Original Article

The effects of information platform-based nursing on preventing venous thromboembolism in patients with hip fractures

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ABSTRACT

Purpose: Venous thromboembolism (VTE) is a major health issue among hip fracture patients. This study aimed to develop an information platform based on a mobile application and then evaluate whether information platform-based nursing could improve patient's drug compliance and reduce the incidence of VTE in hip fracture patients.

Methods: This study retrospectively analyzed hip fracture patients who were treated with conventional prevention and intervention methods for VTE (control group) between January 2008 and November 2012, and prospectively analyzed hip fracture patients who were treated with nursing intervention based on the information platform (study group) between January 2016 and September 2017. All the patients included in the both groups were hip fracture patients who had an age over 50 years, treated with surgery, and hospitalized $\geq$ 48 h. Patients were excluded if they admitted to hospital due to old fractures, had a severe bleeding after 72 h of admission, diagnosed with any type of VTE, or refused to participate in the study. The information platform was divided into medical, nursing, and patient interface. Based on the information platform, medical practitioners and nurses could perform risk assessments, monitoring management and early warnings, preventions and treatments, health educations, follow-up, and other aspects of nursing interventions for patients. This study compared essential characteristics, drug compliance, VTE occurrence, and mean length of hospitalization between the two groups. Besides, a subgroup analysis was performed in the study group according to different drug compliances. SPSS 18.0 software (IBM Corp., NY, and USA) was used for statistical analysis.

Results: Altogether 1177 patients were included in the control group, and 491 patients in the study group. Regarding baseline data, patients in the study group had more morbidities than those in the control group ($p < 0.05$). The difference of drug compliance between the two groups was statistically significant ($p < 0.001$): 761 (64.7%) of the patients in the control group and only 30 (6.1%) patients in the study group had poor drug compliance. In terms of VTE, 10.7% patients (126/1177) in the control group had VTE, and the rate in the study group was 7.1% (35/491), showing a statistically significant difference ($p = 0.02$). Moreover, the average length of hospitalization in the study group was also significantly lower than that in the control group (10.4 days *vs.* 13.7 days, $p < 0.001$). Subgroup analyses of the study group showed that the incidence of VTE in patients with poor, partial, and good compliances were 56.7% (17/30), 5.8% (10/171), and 2.8% (8/290), respectively, revealing a significantly huge difference ($p < 0.001$).

Conclusions: Poor drug compliance leads to higher VTE occurrence. The information platform-based nursing can effectively improve the compliance of hip fracture patients and thus considerably reduce the incidence of VTE. The mobile application may be an effective tool to prevent VTE in hip fracture patients.

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Introduction

Venous thromboembolism (VTE), including deep vein thrombosis (DVT) and pulmonary thromboembolism (PE), is regarded as one of the most severe complications of fracture patients.[1] Studies have shown that the prevalence of VTE ranged from 2.7% to 18% for DVT and 1.4%—10% for PE.[2-6] Besides, VTE patients experienced 10 times the health burden and twice the length of hospitalization compared to patients without VTE.[7]

Previously, researchers found that the compliance of patients with hip fracture was an independent VTE risk factor.[8] The continuous nursing model represented a new nursing strategy by elongating the nursing intervention towards the post-discharge period,[9,10] facilitating medication guidance, efficient information collection and feedback, and improving patient compliance.[9,11,12] However, clinically, the continuous nursing model was relatively difficult to provide comprehensive and individualized nursing care in China due to the large population, organizational barriers,[13] widespread gaps in the quality, and inadequate nursing care systems.[14] Fortunately, mobile applications (APPs), which have become increasingly relevant to healthcare,[18,19] could provide innovative opportunities for communication among medical practitioners, nurses and patients. Mobile APPs could present comprehensive and personal strategies, including diet, physical exercise, psychotherapy and even provide the unique data of health outcomes.[19]

The platforms based on mobile APPs have been used to decrease stress on the patient and improve compliance for oral drugs in patients with cancers,[20] chronic diseases, and pregnancy women, the results were relatively satisfactory.[21-25] Generally speaking, mobile APPs included reminders for medication plan, symptom-reporting scales, and patient's education, all of which aimed at improving patient's difficulties with adherence, enhancing patient's disease awareness, alleviating patient's mental distress, and finally warranting to positively tuning patient's outcomes. However, despite a great number of existing health APPs, validated APPs to prevent VTE among hip fracture patients are lacking.

Therefore, this study aimed to develop an information platform using a mobile APP to further evaluate if the implementation of nursing intervention based on the information platform can improve patient's drug compliance, and thus reduce the incidence of VTE in patients with hip fractures, to provide a new clinical intervention method for preventing VTE.

Methods

Patients

This study retrospectively analyzed hip fracture patients treated with conventional prevention and intervention of VTE (control group) between January 2008 and November 2012, and prospectively analyzed hip fracture patients treated with nursing intervention based on the information platform (study group) between January 2016 and September 2017. Hip fracture patients aged ≥50 years, treated by surgery and hospitalized for ≥48 h were included in the control group. Patients with pathological fractures, failed to receive surgery for various reasons, diagnosed of any type of VTE before admission or operation or prohibited drugs to prevent VTE due to bleeding risk were excluded from the group. For the study group, inclusion criteria were (1) patient aged more than 18 years, (2) hip fracture patients treated with surgery, and (3) patients with a length of hospitalization of 48 h or above. And the exclusion criteria were (1) patients admitted to the hospital due to old fractures, i.e., fracture occurred for more than 2 weeks, (2) patients with severe bleeding after 72 h of admission, which could not be effectively controlled, (3) patients with mental diseases who cannot communicate normally, (4) diagnosis of any types of VTE before admission or operation, and (5) patients who refused to participate in the study. Fig. 1 shows the patient's flowchart.

Ethical approval

This study was performed in compliance with the World Medical Association Declaration of Helsinki. It was approved by the Medical Ethics Committee of the Chinese PLA General Hospital and registered by Chinese Clinical Trial Registry (the number is ChiCTR-ECH-14004383, registry year: 2014). All participants have signed informed consent forms before the study. We obtained the consents and data-access permission from all the study participants prior to study commencement.

Sample calculation

In the study, alpha was set as 0.025 and 1-beta set as 0.90. The sample allocation ratio was 2:1 and the difference of the two groups was 0.05. The rate of VTE in the control group was set as 10.0%. Then, when the control group has 800 cases and the study group has 400 cases, the statistical power could be 0.67.

Intervention methods

The control group

In the control group, standard methods of VTE prevention and intervention were used. VTE prevention guidelines include risk assessment, risk monitoring and management, health education, and guidance after discharge. The implementation methods were mainly oral and paper-based education.

Risk assessment: After a patient was admitted to the hospital, the physician in charge completed the paper-based risk assessment
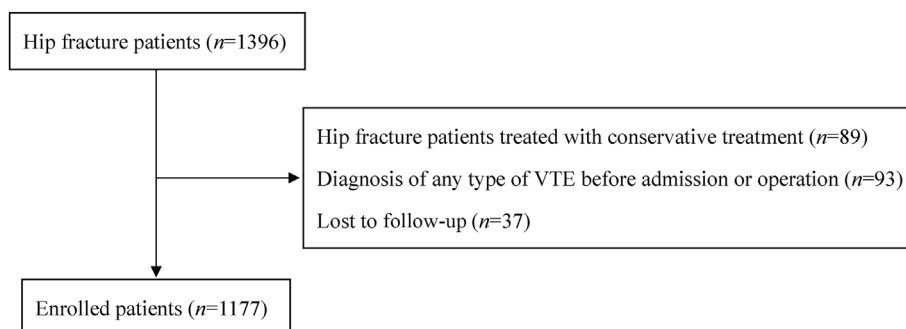

Fig. 1. Patient's flowchart.

and prediction tool score and the Caprini score.[26,27] The risk assessment and prediction tool score was used to predict the patient's risk of requiring extended inpatient rehabilitation after hip joint arthroplasty.[28] The physician in charge issued orders according to the patient's plasma D-dimer, lower extremity venous ultrasound, and other relevant tests. Afterward, nurses performed corresponding measures according to the risk score results and the orders.

Risk monitoring and management: During hospitalization, medical practitioners should regularly review risk monitoring indexes of patients, such as D-dimer and lower extremity venous ultrasound, and observe a progressive course of VTE. If the indexes were abnormal, corresponding medication schemes should be modified.

Health education: During hospitalization, the nurses in charge should conduct oral education on VTE prevention and management to the patients, and a brochure to discuss diseases-related knowledge, diet, smoking cessation, self-care, medication, examination, and functional exercise so that the patients and their families could fully understand treatment outcomes, and cooperate accordingly with the medical practitioners and nurses. Meanwhile, nurses of each shift should supervise the implementation of all these measures.

Guidance after discharge: Medical practitioners and nurses should perform post-discharge education for patients, explain the key points of home care, and inform patients to regularly visit a medical practitioner in case of any abnormality after patients were discharged from hospital. But supervision strategy was not performed after discharge.

The study group

Based on the information platform, medical practitioners implemented the risk assessment, monitoring management and early warnings, prevention and treatment, health education, follow-up, and other aspects of nursing interventions in the study group (Fig. 2). The information platform was divided into medical, nursing, and patient interfaces (Fig. 3). This information platform could both be installed in Android and iOS system. Details of the design and function of the information platform were presented in the Appendix A Supplementary 1. As for the study group, patients were monitored and intervened by using the information platform during and after hospitalization.

Outcome comparison between the study and control group

Basic parameters of patients like age, gender, VTE history, hypertension, ischemic heart disease, cerebrovascular disease, lung diseases, diabetes, liver disease, kidney disease, and tumor were presented and compared between the two groups. Furthermore, patients' drug compliance, VTE, and length of hospitalization were investigated and compared between the two groups.

Definition of drug compliance was as follows: Poor compliance was defined as drug prevention time shorter than 14 days or no drug prevention at all; Partial compliance was defined as drug prevention time 14–27 days after surgery; Good compliance was defined as drug prevention time lasting 28 days after surgery.

VTE includes DVT and PE. At the time of admission, all patients were routinely examined by full-length venous compression ultrasound of the lower extremities. According to the results, DVT was diagnosed, and the location was recorded. For patients with clinically suspected DVT symptoms, such as leg swelling, local tenderness, and fever of unknown causes, venous compression ultrasound should be repeated in time. The diagnosis should also be made according to the ultrasound results. Patients with suspected PE symptoms like chest pain, and dyspnea, were tested with pulmonary ventilation/perfusion scan or spiral CT. All patients came to the hospital for re-examination at 4, 8, and 12 weeks after the procedure. If a clinician detected any suspicious DVT or PE symptoms, the clinician would recommend full-length venous compression ultrasound of the lower extremities or pulmonary ventilation/perfusion scan.
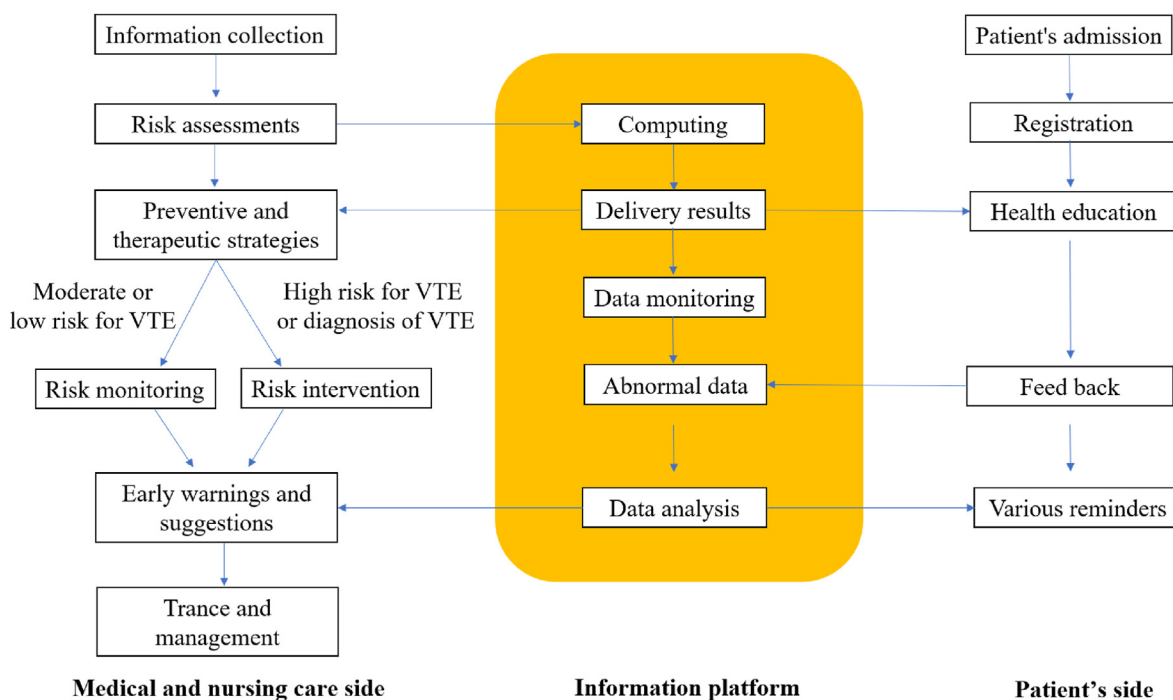
Fig. 2. The structure of the information platform. The information platform served as a bridge between medical workers and patients. Medical practitioners implemented the risk assessment, monitoring management, early warnings, prevention and treatment, health education, follow-up, and other aspects of nursing interventions with this information platform's help. Patients were able to receive health education and various reminders and give feedback using the information platform.

Subgroup analyses of drug compliance in the study group

In the study group, patients were divided into three subgroups according to their drug compliance: good compliance group, partial compliance group, and poor compliance group. Biographical data (age, body mass index (BMI), gender, and fracture type), comorbidities (VTE history, hypertension, ischemic heart disease, cerebrovascular disease, lung diseases, diabetes, liver disease, kidney disease, and tumor), and outcomes (mean hospitalization and VTE) were compared between the three subgroups.

Statistical analysis

SPSS 18.0 software (IBM Corp., NY, and USA) was used for statistical analysis. For continuous variables, the normal distribution was the first tested. For the variables with normal distribution, mean ± SD was used for statistical description, and t-test or ANOVA was used for the statistical test. For data not subjected to the normal distribution, the median (quartile) was used for statistical description, and the Mann-Whitney U test was used for the statistical test. For discrete variables, the statistics were described by count and percentage. The Pearson Chi-square test or Fisher accuracy-test were used for the statistical test.

Results

Patients' demographics

There were 1177 patients in the control group and 491 patients in the study group. There was no substantial difference in age, gender, VTE history, ischemic heart disease, liver disease, tumor history between the two groups. However, in terms of the distribution of hypertension, cerebrovascular disease, lung disease, diabetes, and kidney disease, patients in the study group had higher prevalence rates than those in the control group (Table 1).

The comparison of patients' outcomes

In the control group, 64.7% (761/1177) patients had poor drug compliance, 19.0% (224/1177) patients had partial drug compliance, and only 16.3% (192/1177) patients had good drug compliance. In the study group, only 6.1% (30/491) patients had poor drug compliance, 34.8% (171/491) patients had partial drug compliance, and 59.1% (290/491) patients had good drug compliance. The differences in drug compliance between the two groups were statistically significant ($p < 0.001$). Given the dissimilarly distributed baseline data between the two groups, further use of logistic regression analysis was performed after adjusting for hypertension, cerebrovascular disease, lung disease, diabetes, kidney disease, and additionally, the compliance was still significant (Table 2).

In terms of VTE, 126 patients (10.7%) in the control group had VTE, while only 35 patients (7.1%) in the study group had VTE, and the difference was statistically significant ($p = 0.02$). Moreover, the average length of stay in the study group was also lower than that in the control group (10.4 days *vs.* 13.7 days, $p < 0.001$).

Subgroup analyses of drug compliance in the study group

In the study group, patients were divided into three subgroups according to their drug compliance: good compliance group, partial compliance group and poor compliance group. It was found that there were statistically significant differences among the three groups in age ($p < 0.001$), fracture type ($p < 0.001$), history of VTE ($p < 0.001$), and kidney disease ($p = 0.03$). There was no statistically significant difference in other general characteristics (Table 3).

Afterward, the study analyzed the average length of hospitalization and the occurrence of VTE between the three subgroups (Table 3). The average length of stay in the poor compliance group, partial compliance group, and good compliance group was 14.1 days, 10.8 days, and 9.8 days, respectively ($p = 0.04$). The incidence of VTE in the poor compliance group, partial compliance group, and good compliance group was 56.7%, 5.8%, and 2.8%, respectively ($p < 0.001$).

Discussion

Principal findings

The study developed an information platform based on a mobile APP. It then investigated whether information platform-based nursing could improve a patient's drug compliance and reduce the incidence of VTE in patients with hip fractures. This study found that the information platform-based nursing could effectively enhance the compliance of patients and thus considerably decrease the incidence of VTE in hip fracture patients. Another main finding was that poor drug compliance leads to higher VTE occurrence after subgroup analyses of drug compliance in the study group.

More importantly, this model required the accuracy of information collection, the timeliness of feedback and warning, as well as the standardization of intervention and correction to ensure the overall effectiveness.[15] Unfortunately, the busy clinical nursing workload made it hard to implement such a nursing model in China. Even though some hospitals in China have tried to do so, continuity of care was still insufficient throughout the healthcare system.[16]

Moreover, there were limited communication channels among the patients and their medical practitioners and nurses. Additionally, patients might miss the outpatient service due to the long distance between the hospital and home or the long waiting time for the medical service.[17] Therefore, medical practitioners and nurses cannot fully understand the actual status of patients, and are almost impossible to make any intervention guidance for improving medication compliance.

The effect of information platform-based nursing interventions and on the incidence of VTE

This study found that the incidence of VTE in patients with hip fracture was much lower in the study group than that in the control group. The main reason was that drug prevention was the most effective way to prevent VTE.[29] VTE nursing intervention based on the information platform could significantly improve a patient's medication compliance. The results showed that the proportion of patients with poor drug compliance in the study group could reduce from 64.7% to 6.1%. In comparison, the proportion of patients with good drug compliance could increase from 16.6% to 59.1% with the help of the information platform. According to the American College of Chest Physician guidelines, anticoagulant therapy for hip fracture patients was recommended to use for 35 days.[30] Under the VTE nursing intervention based on the information platform, the average hospitalization time of patients was shortened from 13.7 days to 10.4 days.

The effect of information platform-based nursing interventions on drug compliance among patients with other diseases

In this study, baseline data comparisons showed that some factors were dissimilarly distributed between the control and study group. The incidence of comorbidities was higher in the study group than that in the control group. Theoretically, the basic
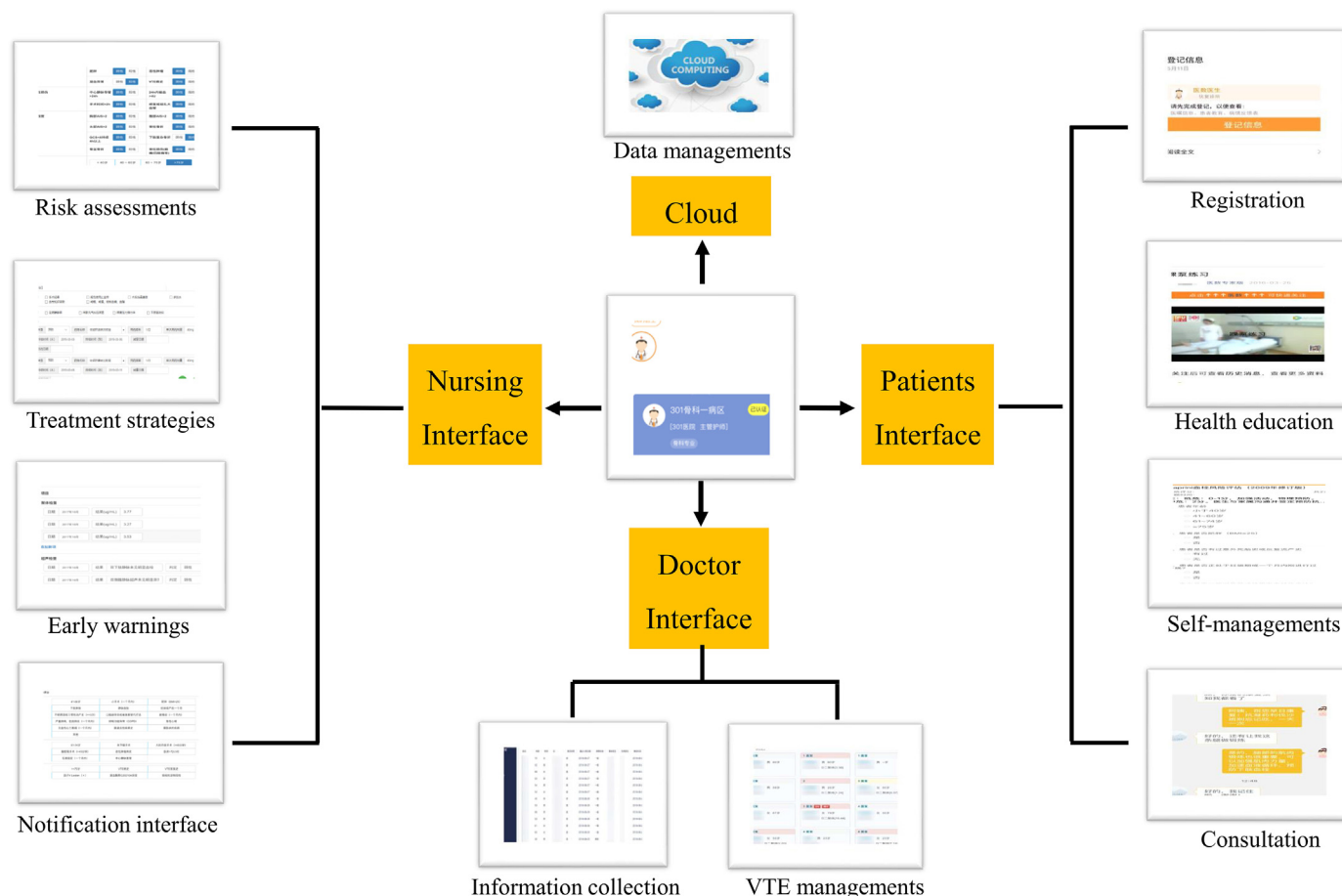
Fig. 3. A brief introduction of the medical, nursing, and patient's interfaces. In the medical and nursing interface, doctors and nurses could implement VTE monitoring and management information collection. In the patient interface, patients could receive information about health education, various reminders, and management applications via the information platform. Besides, patients could consult and communicate with their doctors or nurses through the platform.
VTE: venous thromboembolism

Table 1
Patients' basic characteristics of the two groups.

Characteristics	The control group ($n = 1177$)	The study group ($n = 491$)	p value
Age (years)	75.2 (10.2)	75 (13.3)	0.771
Gender			
Male	436 (37.0)	173 (35.2)	0.484
Female	741 (63.0)	318 (64.8)	
Comorbidities			
VTE history	20 (1.7)	11 (2.2)	0.456
Hypertension	547 (46.5)	260 (53.0)	0.016
Ischemic heart disease	216 (18.4)	88 (17.9)	0.836
Cerebrovascular disease	183 (15.5)	108 (22.0)	0.002
Lung diseases	90 (7.6)	53 (10.8)	0.036
Diabetes	246 (20.9)	138 (28.1)	0.001
Liver disease	18 (1.5)	9 (1.8)	0.654
Kidney disease	32 (2.7)	23 (4.7)	0.040
Tumor	54 (4.6)	16 (3.3)	0.217

Age was presented as mean (SD) and others as n (%).
SD: standard deviation; VTE: venous thromboembolism.

characteristics should be randomized in the two groups to ensure the balance of baseline information between the two groups. However, randomization was generally difficult to achieve in clinical nursing, so there would be some differences in baseline variables between the two groups.

Notably, in this study, there was more comorbidity in the study group than that in the control group. Previous studies have suggested that patients with more comorbidities should have lower compliance,[31,32] especially for VTE, which was regarded as an insidious disease. However, the study group's medication compliance was still better than that of the control group after receiving VTE nursing intervention based on the information platform, thus indicating that the effects of VTE nursing intervention using the information platform produced even more positive outcomes. In further analysis, this study used the logistic regression model to correct several factors of uneven baseline data, and the influence of

Table 2
Comparison of patients' outcomes between the two groups.

Characteristics	The control group ($n = 1177$)	The study group ($n = 491$)	p value
Drug compliance, n (%)			<0.001
Poor	761 (64.7)	30 (6.1)	
Partial	224 (19.0)	171 (34.8)	
Good	192 (16.3)	290 (59.1)	
Venous thromboembolism, n (%)	126 (10.7)	35 (7.1)	0.024
Mean length of hospitalization (days)	13.7	10.4	<0.001

Table 3
Subgroup analyses of drug compliance in the study group.

Characteristics	Poor ($n = 30$)	Partial ($n = 171$)	Good ($n = 290$)	p values
Age (years)	83.4 (9.3)	71.1 (13.4)	76.5 (12.9)	<0.001
BMI (kg/m^2)				0.192
<18.5	9 (30.0)	20 (11.7)	36 (12.4)	
18.5—24.9	15 (50.0)	104 (60.8)	166 (57.2)	
25—30	5 (16.7)	39 (0.2)	75 (0.3)	
≥30	1 (3.3)	8 (4.7)	13 (4.5)	
Gender				0.149
Male	9 (30.0)	70 (40.9)	94 (0.3)	
Female	21 (70.0)	101 (59.1)	196 (0.7)	
Fracture types				<0.001
Intertrochanteric fracture	23 (76.7)	83 (48.5)	112 (38.6)	
Femoral neck fracture	7 (23.3)	88 (51.5)	178 (61.4)	
Comorbidities				
VTE history	6 (20.0)	4 (2.3)	1 (0.3)	<0.001
Hypertension	16 (53.3)	88 (51.5)	156 (53.8)	0.888
Ischemic heart disease	6 (20.0)	30 (17.5)	52 (17.9)	0.949
Cerebrovascular disease	9 (30.0)	37 (21.6)	62 (21.4)	0.550
Lung diseases	5 (16.7)	17 (9.9)	31 (10.7)	0.547
Diabetes	11 (36.7)	48 (28.1)	79 (27.2)	0.550
Liver disease	0 (0)	2 (1.2)	7 (2.4)	0.467
Kidney disease	4 (13.3)	10 (5.8)	9 (3.1)	0.028
Tumor	3 (10.0)	4 (2.3)	9 (3.1)	0.090
Mean hospitalization (days)	14.1	10.8	9.8	0.044
VTE	17 (56.7)	10 (5.8)	8 (2.8)	<0.001

Age was presented as mean (SD), and others as n (%) or mean.
SD: standard deviation; BMI: body mass index; VTE: venous thromboembolism.

compliance was still found to be significant. At the same time, to verify whether the results were robust, this study conducted a sensitivity analysis. The results showed that the study group's compliance was still better than that of the control group, and the differences between the two groups were statistically significant.

Characteristics of patients with poor compliance in the study group

In this study, the patients among the study group were divided into three subgroups according to the extent of drug compliance: good compliance group, partial compliance group and poor compliance group. The general characteristics were compared between the three subgroups. The results showed that there were statistically significant differences among the three groups in age ($p < 0.001$), fracture type ($p < 0.001$), VTE history ($p < 0.001$) and kidney disease ($p=0.03$), while BMI, gender, and most of the co-existing diseases were not statistically significant among the three subgroups. In the poor compliance group, patients were older, and had a higher proportion of intertrochanteric fractures, VTE history, and kidney disease than those in other two subgroups. This suggested that age, fracture type, history of VTE, and kidney disease may be related to drug compliance.

However, previously, researchers have clearly confirmed that drug compliance was still highly independent of postoperative VTE incidence, even after adjusting other risk factors of VTE, such as age, gender, fracture type, physical prevention, and pre-operative drug prevention. At the same time, this study found that patients in the

study group with good compliance had a shorter average length of hospitalization and lower incidence of VTE. This once again confirmed that medication compliance was an independent risk factor for the occurrence of VTE. Other studies have proved that good drug compliance meant low incidence of VTE.[33]

The role of information technology in improving drug compliance

In recent years, the application of information technology has become increasing popular in the field of chronic disease management, including long-term antiretroviral treatment of acquired immune deficiency syndrome (AIDS),[34] diabetes,[25] cancers,[21,23] and hypertension,[35] aiming at improving patient's drug compliance. Lester and his colleagues[34] analyzed 538 AIDS patients receiving antiretroviral treatments in a randomized controlled study. The researchers randomly assigned all the subjects to a mobile phone with a short message service intervention group and the control group. The subjects in the intervention group were able to receive a message sent by the nurse and were asked on a weekly basis about their conditions through mobile devices, such as mobile phones or other communication devices, and were asked to reply within 48 h.[34] When the patient replied poorly or failed to respond in time, the clinical staff would further call the subject, encouraging and reminding the subject and making sure if the patient need any assistance. The results of this study showed that 62% (168/273) of the patients had self-reported adherence in the intervention group, which was statistically higher than that in the control group (50%,

132/265).[34] When the patient's compliance was improved, the treatment effects in the intervention group were also considerably better than that in the control group.

The use of information technology overcame the communication barriers between medical practitioners and patients. Meanwhile, the researchers pointed out that the mobile phone short message services enhanced the patient's health views to a certain extent, which was also an important influencing factor for the patient's compliance.[34] Other studies also reported the use of information technology to manage chronic diseases, including AIDS,[34] diabetes,[25] cancers,[21,23] and hypertension.[35] Unless a physiological index (such as serum glucose or blood pressure) largely fluctuated, these chronic diseases would not show serious clinical symptoms. The patient's medication compliance would considerably decrease, especially when patients had frequently scheduled medication regimens.[36] Therefore, the use of information technology could provide a new channel for medical practitioners and nurses to monitor the patient's medication intake. A meta-analysis showed that mobile phone text messaging nearly doubles the odds of medication adherence.[37]

Hip fracture patients were likely to develop VTE after surgery due to long-term bed rest and immobilization.[38] However, at present, a particular VTE management information platform is still lacking in clinical settings. VTE also has latency characteristics, and once symptoms appear, patients might expire in a very short time.[39] Therefore, in the construction of an information platform, apart from considering the characteristics and advantages of previous information platforms for other chronic diseases, researchers should also develop targeted VTE settings. The platform should cover all the contents of the patient's admission risk assessment, risk monitoring, prevention and treatment, health education, and long-term follow-up intervention of VTE. Simultaneously, researchers should determine the features of text message interventions that improve medication compliance and appropriate patient populations, sustained effects, and factors influencing clinical outcomes.[37]

According to the requirements mentioned above, this study designed and developed the Venous Thrombosis Management Platform for Hospital Trauma Orthopedic (Computer software copyright registration No. 2018sr427344) by cooperating with the Servbus Medical Cloud Technology Company. The platform has been updated 17 times and gradually optimized the structured contents of medical records, WeChat follow-up, photo recognition of examination results, outpatient schedule reminder, patient's consultation, and communication. The advantages of the information platform mainly included (1) timely information collection and recording, (2) quantification of VTE risk evaluation, (3) monitoring and an early warning of VTE, and (4) remote education and patient feedback. Our study also confirmed the information platform-based nursing could effectively improve the compliance of patients with hip fracture and thus considerably reduce the incidence of VTE. Moreover, as the burden of chronic diseases was heavy and increasing, the need for an information platform to manage other diseases would also be a major step forward. Our information platform could also be shaped accordingly so that it could be expanded to use in different populations.

Limitations and future investigations

This study mainly focused on the improvement of drug compliance when the information platform was initially designed. During the implementation of the information platform-based nursing intervention, this study found that the positive effects of the information platform were not only to improve drug compliance but also to help achieve the homogenization of nursing and facilitate patient's mental and psychological health. However, the results were not shown in the study.

Many comprehensive factors were also responsible for the improvement of VTE prevention effects. For example, the compliance of using the APP was not evaluated in the study. Although, these factors were not observed as outcome events in the study design, there was also no reliable data to confirm whether the effect exists. Therefore, the next study should design the corresponding clinical trials to explore these problems. Besides, the current scenario was a single-center study and we ended the study in the year of 2017, so it was difficult to avoid admission bias. Consequently, the study needs to be further confirmed in a multi-center investigation. There were still some patients with poor compliance after implementing VTE nursing intervention based on the information platform. The reason might be that the factors affecting compliance have not been comprehensively considered, or some patients were not familiar with the use of mobile phones or platforms. For example, educational level, economic level, and cultural background might affect patient's compliance, but those factors were not evaluated in the study. Therefore, appropriate patient populations, sustained effects, and factors influencing clinical outcomes should be investigated in future studies.

In conclusion, poor drug compliance leads to higher VTE occurrence. The information platform-based nursing effectively improves the medication compliance of hip fracture patients and thus significantly reduces VTE incidence. The mobile APP may be an effective tool to prevent VTE in hip fracture patients.

Funding

Ethical statement

This study was performed in compliance with the World Medical Association Declaration of Helsinki. It was approved by the Medical Ethics Committee of the Chinese PLA General Hospital and registered by Chinese Clinical Trial Registry (the number is ChiCTR-ECH-14004383, registry year: 2014). All participants have signed informed consent forms in writing before the study. We obtained consents and data-access permission from all the study participants prior to study.

Declaration of competing interest

The authors report no conflicts of interest in this work.

Author contributions

Yuan Gao, Xiao-Jie Fu, Ming-Xing Lei and Peng-Bin Yin designed the study. Yuan Gao, Peng-Bin Yin and Yu-Tong Meng interpreted the data and drafted the manuscript. Yuan Gao, Xiao-Jie Fu and Ming-Xing Lei evaluated the APP. Yuan Gao, Qing-Mei Wang, and Hong-Ying Pi provided a critical review of the manuscript. All authors have reviewed the article.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.cjtee.2022.06.004.

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