i>P</i> -value	< 0.001	< 0.001

Data are presented as mean $\pm$ SD.

Table 7 Relevant guidelines in cardiac rehabilitation.

Release time	Name
2018	China cardiac rehabilitation and secondary prevention guideline 2018 Essentials ^[11]
2018	Chinese expert consensus on exercise rehabilitation of patients with stable CAD aged 75 and above ^[12]
2020	Expert consensus on cardiac rehabilitation after CABG ^[13]
2020	Chinese expert consensus on cardiac rehabilitation of chronic heart failure ^[14]
2021	Chinese expert consensus on cardiac rehabilitation of patients with atrial fibrillation ^[15]
2021	Chinese expert consensus on exercise rehabilitation for adult patients with pulmonary hypertension ^[16]
2022	Chinese expert consensus on the clinical normative application of 6MWT ^[17]
2022	Chinese expert consensus on home-based rehabilitation for patients with cardiovascular diseases ^[18]

CABG: coronary artery bypass grafting; CAD: coronary artery disease.

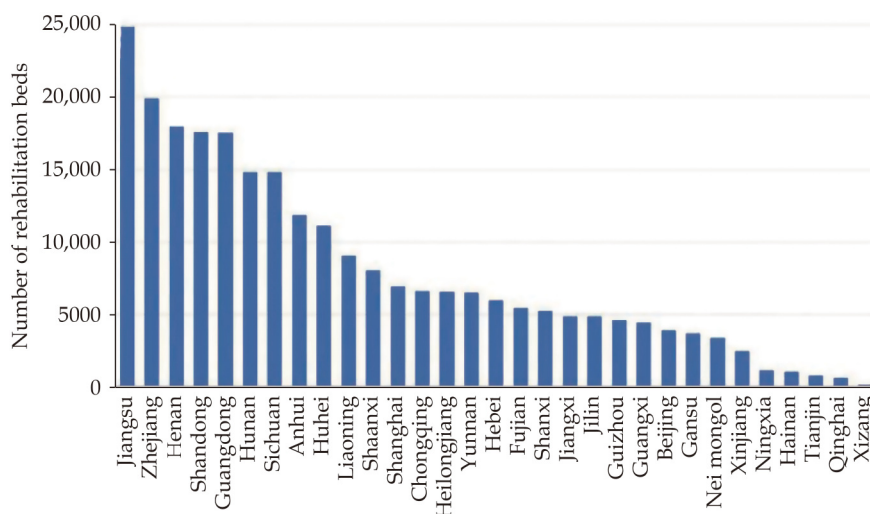


Figure 5 Numbers of rehabilitation beds in hospitals nationwide from 2015 to 2020.



246,907 nationwide in 2020, and the top five provinces in terms of bed numbers were Jiangsu, Zhejiang, Henan, Shandong, and Guangdong (Figure 6).^[19] The number of rehabilitation practitioners is also constantly increasing. A national survey in 2009 found that there were 16,000 physicians, 14,000 therapists, and 12,000 nurses engaging in medical rehabilitation. In 2018, the number of rehabilitation physicians and nurses in China increased to 38,000 and 15,000 respectively.^[20]

In recent years, Chengdu, Shenzhen, Shanghai, Jiangsu and Hebei conducted surveys on the bed and personnel structure of rehabilitation departments using survey questionnaires or online questionnaires.

In 2018, the Chengdu Rehabilitation Quality Control Center conducted a questionnaire survey on the number of beds and staffing in comprehensive hospitals, rehabilitation medical departments of traditional Chinese medicine hospitals, and rehabilitation hospitals in 22 districts (cities) and counties of Chengdu. The survey results showed that there were a total of 514 rehabilitation physicians and 415 therapists in rehabilitation departments of 66 secondary or above medical institutions, among which, 43 medical institutions had inpatient service in their rehabilitation departments, with a total of 1,781 designated beds. In 2019, the Chengdu Rehabilitation Quality Control Center conducted on-site investigation on 37 designated rehabilitation medical insurance institutions within the jurisdiction of Chengdu, including 1 National Health Commission affiliated medical institution, 7 provincial medical institutions, and 29 municipal medical institutions. The survey showed that there were a total of 681 rehabilitation physicians and 716 rehabilitation therapists in these institutions.^[21]

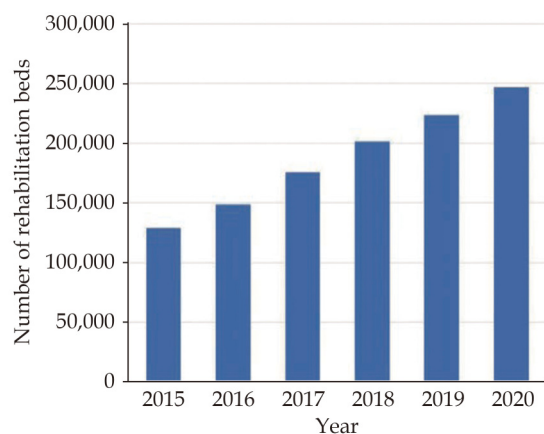


Figure 6 Numbers of rehabilitation beds in various regions of China in 2020.

From September to November 2019, Shenzhen conducted an online survey of 55 medical institutions with rehabilitation departments, and there were a total of 3,312 beds, 629 rehabilitation physicians, 902 therapists, and 790 nurses.^[22]

From June to July 2020, Shanghai conducted a survey of 311 tertiary, secondary, primary, and unranked medical institutions. Among them, 254 medical institutions had rehabilitation departments, with a total of 1,414 rehabilitation physicians, 2,668 rehabilitation therapists, and 1,614 rehabilitation nurses.^[23]

From December 2019 to October 2020, researchers in Jiangsu surveyed a total of 666 primary medical institutions through the “National Rehabilitation Medical Resource Survey System” network platform, with a total of 395 (59.31%) having rehabilitation departments or general practice clinics mainly focused on rehabilitation. Among them, 223 hospitals provided inpatient service, with a total of 3,967 beds of rehabilitation as the main function. There were a total of 234 rehabilitation physicians, 725 rehabilitation therapists, and 2,047 nurses in these 395 primary medical institutions.^[24]

From November to December 2020, staff in Hebei distributed WeChat questionnaires to 132 county-level comprehensive hospitals in the province, of which 107 hospitals had rehabilitation departments and had a total of 1,805 designated beds.^[25]

Rehabilitation assessment

From August 2015 to July 2019, a multi-center study involving 1,312 hospitals investigated factors related to rehabilitation assessment in hospitalized patients with cerebral hemorrhage and the relationship between rehabilitation assessment and prognosis during hospitalization. A total of 85,664 intracerebral hemorrhage patients were included, with an average age of 62.9 ± 12.9 years, and 37.5% were female. The results showed that 62,228 (72.6%) patients were assessed for rehabilitation. In multivariate analysis, patients with a history of hypertension, a history of peripheral artery disease, a higher Glasgow Coma Scale score at admission, dysphagia screening, carotid vessel imaging, and a longer length of hospital stay were more likely to undergo rehabilitation assessments. On the contrary, patients admitted to intensive care units and tertiary hospitals were less likely to be assessed during hospitalization. Urban residents with basic medical insurance were more likely to receive assessment than self-funded patients. Compared to pa-

tients who did not get rehabilitation assessment, those got rehabilitation assessment had longer hospital stays and lower in-hospital mortality.^[26]

Early rehabilitation

Early rehabilitation could help improve the neurological functions of patients with acute ischemic or hemorrhagic stroke, reduce the incidence of deep vein thrombosis, and improve their quality of life, but the time point for early or ultra early rehabilitation is still controversial.^[27]

A study divided 86 patients with ischemic stroke into an ultra early rehabilitation group of 41 cases (within 72 hours of onset) and an early rehabilitation group of 45 cases (within 72 h to 7 days of onset). Except for different intervention time points, the rehabilitation plans of the two groups were the same. The results showed that the National Institutes of Health Stroke Scale (NIHSS) and Fugl-Meyer Assessment (FMA) scores of patients in the ultra early rehabilitation group were significantly higher than those in the early rehabilitation group at 1 month and 3 months of onset, and the rehabilitation efficacy of the ultra early group was better than that of the early group.^[28] Another study compared the difference between patients starting rehabilitation treatment 24 to 48 h after onset (early rehabilitation group) and 72 to 96 hours after onset (standard rehabilitation group). One hundred and ten patients were randomized into two groups and received physical rehabilitation therapy including limb movement, stretching, rolling, bed sitting, standing, physical strength, and daily living ability training on the affected side. The results showed that compared to the standard rehabilitation group, the early rehabilitation group showed a decrease in the modified Rankin Scale (mRS) score at 90 days of onset, and a significant improvement in the lower extremity FMA score in the first week after stroke onset. However, there was no significant difference in the lower extremity motor function scores between the two groups at 3 months.^[29]

A study on early rehabilitation training of patients with hemorrhagic stroke included a total of 82 patients, with 41 in the early intervention group and 41 in the control group. The study found that compared to rehabilitation training within 3 to 4 weeks after onset, early intervention training between 2 and 7 days after onset was more beneficial for improving motor function, neurological function, and daily living abilities in patients with hemorrhagic stroke.^[30]

There is a lack of evidence for the benefits of early rehabilitation in patients with acute ischemic stroke after endovascular treatment. A multi-center, prospective study evaluated early rehabilitation on outcomes in stroke patients with large vessel occlusion who received endovascular treatment. 1,126 patients were divided into the early rehabilitation group [273 patients (24.2%) starting rehabilitation within one week of onset] and the standard care group of 853 patients (75.8%). The early rehabilitation group received rehabilitation intervention for 45 min per day, 5–7 days per week, on the basis of standard care treatment, with a maximum intervention time of 14 days. Although there was no significant difference in functional recovery (mRS 0–2) between the two groups at 90 days of onset, compared to the standard care group, early rehabilitation group had a lower 90-day mortality (6.2% vs. 20.5%, $P < 0.01$).^[31]

Application of traditional medicine and modern technology in China's tertiary stroke rehabilitation

Traditional Chinese medicine and health preservation methods (such as Qigong, Baduanjin, acupuncture and, etc.) combined with modern medical technology are increasingly used in the rehabilitation of stroke patients. Liuzijue Qigong combining conventional phonetic training could effectively improve the respiratory function and speech ability of patients with post-stroke motor aphasia.^[32] Combining conventional breathing training could improve trunk control ability, respiratory muscle function, and daily living activity ability in early stroke patients.^[33] Combining basic vocal training could improve the respiratory control ability and comprehensive speech ability of stroke patients with dysarthria.^[34] Combining conventional rehabilitation training could improve the balance function of stroke patients.^[35] Baduanjin exercise could ameliorate limb motor function, balance function, muscle strength, and gait in patients with post-stroke cognitive impairment.^[36] Interactive dynamic scalp acupuncture combined with lower limb robot training could effectively enhance the lower extremity motor function and walking ability of stroke patients.^[37]

The application of new technologies in the rehabilitation of stroke patients has also achieved some results. Brain-computer interface-operated lower limb rehabilitation robot and Sensorimotor rhythm-brain computer interface could improve the motor function of stroke patients and promote the recovery of cognitive function.^[38–40] Immersive virtual reality environment could



improve the upper extremity function of stroke patients, and transcutaneous auricular vagal nerve stimulation combined with conventional rehabilitation training could significantly improve the motor and sensory functions of stroke patients.^[41,42] An exoneuromusculoskeleton driven by electromyography could improve upper limb muscle coordination.^[43]

Large-scale Rehabilitation Projects in Recent Years in China

ICF studies

The International Classification of Functioning, Disability and Health (ICF) Core Set for Stroke could be used to evaluate the function, structure, activity and participation, and environmental factors of stroke rehabilitation patients. Research under the ICF framework could improve lower extremity motility, speech function, and evaluate swallowing function. Based on ICF Core Set, 113 stroke patients were selected and divided into the ischemic group ($n = 67$) and the hemorrhagic group ($n = 46$). Lower extremity exercise included joint function training, muscle strength training, endurance training, walking training, and wheelchair training. Patients were equipped with foot pads to provide plantar sound feedback. Both groups received lower limb motor training with plantar sound feedback, with a duration of 30 min per session, twice a day, for a total of 8 weeks. The gait part of the ICF Core Set for Stroke, the lower extremity part of the Fugl-Meyer Assessment (FMA-LE), the timed “up & go” test (TUGT), and the modified Barthel Index (MBI) were used for evaluation. The results showed that the combination of exercise therapy and plantar sound feedback could significantly improve the lower extremity motility, movement, and daily living activities of hemiplegic gait patients after stroke.^[44] A study used the “Speech Cognitive Assessment Training and Interaction” software under the ICF framework to train stroke patients with naming disorders, including naming training, continuation training, and listing training. The control group was given conventional speech training including naming images and objects, listening and retelling stimuli, and eliciting objects or images. Both groups trained for 40 minutes per session, 5 sessions per week, for a total of 1 month. The naming part of the Western Aphasia Battery was used for effectiveness evaluation. After 2 and 4 weeks of treatment, the software training group’s naming score significantly increased, indicating that the

naming disorder rehabilitation of the “Speech Cognitive Assessment Training and Interaction” aphasia training system under the ICF framework could effectively improve the naming disorder of stroke patients.^[45]

A study on the correlation between ICF-d560 and swallowing function in convalescent stroke patients included 140 convalescent stroke patients with swallowing disorders hospitalized in the rehabilitation department. The subjects were evaluated by two rehabilitation physicians trained through ICF clinical practice. According to ICF-d560, dysphagia was classified into 1–4 levels (1–10 points), and according to the modified Kubota Water Swallowing Test, dysphagia was classified as mild, moderate, and severe. The impact of various clinical risk factors on the screening results of dysphagia was analyzed with the Enter method in linear regression, and the correlation between ICF-d560 and the modified Kubota Water Swallowing Test was explored with Spearman correlation analysis. The results indicated that ICF-d560 had a good correlation with the modified Kubota Water Swallowing Test and could be used as a swallowing function screening tool under the ICF framework.^[46]

Successful explorations of stroke rehabilitation model in China

With the advances of the three-level rehabilitation and Internet technology, a community-family-smart technology assisted rehabilitation model, suitable for the current national conditions, is being explored for stroke rehabilitation. Remote rehabilitation can deliver rehabilitation services through information and communication technology to make up for the current shortage of stroke rehabilitation resources, especially during the pandemic period.

A 6-month study conducted at 3 community health service centers in Fengtai District, Beijing, found that receiving remote rehabilitation guidance from home during community outpatient rehabilitation could improve rehabilitation outcomes for stroke patients. This study randomly divided 240 stroke recovery patients into a control group and a remote rehabilitation group of 120 each. Both groups received community rehabilitation outpatient treatment for 6 months, no less than 3 times a week, and no less than 1 h each time. The remote rehabilitation group received remote rehabilitation guidance through online communication platforms, 2–3 times a week, for about 30 min each time. The results showed that the BI and FMA scores of the remote group were



higher than those of the control group.^[47] A study on task oriented training for discharged stroke patients through remote rehabilitation platforms showed that task oriented training implemented through remote rehabilitation platforms could improve stroke patients' motor function and activities of daily living (ADL). The study randomly divided 80 patients into a control group and a treatment group, with 40 patients in each group. The control group patients made outpatient follow-up visits once a week, and a task oriented training plan was developed by rehabilitation therapists. Patients were required to undergo systematic upper and lower extremity training at home or at the community health service center, twice a day for 60 min each time; The treatment group received follow-up visits through a remote rehabilitation platform, and the rehabilitation therapist developed task oriented training for the patients remotely. Under remote guidance, supervision, and real-time adjustment of the therapist, the patients did 60 min of upper and lower limb training twice a day. At 4 and 8 weeks of treatment, the BI and FMA scores of the remote group were higher than those of the control group.^[48] A 12-week prospective randomized controlled study conducted by Zhongshan Hospital of Fudan University in Shanghai also showed that home-based telerehabilitation improved motor function in stroke patients, and was safe and feasible.^[49]

A community-based rehabilitation for patients with cerebral hemorrhage showed that 3–6 months of community-based rehabilitation not only promoted the recovery of neurological functions, but also improved their medication compliance and quality of life.^[50] The results of a randomized controlled study on the hospital-community integrated service model conducting on 120 elderly stroke patients after discharge showed that applying the hospital-community integrated service model to home rehabilitation of stroke in disabled elderly could improve their self-care ability and self-efficacy, improve medical compliance, and reduce negative emotions.^[51]

A study of a transitional home-based care program after stroke randomly divided 116 patients with ischemic stroke into an intervention group ($n = 58$) and a control group ($n = 58$). The intervention group received a 12-week transitional home-based care program. This program was developed by a team of 1 physical therapist, 1 occupational therapist, 1 speech therapist, 1 neurologist, and 1 rehabilitation doctor based on national guidelines of China, the United States, and Canada. It included one

pre-discharge meeting, six post-discharge home visits (odd weeks), and six telephone follow-up visits (even weeks), with a dedicated hotline managed by nurses available for communication throughout the entire 12 weeks. The control group received medication advice, rehabilitation training, and telephone follow-ups from nurses. Research found that this home-based transitional care program could improve stroke patients' quality of life, ADL, and self-efficacy at 90 and 180 days of intervention.^[52]

Stroke Rehabilitation Guidelines and Consensuses

In January 2022, experts from the Neurorehabilitation Group of Chinese Society of Neurology, the Cerebrovascular Disease Professional Committee of the Chinese Association of Rehabilitation Medicine and the China Rehabilitation Research Center issued the Expert Consensus on Clinical Management of Post-stroke Aphasia, which provides evidence-based medical evidences for standardized clinical management and common clinical issues of post-stroke aphasia, and provides clinical guidance for the rehabilitation of post-stroke aphasia patients.^[53]

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