ORIGINAL RESEARCH

A Mobile Health-Based Management for Patients with Limited Lung Function to Improve Treatment Outcomes and Quality of Life After Minimally Invasive Thoracoscopic Lobectomy

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ABSTRACT

Objective • Limited lung function is an independent risk factor for postoperative respiratory failure in non-small cell lung cancer (NSCLC) patients. In this study, we developed a mobile health-based management for NSCLC patients with limited lung function who were scheduled to receive lobectomy and evaluated its effects on the patient's pulmonary function and quality of life.

Methods • A total of 60 NSCLC patients scheduled to receive minimally invasive thoracoscopic lobectomy were enrolled and then randomized into the traditional management group and the program management group, with 30 patients per group. Based on the WeChat mini program, a management software for patients with limited lung function was established, including two portals: the patient portal and the nurse one. The pain assessment was performed using the Visual Analog Scale (VAS) scores, the cough assessment using the Leicester Cough Questionnaire, and the quality-of-life assessment using the EORTC QLQ-30 at 1 day before surgery, 1 week, 2 weeks, 1 month, 6 months, or 12 months after surgery.

Results • The program management group exhibited an increased PaO_2 (96.68 ± 7.92 vs. 87.69 vs. 5.50; P = .018) concomitant with a declined $PaCO_2$ (38.55 ± 2.79 vs. 40.65 ± 2.17; p = 0.034) at 12 months after surgery compared with the traditional management group. The VAS scores showed significant differences at 2 weeks after surgery between the traditional management (median: 2; range: 2-3) and program management (median: 2; range: 1-2) groups (P = .012). The scores of Leicester Cough Questionnaire showed remarkable differences at 12 months after surgery between the traditional management (20.00 ± 1.54) and program management (18.99 ± 2.08) groups (P = .036). The total scores of EORTC QLQ-30 showed notable differences at 12 months after surgery between the traditional management (83.05 ± 14.09) and program management (90.55 ± 11.32) groups (P = .027).

Conclusion • The study demonstrated improved pulmonary function and a better quality of life conferred by the mobile health-based management based on WeChat mini program for NSCLC patients with limited lung function and undergoing thoracoscopic lobectomy in a long follow up. (*Altern Ther Health Med.* [E-pub ahead of print.])

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INTRODUCTION

Lung cancer represents one of the most prevalent and lethal malignancies worldwide, leading to 2.2 million new lung cancer diagnoses accounting for 11.4% of all new cancer diagnoses and 1.8 million deaths caused by lung cancer accounting for 18.0% of all cancer-related deaths in 2020.[1] The incidence of lung cancer in China has experienced a rapid increase, leading to significant social and economic burdens.[2] Among the various treatment options available, surgical resection remains a mainstay in managing localized lung cancer.[3] Lung cancer lobectomy aims to remove the tumor along with the surrounding lymph nodes to achieve complete eradication of the cancerous tissue, which is often considered the gold standard surgical approach for patients with early-stage non-small cell lung cancer (NSCLC) and certain cases of small cell lung cancer (SCLC), providing both therapeutic benefits and potential for improved long-term survival.[4,5] There is considerable belief that video-assisted thoracoscopic surgery lobectomy leads to better patient outcomes.[6] Regardless of the age at the time of the surgical procedure, lobectomy has been shown to offer improved 5-year survival rates compared to sublobar resection in octogenarians diagnosed with stage-I

lung cancer, and it is recommended that all medically fit patients with stage I cancer be considered for lobectomy as a treatment option.[7] Nevertheless, lobectomy is a major surgical intervention that requires careful patient selection, meticulous surgical technique, and comprehensive post-operative management.[8]

In the last two decades, video-assisted thoracoscopic surgery has been widely applied for lobectomy, which is associated with less postoperative symptom burden and better quality of life compared with traditional thoracotomy for the first year after surgery.[9] In some cases, lung cancer patients experience postoperative pain, accumulating respiratory secretions and an increased risk of pulmonary infection, ultimately resulting in respiratory failure and even death.[10] Preoperative pulmonary dysfunction, such as the decreased diffusing capacity of the lung for carbon dioxide ($DLCO_2$), or preexisting comorbidities, such as interstitial lung disease, are the most significant risk factors for the development of acute pulmonary complications after pulmonary resection in patients with lung cancer.[11] Patients were previously not eligible for open resection due to poor pulmonary function but could tolerate minimally invasive surgery followed by improved postoperative care.[12,13] Prevous studies showed that standard integration of pulmonary rehabilitation into thoracic enhanced recovery after surgery could reduce the incidence of postoperative pulmonary complications, improves respiratory muscle strength and exercise capacity.[14-16] Currently, few outcome data are available regarding befnefits from postoperative care for this fragile population.[17] The most frequently reported postoperative symptoms related to poor quality of life were thoracotomy pain, coughing, fatigue, and dyspnea, and all these symptoms are chronic conditions that receive less attention after discharge.[18] Scientific long-term follow-up and management after discharge are effective approaches to improving lung function, reducing postoperative pain and cough, and enhancing the quality of life for patients.[19] However, the traditional pulmonary function test guidelines for tolerance to operation and occasionally untraceable or delayed follow-up management caused by limited hospital staff and resources fails to meet patients' needs and achieves ideal outcomes in pulmonary function, pain, and cough management, especially for those with limited pulmonary reserve.[20] With the development of wireless technology and smartphones, mobile health based on mobile applications, such as the WeChat platform, has been widely used in managing chronic diseases and long-term follow-up due to more convenient access, personalized services, and large-scale target population.[21] WeChat owned by Chinese tech giant Tencent is the largest social networking application in China and has monthly user base of more than 1 billion people.[22] A previous study reported a WeChat-supported platform, Medication Housekeeper (MediHK), to enhance communication, optimize outcomes, and promote self-management of ambulatory cancer pain in the home setting.[23] An intriguing hypothesis of improved postoperative care with aid of WeChat-supported platform is raised for patients with limited pulmonary function after thoracoscopic lobectomy. In this study, we developed a perioperative management program using the WeChat platform for patients with limited pulmonary function and required to undergo thoracoscopic lobectomy to evaluate the potential effects of this WeChat-based program on improvement of postoperative pulmonary function and quality of life after thoracoscopic lobectomy for NSCLC pateints with limited pulmonary function. For this purpose, we recruited 60 NSCLC patients scheduled to receive minimally invasive thoracoscopic lobectomy and randomized them to two treatment arms: a traditional management and a program management based on the WeChat mini program. Pain and cough scores, and patient quality of life were examined at 1 day before surgery, 1 week, 2 weeks, 1 month, 6 months, or 12 months after surgery

METHODS

Patient recruitment and selection

NSCLC patients scheduled to receive minimally invasive lobectomy were recruited into this study. The inclusion criteria were: i) histopathological diagnosis for NSCLC based on computed tomography (CT) or positron emission tomography and computed tomography (PET-CT) examinations, bronchoscopy biopsies, or lung biopsies; ii) mild or above pulmonary dysfunction in terms of ventilation or diffusion function based on lung function tests; and iii) eligible for minimally invasive lobectomy at our hospital. The exclusion criteria were: i) other malignant tumors or severe dysfunction of organs such as the heart, liver, or kidneys; ii) coexistence of mental disorders or neurological diseases.; and iii) lack of digital literacy. The recruitment occurred at the First People's Hospital of Changzhou from July 2022 to December 2022. The study protocols were approved by the Ethics Committee of the First People's Hospital of Changzhou and performed in accordance with the Declaration of Helsinki. After providing written informed consent to participate in the study, eligible participants were assigned using random number tables into either the traditional or program management groups.

Traditional management protocols

The traditional management protocols involved as followed:

Preoperative education: physicians and nurses introduced themselves to the patients and provided explanations of the disease, surgical plans, precautions, and addressed any concerns or questions from the patients; they guided patients on proper diet and sleep, aiming to enhance the patient's understanding of the disease and alleviate their anxiety and fear.

Psychological intervention: Experienced nursing staff assessed the psychological status of the patients and identified their psychological needs; they offered encouragement, comfort, and psychological counseling, motivating patients to actively cooperate with the treatment; they also shared successful case stories of postoperative recovery to help patients build confidence in overcoming the disease.

Preoperative training: Patients were instructed to perform deep breathing exercises, effective coughing techniques, and chest and abdominal breathing exercises before surgery; they were advised to quit smoking and drinking.

Social support: family members received education on disease knowledge to understand their important role in the patient's recovery process; this aimed to improve their cooperation and support for the patient's rehabilitation, enabling the patient to face the surgery and postoperative recovery process positively and optimistically. Telephone follow-up within 7 days postoperatively: Traditional methods such as telephone follow-up and outpatient visits were used for follow-up within the first week after surgery; each follow-up recorded the patient's recovery exercise progress, daily activities, self-care, healthy diet, and medication usage.

Outpatient follow-up visits: Patients were instructed to continue respiratory function training on their own after discharge; they were advised to regularly visit the medical institution for outpatient follow-up appointments; During these visits, the patient's treatment progress, occurrence of pulmonary complications, blood gas analysis, lung function tests, chest CT scans (plain or enhanced), and other relevant examinations were conducted; the subsequent treatment decisions were adjusted based on the results of these assessments during each visit.

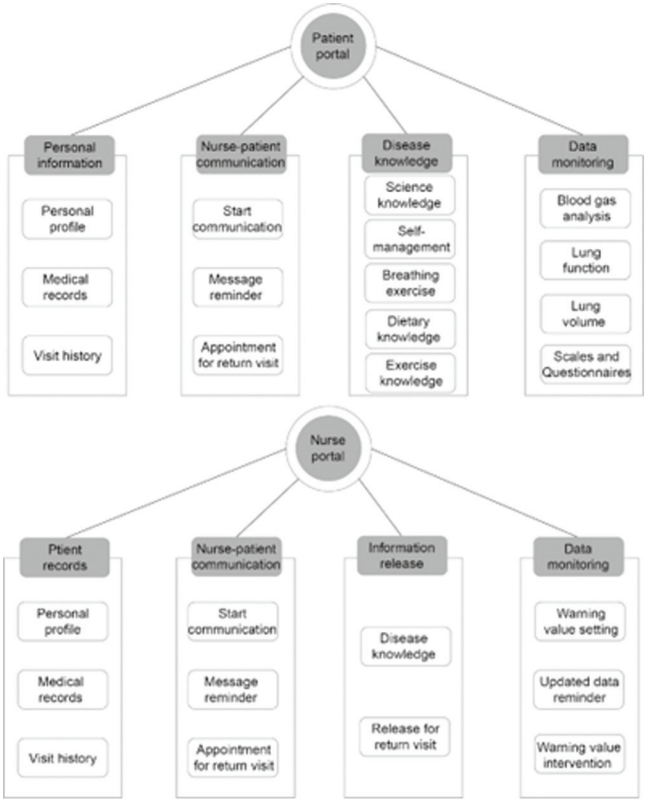
The management protocols based on WeChat mini program

After the WeChat mini program was completed, three third-party product managers and three project managers were asked to test this mini program prior to launching. The testing models involved user interface, system fluency, functional connectivity, and data storage. Each model was scored 0-100 points, with the average scores calculated. A total scores ≥ 90 were considered as excellent, 80-89 as good, 70-79 as normal, and < 70 as poor. If the total scores were less than 80, this WeChat mini program needed further optimization prior to launching.

After developing, evaluating, debugging, and optimizing this WeChat mini program, the first step was to conduct training for the management team. The team members are required to master the usage of the patient and nurse portals on the management platform. The learning effectiveness of the team members is assessed, and they can only participate in management after passing the assessment. At the same time, a user manual for the patient portal on the management platform is created. The management team members explain the management platform's usage methods to the patients and distribute the user manual. During the hospitalization period, the management team members guide the patients in using the patient portal software. After surgery, the patients received a 1-year follow-up management based on the management platform.

The finialized management software for patients with limited lung function based on the WeChat mini program was established and implemented, including two portals: the patient portal and the nurse one (Figure 1).

Figure 1. Management model based on WeChat mini program.



The patient portal consists of four modules: personal information, nurse-patient communication, disease knowledge, and data monitoring.

Personal information: This module involves personal profile, medical records, and visit history. When patients joined the program thourgh this Wechat mini program, doctors fill in their personal profiles, including gender, age, personal history, medical history, and diagnosis results. Patients can access their personal visit history, which covers visit dates, hospitals, and attending doctors.

Nurse-patient communication: This module enables real-time communication between patients and responsible nurses. Patients can initiate communication with their assigned nurse, and the nurse can choose communication time slots and use text, voice, or video formats to communicate with the patient. The message reminder involves reminders for follow-up visits, data entry, data anomalies, and nurse communication.

Disease knowledge: This module includes sections on popular science knowledge, self-management knowledge, respiratory training knowledge, dietary knowledge, and exercise knowledge. Nurses regularly publish disease-related knowledge for patients to read. Each article has a comment section where patients can ask questions about the content, and the author answers the patients' queries.

Data monitoring: This module includes functions for blood gas analysis, ventilation and diffusion function, and lung volume CT quantification analysis. Based on the

monitoring schedule set by the nurse, patient indicator test results are collected promptly to ensure data accuracy. Images can be uploaded, and the system utilizes Optical Character Recognition to automatically input the data. Doctors set individualized warning values for blood gas analysis, ventilation and diffusion function, and lung volume CT quantification analysis for each patient. If a patient's data exceeds the warning values, an alert is sent to the patient and the responsible physician. The physician needs to promptly contact the patient to determine the cause of the data anomaly and, if necessary, instruct the patient to schedule a follow-up visit to adjust the intervention plan. Patient rating scales (pain, cough, and quality of life) include the Visual Analog Scale (VAS) for pain assessment, Leicester Cough Questionnaire for cough assessment, and EORTC QLQ-30 for quality-of-life assessment.

The nurse portal includes four modules: patient profiles, nurse-patient communication, information release, and data monitoring.

Patient profiles: The demographic and clinical variables of included patients were recorded in this module, and the nurses can assist patients in establishing personal files. Synchronize patients' personal profiles, medical records, and visit history.

Nurse-patient communication: Nurses can initiate communication with patients and proactively schedule follow-up visits.

Information release: This module includes two functions: disease knowledge publishing and follow-up information publishing. For each patient, set a fixed follow-up time. The system automatically sends reminder messages to the patient in three days, two days, and one day before the scheduled follow-up. Nurses can use this function to set specific re-examination times and send reminder messages to patients.

Data monitoring: Based on the characteristics of the patient's condition, set alarming levels for blood gas analysis, ventilation and diffusion function. Instruct patients to regularly visit the medical institution for outpatient follow-up. If the test results exceed the warning values, the system prompts the nurse to communicate with the patient promptly. The nurse should determine the cause of the abnormal test results and adjust the intervention plan if necessary.

Outcome measurements

The outcome measurements included the changes of arterial oxygen partial pressure (PaO_2), arterial carbon dioxide partial pressure ($PaCO_2$), lung ventilation and diffusion functions by Best forced vital capacity (FVC), forced expiratory volume in 1 second (FEV1) and percent of FVC exhaled in the first second (FEV1/FVC), peak expiratory flow (PEF), and $DLCO_2$, pain assessment using the VAS scores, cough assessment using the Leicester Cough Questionnaire, and quality-of-life assessment using the EORTC QLQ-30.

The blood gas analyzer (Roche Diagnostics, Indianapolis, IN, USA) was used to examine PaO_2 and $PaCO_2$. The VAS is a 10-grade assessment tool ranging from 1-10 corresponding to no pain and extreme pain for quantifying patient pain at 1 day before surgery, 1 week, 2 weeks, 1 month, 6 months, or 12 months after surgery.[24] The Leicester Cough Questionnaire was used to evaluate the degree of cough in patients at 1 day before surgery, 1 week, 2 weeks, 1 month, 6 months, or 12 months after surgery.[25] The EORTC QLQ-30 is a disease-specific health-related scale to evaluate quality of life, which has a score ranging from 0 to 100, wherein a higher score reflects either better function or worse symptomatic effect.[26]

Table 1. Baseline patient characteristics.

Characteristic	Traditional (n = 30)	Program (n = 30)	*P* value
Age (year)	53.73 ± 10.68	51.07 ± 9.49	.311
Sex (male, n/%)	5 (16.67%)	7 (23.33%)	.519
BMI (kg/m^2)	22.75 ± 3.28	23.61 ± 4.18	.380
Education level (year)	10.33 ± 2.96	10.90 ± 2.80	.449
Hospital LOS (d)	7 (5.8, 9)	7 (6, 8)	.908
Hypertension (n/%)	3 (10.00%)	5 (16.67%)	.448

Abbreviaitions: BMI, body mass index; LOS, length of stay.

Statistical analysis

Continuous variables were presented as mean ± standard deviation (sd) and analyzed between two groups using the independent *t* test for normally distributed data. For not normally distributed data, median (25% percentile, 75% percentile) was shown andMann-Whitney U test was used for statistical analysis between two groups. The comparisons among different time points in a group and in two groups were evaluated using repeated measure analysis of variance (ANOVA) followed by Tukey's multiple comparisons test. Moreover, categorical variables (n/%) were analyzed by the chi-square test. All statistical tests used a two-tailed $P < .05$ as statistically significant in GraphPad prism, version 6.0 (GraphPad, San Diego, CA, USA).

RESULTS

Baseline patient characteristics

In total, 60 NSCLC patients scheduled to receive minimally invasive lobectomy were enrolled and then randomized into the traditional and program management groups, with 30 patients per group. Table 1 summarized the baseline patient characteristics of both groups, including age, sex, body mass index (BMI), education level, hospital length of stay (LOS), and comorbid diseases. No significant differences were noted about these baseline patient characteristics between the traditional and program management groups ($P > .05$).

Effects of management information system on PaO_2 and $PaCO_2$ of NSCLC patients undergoing thoracoscopic lobectomy

After thoracoscopic lobectomy, pateints may experience respiratory insufficiency characterized by reduced PaO_2 and/or increased $PaCO_2$ (23922525). The PaO_2 and $PaCO_2$ were recorded 1 day before surgery, 1 month after surgery, 6 months after surgery, and 12 months after surgery and compared between the traditional and program management

groups. The mean values of PaO_2 in the program management group and the traditional management group were 96.68 and 87.69, respectively. The mean values of $PaCO_2$ in the program management group and the traditional management group were 38.55 and 40.65, respectively. The program management group exhibited an increased PaO_2 concomitant with a declined $PaCO_2$ at 12 months after surgery ($P = .018$ and $P = .034$, Table 2). No significant differences were noted between the traditional and program management groups at 1 day before surgery, 1 month after surgery, and 6 months after surgery ($P > .05$). These data suggested that the mobile health-based management based on WeChat mini program could improve respiratory function of NSCLC patients with limited lung function after thoracoscopic lobectomy.

Effects of management information system on lung function of NSCLC patients undergoing thoracoscopic lobectomy

A reduced ratio of FEV1/FVC is known to be associated with an increased lung cancer risk (23101666). The Best FVC, FEV1/FVC, PEF, and $DLCO_2$ were recorded 1 day before surgery, 1 month after surgery, 6 months after surgery, and 12 months after surgery and compared between the traditional and program management groups. As shown in Table 3, no significant differences were noted between the traditional and program management groups at 1 day before surgery, 1 month after surgery, 6 months after surgery, and 12 months after surgery ($P > .05$). Although the mobile health-based management based on WeChat mini program exerted no statistatical significant impact on lung function of NSCLC patients with limited lung function after thoracoscopic lobectomy, further large-scale studies with follow-up more than 12 months are warranted.

Effects of management information system on patient's quality of life after thoracoscopic lobectomy

The quality of life of NSCLC patients undergoing lobectomy was evaluated by the scores of VAS and Leicester Cough Questionnaire at 1 week after surgery, 2 weeks after surgery, 1 month after surgery, 6 months after surgery, or 12 months after surgery, as well as the scores of EORTC QLQ-30 at 1 month after surgery, 6 months after surgery, or 12 months after surgery (Table 4). The VAS scores showed significant differences at 2 weeks after surgery between the traditional management (median: 2; range: 2-3) and program management (median: 2; range: 1-2) groups ($P = .012$). The scores of Leicester Cough Questionnaire showed remarkable differences at 12 months after surgery between the traditional management (20.00 ± 1.54) and program management (18.99 ± 2.08) groups ($P = .036$). The total scores of EORTC QLQ-30 showed notable differences at 12 months after surgery between the traditional management (83.05 ± 14.09) and program management (90.55 ± 11.32) groups ($P = .027$). These data suggested that the mobile health-based management based on WeChat mini program could improve quality of life of NSCLC patients with limited lung function after thoracoscopic lobectomy.

Table 2. The PaO_2 and $PaCO_2$ at 1 day before surgery, 1 month after surgery, 6 months after surgery, and 12 months after surgery between the traditional management group and the program management group.

	Traditional (n = 30)	Program (n = 30)	*P* value
PaO_2 (mean ± sd)			
1 day before surgery	85.24 ± 10.24	90.12 ± 12.22	.588
1 month after surgery	93.70 ± 13.46	94.22 ± 13.11	.999
6 months after surgery	87.90 ± 6.86	93.69 ± 9.44	.360
12 months after surgery	87.69 ± 5.5	96.68 ± 7.92	.018
$PaCO_2$ (mean ± sd)			
1 day before surgery	42.06 ± 2.59	41.21 ±3.4	.901
1 month after surgery	40.45 ± 2.47	40.62 ±2.15	.999
6 months after surgery	40.26 ±2.42	40.62 ±2.15	.999
12 months after surgery	40.65 ±2.17	38.55 ±2.79	.034

Table 3. The Best FVC, PEF, and $DLCO_2$ at 1 day before surgery, 1 month after surgery, 6 months after surgery, and 12 months after surgery between the traditional management group and the program management group.

	Traditional (n = 30)	Program (n = 30)	*P* value
Best FVC (mean ± sd)			
1 day before surgery	93.77 ± 12.22	94.5 ± 10.67	.999
1 month after surgery	79.27 ± 13.35	77.11 ± 13.58	.998
6 months after surgery	88.03 ± 12.66	90.88 ± 14.31	.991
12 months after surgery	86.14 ± 12.28	92.78 ± 16.83	.534
FEV1/FVC (mean ± sd)			
1 day before surgery	106.00 ± 6.00	104.00 ± 6.00	.937
1 month after surgery	104.00 ± 6.80	102.00 ± 7.00	.937
6 months after surgery	103.00 ± 6.00	101.00 ± 6.00	.942
12 months after surgery	104.00 ± 5.00	102.00 ± 9.00	.935
PEF (mean ± sd)			
1 day before surgery	86.97 ± 16.55	89.40 ± 20.96	.999
1 month after surgery	84.96 ± 18.86	76.29 ± 20.23	.649
6 months after surgery	90.71 ± 21.43	88.89 ± 18.43	.999
12 months after surgery	89.28 ± 17.89	90.89 ± 17.92	.999
$DLCO_2$ (mean ± sd)			
1 day before surgery	93.30 ± 11.39	96.37 ± 14.56	.988
1 month after surgery	82.28 ± 17.34	81.93 ± 15.1	.999
6 months after surgery	90.07 ± 11.37	85.61 ± 12.37	.909
12 months after surgery	90.24 ± 12.32	86.59 ± 13.19	.968

Table 4. The scores of VAS, Leicester Cough Questionnaire, and EORTC QLQ-30 of NSCLC patients at 1 week, 2 weeks, 1 month, 6 months, or 12 months after surgery.

Scale	Traditional (n = 30)	Program (n = 30)	*P* value
VAS, median (Q1, Q3)			
1 week after surgery	4 (3, 4)	3 (2, 5)	ns
2 week after surgery	2 (2, 3)	2 (1, 2)	.012
1 month after surgery	2 (1, 2)	1.5 (1, 3)	ns
6 months after surgery	0 (0, 1)	1 (0, 1)	ns
12 months after surgery	0 (0, 0.25)	0 (0, 1)	ns
Leicester Cough Questionnaire (mean ± sd)			
1 week after surgery	12.77 ± 2.66	13.85 ± 2.93	ns
2 week after surgery	14.62 ± 2.25	15.08 ± 3.85	ns
1 month after surgery	16.11 ± 2.05	16.36 ± 3.33	ns
6 months after surgery	18.90 ± 2.03	17.89 ± 2.80	ns
12 months after surgery	20.00 ± 1.54	18.99 ± 2.08	.036
EORTC QLQ-30 (mean ± sd)			
1 month after surgery	70.56 ± 15.59	71.11 ± 16.48	ns
6 months after surgery	85.28 ± 12.12	79.44 ± 18.40	ns
12 months after surgery	83.05 ± 14.09	90.55 ± 11.32	.027

Abbreviations: VAS, Visual Analog Scale; ns, not significant.

DISCUSSION

Mobile health interventions have demonstrated their effectiveness in reducing the stigma experienced by cancer patients and enhancing their treatment experience, which provides an alternative method to address the challenges of limited healthcare professionals and delayed information dissemination.[22] Herein, we developed a mobile health-based

management based on the WeChat mini program for NSCLC patients with limited lung function after thoracoscopic lobectomy, which involves the patient portal and the nurse one.

Different from other mobile health platforms specific for lung cancer, for example Ciani et al.'s LuCApp[27] and Hanshall and Davey's iEXHALE,[28] our present WeChat mini program is based on social network platform. Chinese patients, even older patients, have been familiar with or easy to accept education for mobile health. The mobile health-based management based on the WeChat mini program allows WeChat followers to access information, input data, communicate with peers and medical staff registered in this program, and it has no special requirement for the mobile operating system.[29] Concerning the content, the LuCApp mianly focused on symptom monitoring and the iEXHALE primiarily focused on postoperative pulmonary rehabilitation, the WeChat mini program in this study contained multiple modules from preoperative period to postoperative period to achieve self-management, self-monitoring, doctor-patient real-time communication, as well as nurse monitoring, online follow-up, and data supervision. At the same time, the establishment of the WeChat mini program could prevent delayed feedback and poor-quality follow-up data caused by human and material resource insufficiency.[30]

NSCLC patients with limited lung function after thoracoscopic lobectomy after discharge are lack of self-management skills and a sustainable professional or peer-support platform. Better patient involvement in health management and adopting targeted self-care behaviors to mitigate the impact of cancer and treatment while optimizing overall well-being are pivotal for ensuring high-quality healthcare and cancer care.[31] Emerging evidence suggests that mobile health (mHealth) interventions aimed at promoting self-management have the potential to enhance pain and fatigue outcomes among cancer survivors and show promising results in addressing psychological distress and sleep-related issues.[32] However, the mobile health application only focusing on self-management of symptoms and health-related quality of life failed and failed to improve the patient's knowledge, skills, and confidence for self-management in cancer survivors.[33] In this study, the mobile health-based management based on the WeChat mini program involves two target users, patients and nurses, providing professional or peer-support for monitoring patient data symptoms.

Since different forms of pulmonary resections are performed in lung cancer cases, particularly among patients with limited lung function due to different degrees of bronchial obstruction, it is crucial to evaluate the changes in levels-partial pressures of blood gases (PaO_2 and $PaCO_2$) before and after lung surgery to prevent the onset of respiratory insufficiency.[34] The patients with NSCLC bear a relatively huge symptom burden from pain, dyspnea, cough, fatigue, depression, and anxiety after pulmonary resection, significantly affecting their quality of life.[35] A multicenter randomized controlled trial demonstrated that patient-reported outcome management following pulmonary resection could alleviate symptom burdens and reduce the incidence of postoperative complications compared to conventional care for up to 4 weeks after discharge.[36] The patient portal of our mobile health-based management consists of four modules: personal information, nurse-patient communication, disease knowledge, and data monitoring. When patients join the program, doctors fill in their personal profiles, including gender, age, personal history, medical history, and diagnosis results. The NSCLC patients with limited lung function after thoracoscopic lobectomy had increased PaO_2, declined $PaCO_2$, reduced pain and cough scores, and increased scores reflecting quality of life at 12 months after surgery after receiving the mobile health-based management developed compared with those receiving self-management.

A few limitations should be noted. Firstly, although mobile health-based management is easy-to-access, it requires digital literacy. Advanced age is common among lung cancer populations, which may weaken the feasibility of the mobile health-based management for large populations. Accordingly, further efforts, such as clear manuals with stepwise diagrams or Loop-Playback vedio, are made to provide digital literacy training or support for older patients to enhance their engagement with the system. Secondly, a lag in communication between patients and healthcare workers may occur due to limited functions of the platform. For example, the mobile health-based management failed to give interactive feedback to the patient's symptom self-assessment results. Future updates are required to achieve real-time feedback with the aid of artificial intelligence. Thirdly, a small sample size over 1-year period of time needs the evaluation of large-scale population and long-term effects. Future studies should recruite more samples and analyze outcomes according to age-stratification.

CONCLUSION

In conclusion, the mobile health-based management based on the WeChat mini program could lead to improved pulmonary function and a better quality of life for NSCLC patients with limited lung function after thoracoscopic lobectomy in a long follow-up. Continuous updates of the public account should be adapted to patients' specific needs and preferences with NSCLC. Extending the follow-up time to 18 and 24 months, incorporating machine learning or continuous update of this mini program using artificial intelligence for intelligent feedback, and expanding the system to address other aspects of patient care are expected to enhance the compatibility and superiority of the mobile health-based management based on the WeChat mini program for patients with limited lung function after minimally invasive thoracoscopic lobectomy.

AVAILABILITY OF DATA AND MATERIALS

The data used for the study are available in the present study.

COMPETING INTERESTS

None of the authors have a conflict of interest to disclose.

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