

Original Article

Prevention of deep venous thrombosis in patients undergoing knee arthroplasty by intermittent pneumatic compression apparatus

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Abstract: Objective: This study discussed and analyzed the preventive value of intermittent pneumatic compression combined with early rehabilitation training for deep vein thrombosis (DVT) in patients undergoing total knee arthroplasty (TKA). Methods: During January 2019 to April 2020, 85 patients who underwent TKA in our hospital were selected as subjects, and were randomly divided into an observation group (n=44) and control group (n=41) by table of random numbers. The control group patients received conventional nursing care after TKA surgery, while the observation group received combinative treatment of intermittent pneumatic compression therapy and early rehabilitation training like the conventional treatment in the control group. Subsequently, the circumference and mobility of knee joint, hemorrheologic indexes and the incidence of DVT between the two groups of patients before and after surgery were compared. Results: The knee circumferences of the two groups on 3 d and 7 d preoperatively were higher than 1 d before surgery ($P<0.05$), and the indexes of the observation group on 3 d and 7 d preoperatively were lower than that of the control group ($P<0.05$). The range of motion (ROM) of the two groups 3 d postoperatively were higher than that before surgery ($P<0.05$), the ROM in observation group 7 d postoperatively was increased than 3 d postoperatively ($P<0.05$), and the observation group had higher ROM on 3 d and 7 d postoperatively than that of control group ($P<0.05$). The two groups of patients had insignificant difference in knee function before treatment ($P>0.05$); the knee function of the two groups after treatment was better than pretreatment ($P<0.05$), and the observation group was better than the control group ($P<0.05$). The observation group had lower DVT incidence than the control group ($P<0.05$). Conclusion: Combinative treatment of intermittent pneumatic compression and early rehabilitation training can effectively improve the postoperative knee function of patients undergoing TKA, promote recovery, and effectively prevent DVT. In conclusion, the combinative treatment is worthy of clinical application.

Keywords: Intermittent pneumatic compression, early rehabilitation training, total knee replacement, deep vein thrombosis

Introduction

Total knee arthroplasty (TKA) is a major treatment for severe knee injuries. However, the incidence of deep vein thrombosis (DVT) in patients after TKA is as high as 30%, which leads to a prolonged postoperative hospital stay, increased economic burden, and even the death of patients caused by pulmonary embolism [1, 2]. Studies have shown [3, 4] that early postoperative rehabilitation training can effectively prevent muscle adhesion and improve knee function, and is currently an effective way commonly applied clinically to prevent postoperative DVT. Intermittent pneumatic compression is an effective physical preventive mea-

sure. It can promote blood return and postoperative circulation of lower limbs, thus effectively preventing the formation of postoperative DVT in patients [5, 6]. In order to further reduce the incidence of DVT in patients after TKA, this study explored and analyzed the preventive value of intermittent pneumatic compression combined with early rehabilitation training on the prevention of DVT in patients who underwent TKA.

Materials and methods

Research subjects

During January 2019 to April 2020, 85 patients who underwent TKA in our hospital were select-

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ed as research subjects, and were randomly divided into an observation group (n=44) and control group (n=41) by table of random numbers. The study was carried out under the approval of hospital ethics committee.

Inclusive and exclusive criteria

Inclusion criteria: (1) Patients admitted for knee osteoarthritis, traumatic arthritis or rheumatoid arthritis, and who were to undergo TKA surgery; (2) All surgeries were performed by qualified physicians in our hospital; (3) The age of the patients ranged from 60 to 80 years old; and (4) Patients voluntarily signed an informed consent.

Exclusion criteria: (1) Patients with dysfunction of vital organs such as heart, liver, kidney or lung; (2) Patients with psychiatric disorders; (3) Patients with hematological diseases; (4) Patients with coagulation mechanism disorders; or (5) Patients with poor treatment compliance.

Methods

The control-group patients received conventional nursing care after TKA surgery, including Cefuroxime (Southwest Pharmaceutical Co., Ltd., H20183120) treatment within 3 days after surgery to prevent infection, and conventional analgesic pump for pain relief. In addition, the Low molecular weight heparin (Hebei Changshan Biochemical Pharmaceutical Co., Ltd., H20063910) was used to prevent postoperative DVT of patients. The drainage tube was removed within 24 to 48 hours, and routine drug replacement was performed. The patients were also instructed to perform exercises of straightening legs to elevate and passively flex and extend the knees.

The observation-group was given combinative treatment of intermittent pneumatic compression therapy and early rehabilitation training on the basis of the conventional treatment in the control group. We used intermittent pneumatic compression unit to treat patients with lower limb air pressure 8 hours postoperatively. The operator lifted the patient's leg, fixed the pressure leg sleeves on the leg, turned on the switch, and controlled the pressure at 60-200 mmHg. The treatment was performed 1 h/time and twice/d. Early rehabilitation training for patients: the patients were instructed to per-

form autonomic quadriceps contraction exercises and ankle pump exercises 6 h after surgeries. The recommended exercise amount was 60-100 times; they were also instructed to perform knee extension and flexion exercises on the 1st postoperative day. When extending knees, patients adopted the cushion to raise the ankle, and gently pressed the knee joint with hands. When bending the knees, they held the middle part of thighs with both hands and lifted up. The recommended range of exercise was based on patient's tolerance, and the duration of exercise was 5 min per day; The patients added straight leg raising exercises for 2 to 3 days after surgery, and leg elevation was subject to the patient's tolerance. After removing the drainage tube, the patients added the continuous passive motion (CPM) for passive training. The device was started at 20° and gradually increased to 30°. After the CPM, patients were treated with an ice compress for 30 min; The recommended amount of exercise was 30 min each time and twice a day. We recommended the patients to walk on the grounds under supervision 4 d after surgery. The weight-bearing walking exercise was subject to the patient's individual tolerance, and the training was gradually increased. Meanwhile, according to the knee function and tolerance, the patients gradually increased their range of motion (ROM), and added exercises of hip flexion, active flexion, and squatting against walls.

Observation of indexes

(1) The circumference of the affected knee joint between the two groups was compared on the 1st day before surgery, the 3rd day, and the 7th day after surgery respectively. The operator wore sterile gloves, disinfected the measuring tape with iodine, and measured the midpoint of patient's patella. (2) The ROMs of patients' knee joints were compared between the two groups 1 d before surgery, 3 d and 7 d after surgery. (3) The hip and knee joint functions of the two groups before and after treatment were compared, and the Hospital for Special Surgery (HSS) was used to evaluate the knee function of the patients [7]. The scale included stability (10 points), flexion deformity (10 points), muscle strength score (10 points), activity score (1 point per 8°, 18 points), functional score (22 points), and pain score (30 points). Higher scores referred to a better knee function of the patients. (4) The DVT incidence

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Table 1. Comparison of clinical data between two groups of patients

Clinical data	Observation group (n=44)	Control group (n=41)	t/ χ^2	P
Gender				
Male	25	27	0.730	0.393
Female	19	14		
Age (yd, $\bar{x} \pm s$)	68.34 \pm 4.11	69.95 \pm 5.20	1.589	0.116
BMI (kg/m ² , $\bar{x} \pm s$)	24.03 \pm 2.39	23.71 \pm 2.68	0.582	0.562
Surgical site				
Left	18	12	1.259	0.262
Right	26	29		

Table 2. Comparison of knee circumference before and after surgery between two groups (cm, $\bar{x} \pm s$)

Group	Number of cases	1 d before surgery	3 d after surgery	7 d after surgery
Observation group	44	32.07 \pm 3.78	39.03 \pm 4.03*	34.18 \pm 4.28*
Control group	41	32.87 \pm 3.42	43.08 \pm 6.42*	36.17 \pm 4.64*
t	-	1.021	3.509	2.057
P	-	0.310	0.001	0.043

Note: Compared with 1 d before surgery, * $P < 0.05$.

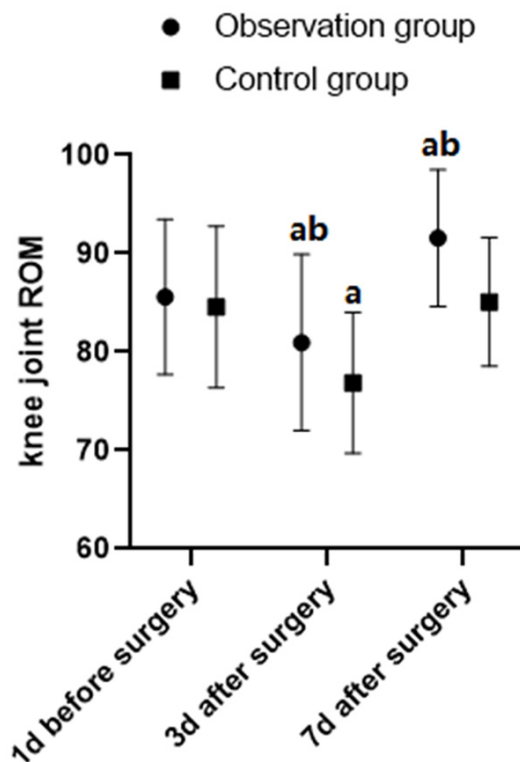


Figure 1. Comparison of knee joint ROM between two groups before and after surgery. Note: compared with 1 d before surgery, a, $P < 0.05$; compared with control group, b, $P < 0.05$.

14 d after surgery was compared between the two groups, and the diagnosis of DVT was based on *The Guidelines for the Prevention of VTE* by NICE.

Statistical analysis

Statistical software SPSS 23.0 was applied for processing and analysis of the research data. The measured data were expressed by ($\bar{x} \pm s$) and compared by *t*-test; and the counted data were expressed by percentage, and the enumerated data were compared by χ^2 test. $P < 0.05$ was regarded as significant.

Results

Clinical data

The comparison of clinical data between the two groups had no statistically significant difference ($P > 0.05$), as shown in **Table 1**.

Comparison of knee circumference before and after operation between the two groups

The knee circumferences of the two groups on 3 d and 7 d preoperatively were higher than 1 d before surgery ($P < 0.05$), and the indexes of the observation group on 3 d and 7 d preoperatively were lower than those of the control group ($P < 0.05$) (**Table 2**).

Comparison of knee joint ROM before and after surgery between two groups

The ROMs of the two groups 3 d postoperatively were obviously higher than that before surgery ($P < 0.05$). ROM in the observation group 7 d postoperatively was increased versus 3 d postoperatively ($P < 0.05$), and the observation group had higher ROM on 3 d and 7 d postoperatively than the control group ($P < 0.05$) (**Figure 1**).

Comparison of hip and knee joint functions between two groups before and after surgery

The two groups of patients had insignificant difference in knee function before treatment

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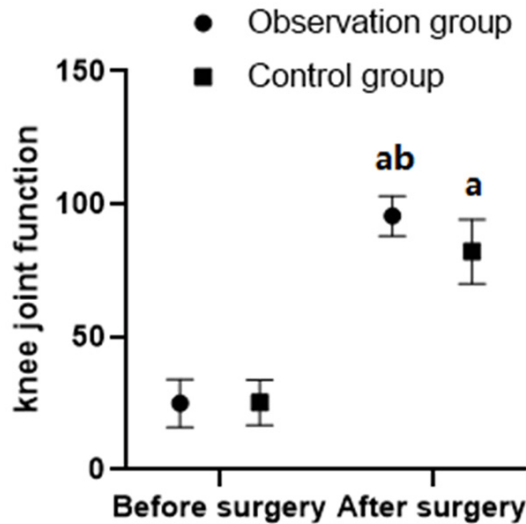


Figure 2. Comparison of knee joint function between two groups before and after surgery. Note: compared with before surgery, a, $P < 0.05$; compared with control group, b, $P < 0.05$.

($P > 0.05$). The knee function of the two groups after treatment was better than in pre-treatment ($P < 0.05$), and the observation group was better than the control group ($P < 0.05$) (Figure 2).

Comparison of DVT incidence between the two groups

The DVT incidence was 11.36% in the observation group and 26.83% in the control group. The observation group had lower DVT incidence than the control group ($P < 0.05$) (Table 3).

Discussion

The incidence of osteoarthropathy in middle-aged and elderly people in China is increasing with increased aging of the population. As the most widely used surgical method in orthopedic surgery, total knee arthroplasty (TKA) has been popularized all over the world. Osteoarthritis patients can be successfully treated due to the good surgical results and safety of TKA. The patient's joint pain can be relieved, and the joint function and quality of life may be greatly improved [8, 9]. However, TKA has a high incidence of postoperative DVT, which increases the medical expenses of patients, reduces the surgical effect, and at the same time increases the incidence of pulmonary embolism in patients and even endangers their life [10]. This

study explored and analyzed the value of combinative treatment of intermittent pneumatic compression and early rehabilitation training for prevention of DVT in patients undergoing TKA.

Abnormal blood coagulation in the venous lumen of patients with DVT leads to luminal obstruction and abnormal blood flow, and these adverse phenomena of vascular circulation dysfunction will further induce pulmonary embolism [11]. After TKA surgery, surgical stress promotes the increase of prothrombin kinase and fibrinogen in patients, and the exogenous coagulation channels are activated, leading to a hypercoagulable state of blood [12, 13]. In addition, since TKA patients have to stay in bed for quite a long time after surgery, their lower limb blood circulation slows down, resulting in a higher incidence of DVT [14].

Voluntary functional training is the main focus in terms of conventional post-TKA nursing care of patients, and the effect it has achieved was not good since the rationality and intensity of training were affected by subjective factors of patients. This study, on the basis of conventional nursing care, explored and analyzed the preventive value of intermittent pneumatic compression combined with early rehabilitation training for prevention of DVT in patients undergoing TKA. The results showed that the DVT incidence in observation group was lower than that in the control group. This was consistent with the related research results [15, 16], and suggested that the effective postoperative nursing intervention could play an important role in preventing postoperative DVT. In the early postoperative stage, when the patient's soft tissues inside and outside the joint have not been formed, and the degree of adhesion is relatively low, early active functional training can play a positive role in promoting venous lymphatic return and effectively prevent the formation of DVT [17, 18].

The knee circumferences of the observation group on 3 d and 7 d preoperatively were obviously lower than those of the control group. The ROMs of the observation group on 3 d and 7 d preoperatively were apparently higher than that of the control group, and the observation group had better knee function than the control group. In this study, the observation-group patients carried out the functional exercise of

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Table 3. Comparison of DVT incidence between the two groups of patients [n (%)]

Group	Number of cases	Happened	Not happened
Observation group	44	5 (11.36)	39 (88.64)
Control group	41	11 (26.83)	30 (73.17)
χ^2	-	4.252	
P	-	0.039	

isometric contraction and ankle pump exercises under the guidance of professional rehabilitation trainer 6 h after surgery, which can effectively relieve the swelling of affected limb and reduce the pressure in joint cavity [19, 20]. 7 d after surgery, a large amount of collagen is generated around the knee, and the irregular deposition of collagen can affect the range of motion of knee joint and reduce the patient's knee function. Under the guidance of professional trainers, patients can complete rational and regular functional exercise, which can effectively adjust the direction of collagen fibers, improve the function of the knee joint, and promote ROM of the knee joint [21, 22]. The intermittent pneumatic compression unit is a preventive measure for DVT of the lower limbs. The unit uses airbags to inflate and squeeze the patient's local limbs from the distal end to the proximal end, thereby achieving the purpose of passively contracting and relaxing muscles. During treatment, the venous blood of patients fills rapidly during decompression and returns rapidly at the time of compression, which helps increase the local blood flow velocity and reduces the risk of DVT caused by blood flow retardation [23, 24]. In addition, the intermittent pneumatic compression is non-invasive, convenient to use, and safe. Application of this method on the basis of conventional measures can effectively prevent the occurrence of DVT and improve postoperative joint function of patients undergoing TKA [25, 26].

However, due to the relatively small sample quantity included in this study, and lack of in-depth research and analysis of its possible mechanisms, it is suggested to enlarge the sample size in further research to obtain more reliable clinical evidence.

The combinative treatment of intermittent pneumatic compression and early rehabilitation training can effectively improve the postopera-

tive knee function of patients undergoing TKA, promote their postoperative recovery, and effectively prevent the occurrence of DVT. In conclusion, it is worthy of clinical application.

Disclosure of conflict of interest

None.

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