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Effectiveness of visual management health education in preventing venous thromboembolism in patients with complete occlusion of chronic coronary arteries

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Abstract

Objective Exploring the effectiveness of visually managed health education in reducing the risk of venous thromboembolism in patients with complete occlusion of chronic coronary arteries.

Methods In this study, 100 patients with chronic total occlusion of coronary arteries and undergoing percutaneous coronary intervention (PCI) in cardiovascular medicine were included and divided into a test group and a control group with 50 patients in each group. Patients in the test group received health education based on visualization management, while patients in the control group received conventional health education. Relevant data were collected for further comparison. Statistical analysis was performed using SPSS and t-test and χ^2 test were used to analyze the differences.

Results After intervention, there were higher levels of antithrombin III (AT3) and activated partial prothrombin time (APTT), while lower levels of D-dimer (D-D), fibrinogen degradation product (FDP), fibrinogen (FBG), and thrombin time (TT) in the test group than those before intervention. The control group showed decreased AT3 and APTT, while increased D-D, FDP,TT and FBG levels ($P < 0.05$). After intervention, the levels of AT3 and APTT in the test group were higher than those in the control group, while the levels of D-D, FDP, FBG, and TT were lower than those in the latter control group ($P < 0.05$). Furthermore, both groups of patients showed a decrease in Padua scores and an increase in prevention cognition scores after intervention ($P < 0.05$). After intervention, the Padua score of the test group was lower than that of the control group ($P < 0.05$). The test group had higher compliance score ($P < 0.001$) and satisfaction ($P < 0.001$).

Conclusion Visual management health education can effectively improve the effect of health education, increase patients' awareness, compliance and satisfaction with VTE prevention, reduce the risk of lower limb VTE, and improve the coagulation function of CTO patients during PCI.

Keywords Visual management, Visual management-based health education, Chronic total occlusion, Venous thromboembolism, Compliance

Introduction

Chronic total occlusion (CTO) of coronary arteries is the final stage of coronary atherosclerosis. It shows serious atherosclerotic plaque lesions, which eventually lead to complete occlusion of coronary arteries. It is defined

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as complete occlusion [thrombolysis in myocardial infarction (TIMI) grade 0] for at least 3 months [1]. The existing data reveals that the incidence of CTO reaches 15–25% in patients with coronary heart disease during coronary angiography [2]. Moreover, CTO poses a serious threat to human health, which is associated with a higher risk of death, recurrence of ventricular arrhythmia, and persistent angina symptoms [3].

Currently, medical therapy, intervention surgery, and bypass surgery are three major therapeutic options for CTO. Percutaneous coronary intervention (PCI) based on medical therapy is currently the widely used, but there is still controversy over its effectiveness. Successful revascularization for CTO of coronary arteries can improve heart function and prognosis [4, 5]. The most common strategies for revascularization currently include PCI and coronary artery bypass grafting (CABG). Due to the significant trauma of CABG and the possibility of partial replacement with PCI, patients are more willing to undergo PCI [6]. However, due to limited immobility and long time interval to ambulation, patients after PCI have an increased risk of thrombosis, with an incidence of venous thromboembolism (VTE) ranging from 5.00 to 35.00% [7]. The term VTE encompasses deep vein thrombosis (DVT) and pulmonary thromboembolism (PTE), which is a common complication in inpatients and a leading cause of perioperative mortality [8]. It has been confirmed that the hospitalization rate of VTE in China increased more than five-fold from 2007 to 2016 [9]. Significantly, early education on preventing thrombosis can effectively reduce the incidence of VTE [10].

However, CTO occurs frequently in the elderly, with a low degree of education as well. Due to their relatively poor memory and low acceptance, these patients may have a low level of acceptance and mastery of traditional routine oral education. Meanwhile, elderly patients usually have short memories, and may not always be able to remember in the later stage even if they have mastered at the time. Therefore, there is an urgent need for a targeted education approach for elderly CTO patients to enhance the preventive effect of VTE.

Visual management uses various visual and perceptual information that is vivid and intuitive with suitable colors to organize on-site production management. It is a scientific method of using visual sense for management, which transmits and receives information using the simplest and most convenient methods to improve efficiency eventually [11]. In the process, this method uses multiple "visual markers" to display various unreasonable, hidden dangers, waste phenomena, etc. on-site in a visual and textual manner. In terms of its primary features, it regards visual signal identification as the basic tool; and openness and transparency as the fundamental principles to maximize the visibility of managers' demands and intentions, thereby promoting self-management and self-control. It is fast to operate, easy to implement, and has achieved significant results. It has been gradually introduced into nursing work and is widely used in disease prevention [12], medical device management [13], chronic disease management [14], etc., and has achieved good results.

CTO often appears in elderly patients with poor memory and acceptance, and low compliance with medication use and behavioral norms, leading to poor disease control. Visual management uses brightly colored illustrations and videos to provide visual and auditory stimulation to specific patients, leading to a higher degree of mastery. Study hypothesis: Visual management health education is effective in improving health literacy in patients with complete occlusion of chronic coronary arteries, thereby reducing the incidence of venous thromboembolism. Visual management is effective for offering health education to patients, especially for the elderly, which is worth further exploration. Accordingly, this study was conducted to explore the impact of visual management-based health education on CTO patients' cognition and compliance with VTE prevention.

Subjects and methods of study

Subjects of study

Diagnostic criteria for participants: presence of complete occlusion of at least one major coronary artery confirmed by coronary angiography or coronary computed tomography (CT) and duration of occlusion greater than 30 days. Using convenience sampling, this study included 100 patients undergoing PCI who met the inclusion criteria and were admitted to the Department of Cardiovascular Medicine of our hospital from June to December 2023. The enrolled patients were divided into a test group and a control group using a random number table method, with 50 cases in each group. Inclusion criteria: (1) patients aged $\geq$ 18 years old; (2) patients with normal thought, language communication, and the ability to understand and answer questions clearly; and (3) patients diagnosed [1] as CTO through coronary angiography and undergoing PCI; (4) Long term standardized use of anticoagulant drugs after surgery. Exclusion criteria: (1) patients with other malignant tumors; (2) patients with severe diseases involving the heart, liver, kidney, lung, nervous system, and orthopedics; and (3) patients diagnosed with VTE previously.

This study was approved by the Ethics Committee of this hospital (No.: Research 2023-128A), with informed consent provided by all patients.

Sample size calculation

Referring to the literature of previous studies, the effect size was 0.5, the significance level α was set at 0.05, the test efficacy (1-β) was 0.8, and the sample size was calculated to be at least 100 cases using PASS software.

Methods of study

Patients in both groups were provided with the same treatments and health education. The control group received routine health education via oral education and the distribution of brochures. Patients were informed of the purpose and importance of preventing VTE thrombosis according to their conditions of illness. Health education involved explaining DVT's causes, high-risk factors, hazards, clinical manifestations, prevention knowledge, smoking and drinking cessation, and diet; informing patients of physical prevention intervention methods: guiding patients' families to massage patients' lower limbs, informing patients of methods such as regular turning over, deep breathing, and ankle exercises; medication intervention based on the medical advice, advising patients and their families of medication usage methods, adverse reaction observation, regular follow-up, etc. [15].

Patients in the test group were given health education intervention based on visual management (referred to as visual management-based health education), which was described as follows: (1) A visual management-based health education intervention team was established and led by the head nurse of the Interventional Center, involving 2 cardiovascular physicians and 5 interventional nurses. Main responsibilities of the team members: Development and improvement of the visual management-based health education program [15]; visual processing of health education content; training on the implementation of the program; as well as implementation and effect evaluation of the program. (2) The visual management-based health education program was developed through a joint review of relevant domestic and foreign literature by team members. Based on the requirements for VTE prevention, evidence-based nursing methods were used to collect, query, and organize health education knowledge materials for VTE prevention according to the characteristics of CTO patients. Visual management-based health education content screening and visual management methods were determined with the requirements of the "VTE Prevention Guidelines" formulated by the hospital. After the development of the visual management-based health education program for VTE prevention in CTO patients, a chief physician was invited and collaborated for improvement by creating illustrations and videos of intraoperative deep breathing and ankle pumps, ensuring that the content was rendered in a popular and easy-to-understand manner. (3) Visual management-based health education content was processed according to the following steps: ① creation of illustrations and materials of health education: Besides textual explanations, the health education brochure also included rich images, clear and vivid graphic symbols that were easy to understand, such as whole-body venous anatomy diagram, which explained the importance of VTE prevention by combining graphics and text; besides, it also provided a graphic visualization of VTE prevention measures, such as smoking and drinking cessation, dietary choices, scheduled intraoperative ankle pump exercises, deep breathing, etc.; and ② production of intraoperative exercise videos: it has been documented that beep breathing, ankle pump (ankle extension at 20° and flexion at 45°), and deep breathing + ankle exercise could all increase the blood flow velocity of the femoral vein, with the most significant effect and the strongest promoting effect observed in the combined strategy [16]. Therefore, members of the team jointly recorded a video to explain steps and precautions for intraoperative deep breathing and ankle exercises, with background music, commentary, pictures, short video recordings, and subtitles provided during video production [17]. (4) Steps for visual management-based health education: Team members were responsible for explaining the importance and measures of VTE prevention to patients using illustrations, participated in functional exercises jointly, and guided for patients at the same time of watching videos of deep breathing and ankle exercises to improve their mastery of the skills, with a focus on patient tolerance. Intraoperatively, medical staff would promptly remind patients to engage in functional exercises and keep records. A simple educational brochure would be distributed to patients after completing preoperative education. There was a QR code for the video of deep breathing and ankle exercises attached to the back of the brochure, which could be scanned by patients and their families for watching at any time educative.

Data collection

1. Data from the enrolled patients was collected on the day after surgery, including general data, coagulation, and fibrinolysis-related indicators before and after the intervention, Padua score, NIHSS score, thigh circumference, VTE cognition and compliance score after the intervention, satisfaction with health education after the intervention, and VTE occurrence during the intervention.

2. General data: included gender, age, body mass index (BMI), degree of education, length of stay in the hospital, hypertension, diabetes, atrial fibrillation, hyperlipidemia, smoking history, and drinking history.
3. Blood indicators: Coagulation and fibrinolysis-related indicators in this study were fibrinogen (FBG), prothrombin time (PT), activated partial prothrombin time (APTT), thrombin time (TT), D-dimer (D-D), platelet count (PLT), fibrinogen degradation product (FDP), and antithrombin III (AT3). These indicators can help identify patients at high risk of VTE early [18, 19]. On the first day of admission and at the end of intervention, all patients were subjected to the sampling of 5 ml of fasting blood using anticoagulant tubes in the morning, and the blood samples were sent to the laboratory of our hospital for biochemical testing. The reference range of relevant indicators refers to previous research [20], as shown in Table 1.
4. Padua Risk Assessment Scale: This scale included 11 risk factors such as active stage of cancer, history of VTE, advanced age, and obesity. Each item was scored 1–3 points, with high-risk assessed when the score ≥ 4 points and low-risk when the score < 4 points [21, 22]. The Padua Risk Assessment Scale was used to score the risk of DVT in patients during postoperative visits. Patients with scores of ≥ 4 points would indicate a higher risk of thrombosis. For this part of patients, we subcutaneously injected 40 mg of low molecular weight heparin on the first day after surgery, and then orally administered 10 mg of rivaroxaban once a day for 10 days. A total of 47 patients received this treatment, including 21 in the test group and 26 in the control group.
5. VTE Prevention Cognitive and Behavioral Adherence Questionnaire: A VTE prevention cognition and behavioral compliance questionnaire adapted from a previous study [23] was used in CTO patients. This questionnaire consisted of two parts VTE prevention cognition and preventive behavioral compliance. The first part of VTE prevention cognition (7 items) included the definition of VTE, the process and causes of VTE formation, typical symptoms, the harm of VTE, as well as the timing and methods of functional exercise. Using dichotomous scoring, a correct answer was scored as 1 point, and a negative answer as 0 points, with a total score of 0–7 points. Patients with higher scores would have higher levels of VTE prevention cognition. The preventive behavioral compliance section covered four major items smoking and drinking cessation, dietary choices, deep breathing, and ankle exercises. Specific items were selected for evaluation based on patients' situation and condition. With a score of 0, 1, and 2 points (s) for not possible to achieve, partially achieve, and completely achieve, respectively, the total score was obtained and divided by the number of items evaluated to get the average. Patients with higher average scores would have better treatment compliance. Assessments at enrollment and the end for the two groups of patients were performed by members of this intervention team. See Appendix for a questionnaire example.
6. Satisfaction Questionnaire: A satisfaction questionnaire adapted from a previous study [23] was used to evaluate the completeness of VTE prevention health education content, methods and approaches of guidance, and the difficulty level of knowledge learning. Questionnaires were administered during postoperative visits on the second day and collected on-site. Using a Likert-type 5-point scale, patients rated their responses as very dissatisfied, dissatisfied, satisfied, fairly satisfied, or very satisfied, with scores ranging from 0 (very dissatisfied) to 4 (very satisfied). The total score was 12 points, with higher scores indicating greater satisfaction (See Appendix). The flow chart is shown in Fig. 1.

Table 1 Reference range for coagulation and fibrinolysis-related indicators

Items	Hypercoagulable state	Reference range	Hypercoagulable state
FBG(g/L)	< 2	2–4	> 4
PT(s)	> 13.6	13.6–8.8	< 8.8
APTT(s)	> 40	40–26	< 26
TT(s)	< 10	10–18	> 18
D-D(mg/L)	/	0–0.5	> 0.5
PLT($\times 10^9$/L)	< 100	100–300	> 300
FDP(ug/ml)	/	0–5	> 5
AT3(%)	< 75	75–125	> 125

Statistical analysis

Statistical analysis in this study was performed using SPSS 26.0 software. The test of normality was achieved by using the K-S method. The measurement data that met normality was represented by ($x \pm s$), while the comparison of non-paired data and paired data was conducted via independent sample *t*-test and paired *t*-test, respectively. The counting data was expressed as frequency (n) or rate (%); a χ^2 test was used for data meeting the criteria and Fisher's exact probability test for

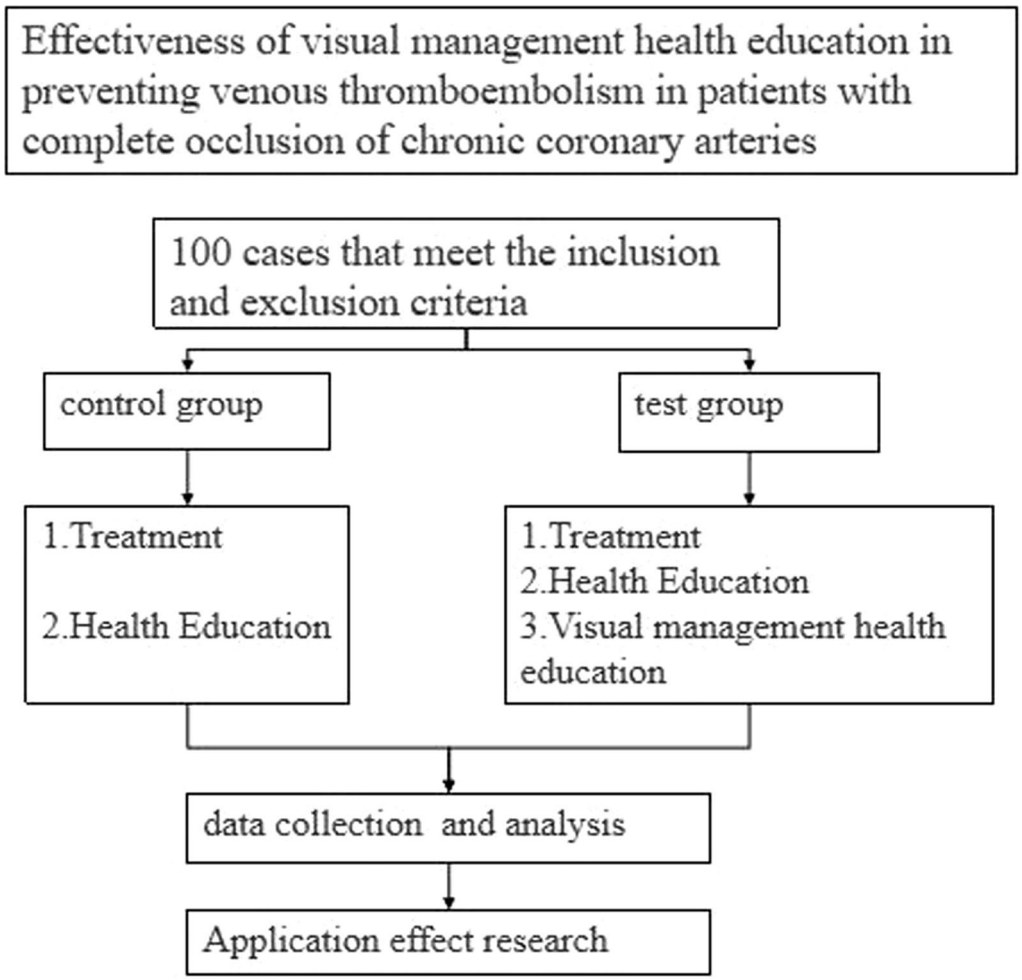

Fig. 1 Flow chart

data that did not meet the criteria. A two-tailed $P<0.05$ meant that the difference was statistically significant.

Quality control

Ensure consistency and standardization of interventions; train investigators to reduce measurement bias; regularly monitor the data collection process to ensure data accuracy and completeness.

Results

General data

As shown in Table 2, there were 50 patients in the test group, including 23 males and 27 females, with an average age of 66.53 ± 10.30 years and an average length of stay in the hospital of 3.47 ± 1.83 days; meanwhile, there were 50 patients in the control group, including 25 males and 25 females, with an average age of 69.43 ± 11.15 years and an average length of stay of 3.77 ± 2.54 days. There was no statistically significant difference in gender, age, BMI, and education degree between groups ($P>0.05$).

Comparison of coagulation and fibrinolysis-related indicators before and after intervention

In Table 3, before the intervention, there was no statistically significant difference in AT3, D-D, FDP, FBG, PT, APTT, and TT between groups ($P>0.05$). Compared with the results before intervention, the levels of AT3 and APTT increased, while the levels of D-D, FDP, FBG, and TT decreased in the test group after intervention; and the control group showed decreased AT3 and APTT, as well as increased D-D, FDP,TT and FBG ($P<0.05$). After the intervention, the levels of AT3 and APTT in the test group were higher than those in the control group, while the levels of D-D, FDP, FBG, and TT were lower than those in the latter group ($P<0.05$).

Table 2 General data

Items	Test group (n = 50)	Control group (n = 50)	*P* value
Gender (male/female)	23/27	25/25	0.689
Age (years, x ± s)	66.53 ± 10.30	69.43 ± 11.15	0.300
BMI (kg/m^2, x ± s)	24.76 ± 2.84	25.04 ± 1.75	0.649
Education degree (n)			0.820
Primary school and below	34	31	
Middle school	11	13	
College degree or above	5	6	
Length of stay in the hospital (days, x ± s)	3.47 ± 1.83	3.77 ± 2.54	0.864
Hypertension (n)	24	28	0.423
Diabetes (n)	7	4	0.338
Atrial fibrillation (n)	4	5	0.727
Hyperlipidemia (n)	6	7	0.776
Smoking history (n)	31	30	0.838
Drinking history (n)	21	23	0.687

Table 3 Comparison of coagulation and fibrinolysis-related indicators before and after intervention

Items	Time	Test group (n = 50)	Control group (n = 50)	*P* value
AT3	Before intervention	88.63 ± 12.57	89.67 ± 9.12	0.713
	After intervention	94.14 ± 8.84*	77.61 ± 10.19*	< 0.001
D-D	Before intervention	0.60 ± 0.23	0.56 ± 0.30	0.480
	After intervention	0.35 ± 0.25*	1.06 ± 0.68*	< 0.001
FDP	Before intervention	3.43 ± 1.10	3.35 ± 1.19	0.771
	After intervention	2.97 ± 0.98*	5.72 ± 2.34*	< 0.001
FBG	Before intervention	3.61 ± 1.24	3.26 ± 0.86	0.220
	After intervention	3.02 ± 0.87*	4.30 ± 1.34*	< 0.001
PT	Before intervention	11.10 ± 1.40	11.74 ± 1.83	0.131
	After intervention	12.01 ± 0.93	11.04 ± 2.57	0.056
APTT	Before intervention	24.75 ± 2.68	26.03 ± 4.07	0.155
	After intervention	29.26 ± 4.59*	23.67 ± 3.99*	< 0.001
TT	Before intervention	19.52 ± 2.95	17.91 ± 1.22	0.081
	After intervention	17.42 ± 3.59*	19.52 ± 2.07*	0.007

FBG: fibrinogen; PT: prothrombin time; APTT: activated partial prothrombin time; TT: thrombin time; D-D: D-dimer; PLT: platelet count; FDP: fibrinogen degradation product; AT3: antithrombin III; *: statistically significant difference when compared with the control group

Table 4 Comparison of Padua score, NIHSS score, thigh circumference, and cognition of prevention before and after intervention

Items	Time	Test group (n = 50)	Control group (n = 50)	*P* value
Padua score	Before intervention	4.40 ± 0.50	4.53 ± 0.51	0.309
	After intervention	1.37 ± 0.49*	4.30 ± 0.79*	< 0.001
Left thigh circumference	Before intervention	58.85 ± 2.45	58.52 ± 2.81	0.629
	After intervention	58.85 ± 2.45	58.52 ± 2.81	0.629
Right thigh circumference	Before intervention	58.95 ± 2.49	58.47 ± 2.78	0.481
	After intervention	58.95 ± 2.49	58.58 ± 2.93	0.594
Prevention cognition score	Before intervention	5.60 ± 0.25	5.61 ± 0.44	0.908
	After intervention	15.45 ± 1.40	11.85 ± 2.02	< 0.001

Comparison of Padua score and thigh circumference before and after intervention

In Table 4, no statistically significant difference was found in the Padua score, left thigh circumference, right thigh circumference, and prevention cognition score between the two groups before intervention ($P > 0.05$). Both groups of patients showed lower Padua scores and higher prevention cognition scores after intervention than those before intervention ($P < 0.05$). Furthermore, after intervention, the test group had a lower Padua score but a higher prevention cognition score than those in the control group ($P < 0.05$). Specifically, the Padua score assesses various factors related to thrombotic risk, including limited mobility, previous VTE history, and heart failure. During the intervention, visual management-based health education was enhanced, providing the test group with more guidance on functional exercises (such as deep breathing and ankle pump exercises) and lower limb massages, which promoted early mobilization and reduced venous stasis caused by prolonged bed rest. This early mobilization and functional exercise significantly improved blood circulation in the lower limbs, reducing the risk of thrombosis, as reflected in the reduced Padua scores post-intervention. While there was no statistically significant difference in left thigh circumference and right thigh circumference between groups ($P > 0.05$).

Comparison of VTE prevention compliance and health education satisfaction between groups after intervention

As presented in Table 5, the test group had higher compliance score (1.61 ± 0.39 VS 0.90 ± 0.26, $P < 0.001$) and satisfaction (11.21 ± 0.89 VS 9.34 ± 0.73, $P < 0.001$) than those in the control group after intervention.

Table 5 Comparison of VTE prevention compliance and health education satisfaction between groups after intervention

Items	Test group (n = 50)	Control group (n = 50)	*P* value
Compliance	1.61 ± 0.39	0.90 ± 0.26	< 0.001
Satisfaction	11.21 ± 0.89	9.34 ± 0.73	< 0.001

Comparison of VTE incidence

During the study, 0 of 50 cases (non-occurred in 50 cases) in the test group and 1 of 50 cases (non-occurred in 49 cases) in the control group developed VTE, with an incidence rate of 0% and 2%, respectively (Table 6).

After the intervention in this study, except for those who voluntarily went to the hospital for follow-up visits, patients were reminded by phone every week to come to the hospital for follow-up visits. According to the 3-month follow-up data after the intervention, there were 0 cases of VTE in the test group, with an incidence rate of 0%; The number of participants in the control group was 2, with an incidence rate of 4% (Table 6).

Discussion

The aim of this study was to investigate the effectiveness of visual management-based health education in preventing venous thromboembolism (VTE) in patients with chronic total occlusion of coronary arteries (CTO). The results of the study revealed the important role of visual management health education in improving patients' knowledge, adherence, and satisfaction with VTE prevention, as well as its positive impact on reducing the risk of VTE and improving coagulation function.

CTO, which accounts for 20–30% of patients undergoing coronary angiography, is a major challenge in coronary intervention and a focus of research [24]. It usually develops from an acute coronary event, with thrombosis evolving over time into occlusive fibrotic and calcified structures [25]. PCI is therapeutic in addition to drugs, but post-procedure patients are at elevated risk of VTE due to activity limitations. Early thromboprophylaxis education can help reduce the incidence of VTE [10].

First, this study found that patients who received visual management health education had significantly higher levels of AT3 and APTT and significantly lower levels of D-D, FDP, FBG and TT after the intervention, indicating that the patients' coagulation function was improved. This result is consistent with previous studies and confirms that effective health education can reduce the

Table 6 Comparison of VTE incidence (Note: Because the data in the table did not meet the requirements of four-grid chi-square test (0 and 1 appeared), the chi-square test was not carried out)

Groups	Non-occurred	Occurred	Incidence rate (%)	*P* value
Test group (n = 50)	50	0	0	-
Control group (n = 50)	49	1	2	
Test group (n = 50)-3 month	50	0	0	-
Control group (n = 50)-3 month	48	2	4	

hypercoagulability of patients after PCI, thereby reducing the risk of thrombosis.

Studies have shown that health education in China mainly relies on oral education, but the method is arbitrary and unattractive [26], which affects the awareness and compliance of VTE prevention in CTO patients [27]. To improve this situation, this study introduces visual management, which is applied to VTE prevention health education for CTO patients by creating graphic brochures and dynamic videos. This method utilizes intuitive visual information and improves patient compliance. A study by Xuejing Liang et al. [28] also showed that visual cartoon brochures can improve the acceptance of education related to tonsillectomy among school-aged children, shorten the time of education, surgery, and hospitalization, reduce complications, and improve satisfaction. In a study by Kang Wei et al. [29], visualization materials helped PCI patients to learn about the disease and improve treatment adherence. Our study not only produced a graphic manual, but also added dynamic videos to further enhance patient acceptance and mastery, thus promising to improve the effectiveness of VTE prevention.

In this study, it was found that the adherence score and satisfaction of the test group were significantly higher than those of the control group ($P < 0.05$), indicating that this method can effectively enhance patient satisfaction. The reason for this is that illustration and video can systematically improve patients' understanding and memory of health knowledge and enhance their sense of achievement. Nurses promote nurse-patient interaction through illustrations and video explanations, which is superior to traditional educational methods and deepens patients' understanding of the content.

The blood coagulation and fibrinolytic systems determine the smoothness of blood circulation in the human body [30]. Currently, coagulation and fibrinolytic results are used clinically as laboratory indicators of the pre-thrombotic state to determine whether a patient is in a hypercoagulable state of blood [31, 32]. In the present study, the difference in FBG, APTT and TT between the test group and the control group after the intervention was statistically significant.FBG has a high affinity for thrombin and accelerates the coagulation reaction [33]. The decrease in FBG and TT detected at the end of the intervention suggests that health education based on visual management can improve the hypercoagulable state of the patient's blood, increase fibrinolytic activity, reduce blood viscosity, accelerate blood flow, and ultimately reduce the risk of thrombosis.

The fibrinolytic system is essential for maintaining blood flow [34], and D-dimer (D-D) is an ideal biomarker for monitoring hypercoagulability [35]. A guideline [36] also recommends that patients with positive D-D according to a risk screening scale be considered at high risk for DVT. In the present study, we found that patients' Padua Thrombosis Risk Scale scores were positively correlated with D-D levels, suggesting that hypercoagulability is associated with an increased risk of thrombosis. In patients undergoing PCI, bed rest and dehydration medication use increased thrombotic risk. Similar studies have shown that the Padua scale has low sensitivity and specificity in predicting thrombotic risk in patients undergoing PCI and is recommended to be used in combination with D-D. In this study [37], patients who received visual management-based health education had increased AT3 levels and decreased markers of hypercoagulability such as D-D, FBG, and FDP, suggesting that visual management health education helps to reduce the risk of VTE in patients. This may be related to increased patient awareness of VTE prevention and increased adherence. With visual aids, patients were able to understand VTE prevention and treatment more intuitively, resulting in improved self-management.

The uniqueness of this study lies in its innovative combination of visual management strategies and health education, focusing on the prevention of venous thromboembolism in patients with complete occlusion of chronic coronary arteries, a high-risk group that provides a theoretical basis for the prevention of VTE and fills the gaps in existing knowledge. The results of this study also suggest that visual management health education may be an effective complementary tool that can be combined with traditional health education methods to improve the effectiveness of health education. The application of this method is not limited to CTO patients, but may also be applicable to other patient groups who need to prevent VTE.

However, there are some limitations of this study. First, this study did not follow up the long-term prognosis of the patients, so it was not possible to assess the impact of visual management health education on the long-term preventive effect of VTE. Second, the patients included in this study came from the same hospital, which was limited by region and sample type, small sample size, short study period, and limited personnel. Finally, due to time constraints, only intraoperative interventions were used in this study. Further in-depth research is needed to expand the sample size and extend the duration of the intervention to obtain sufficient data to provide a more accurate practical basis for developing more effective educational programs.

Future studies could further expand the sample size, explore the effectiveness of visual management health education in other patients with cardiovascular disease, and follow up patients over time to assess its long-term

impact on VTE prevention, as well as optimize the content and modality of education to improve patients' self-management ability.

Conclusion

The results of this study show that visual management-based health education can effectively improve the awareness and compliance of venous thromboembolism (VTE) prevention in patients with chronic total coronary artery occlusion and significantly reduce the risk of VTE. Compared with traditional health education, visual management health education enhances patients' understanding and memory of health information through illustrated materials and dynamic videos, and improves treatment adherence and satisfaction. Therefore, visual management health education is an effective intervention that deserves to be promoted in clinical settings to improve the prognosis and quality of life of CTO patients.

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Author contributions
Ju JQ conceived of the study, and Mao LQ, Xu TT and Weng ZZ participated in its design and data analysis and statistics and Mao LQ helped to draft the manuscript. All authors read and approved the final manuscript.

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Availability of data and materials
All data generated or analysed during this study are included in this article. Further enquiries can be directed to the corresponding author.

Declarations

Ethics approval and consent to participate
This study was conducted in accordance with the Declaration of Helsinki and approved by the ethics committee of the First Affiliated Hospital of Ningbo University(No.: Research 2023-128A).

Informed consent
Written informed consent was obtained from all participants.

Consent for publication
Not applicable.

Competing interests
All of the authors had no any personal, financial, commercial, or academic conflicts of interest separately.

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