• Clinical Research Paper •

Clinical Observation of Neuromuscular Electrical Stimulation in Prevention of Deep Venous Thrombosis after Total Hip Replacement

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Abstract: Purpose To observe the clinical efficacy of GEKO Neuromuscular Electrical Stimulation (NMES) in the prevention of deep venous thrombosis (DVT) after Total Hip Arthroplasty (THA). **Methods** The author used THA in operative treatment of 72 cases of femoral head necrosis from 01-2016 to 08-2016, which were assigned to the observation group (basic prevention method plus NMES) and the control group (basic prevention method). **Results** There was no statistically significant difference (P>0.05) between the two groups in post-operative negative pressure drainage. The observation group was superior to the control group in terms of post-operative VAS score, DVT incidence rate and 3 days post-surgery Plasma D-dimer content. The differences were statistically significant (P<0.05), and no apparent adverse reactions were found in the observation group. **Conclusions** Application of NMES in early recovery of patients after THA could increase the lower limb venous blood flow rate and alleviate pain, serving as an effective physical therapy in the prevention of DVT.

Keywords: Neuromuscular electrical stimulation; femoral head necrosis; total hip arthroplasty; deep venous thrombosis; physical therapy

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Deep venous thrombosis (DVT) is a type of blood disease related to venous backflow obstruction, which leads to venous thromboembolism (VTE) and causes lethal pulmonary thromboembolism (PTE), and is also one of the major causes of the relatively high rate of perioperative mortality and incidence of unexpected deaths in hospitals for patients undergoing major orthopaedic surgery[1]. Three DVT preventative methods include: basic prevention, physical prevention and drug prevention methods. Of these, physical prevention for DVT applies to patients with coagulopathy or with a high risk of bleeding[2]. The author used Total Hip Arthroplasty (THA) in operative treatment of 72 cases of femoral head necrosis from Jan. 2016 to Aug. 2016 and employed Neuromuscular Electrical Stimulation (NMES) physical therapy to prevent the occurrence of DVT. The details are reported below.

1 Data and Methodology

1.1 General Information Inclusion criteria: Ficat stage III-IV femoral head necrosis patients; patients eligible for spinal epidural anaesthesia. Patients with preoperative infectious disease, coagulopathy and a history of venous thromboembolism were excluded. A total of 72 cases, consisting of 45 male and 27 female patients, were included, and assigned randomly into a control group (employing basic preventative methods) and observation group (basic preventative methods plus NMES). Among the 36 cases in the control group were 25 male and 11 female patients: aged 32-76 (53.1±8.0) years old; BMI 17.6-31.8 (24.26±2.78). Among the 36 cases in the observation group were 20 male and 16 female patients: aged 34-67 (53.7±11.7) years old; BMI 20.5-30.1 (25.79±3.69). The two groups were comparable, with no significant statistical differences in gender (χ^2=1.481, P=0.224), age (t=0.27, P=0.788), or BMI (t=1.915, P=0.06).

1.2 Therapies The surgical operations for the 2 groups were completed by the same chief physician. For the control group, basic preventative methods were employed, the surgical operation was standardized to reduce venous intima injury, venous thromboembolism preventative education was given prior to and after the operation, as well as instruction in rehabilitation exercises including early stage muscle relaxation and contraction, active joint movement and massage; and 5 sets of exercises per day, with 100 repetitions of muscle relaxation and contraction and active joint movement, and 20 repetitions of massage in each set. For the observation group, basic preventative methods plus NMES (produced in the UK by Firstkind Limited, trade name GEKO) were applied in preventive treatment. After the operation NMES was employed immediately for 24 hours/time, with 3 days being one treatment course, and low-intensity stimulation was advocated in early stages, then the stimulation could be gradually enhanced.

1.3 Observation Indicators and Efficacy Assessment Criteria For post-operative recovery from anaesthesia, functional exercises were carried out immediately; post-operative negative pressure drainage was observed for 24 hours, with VAS scoring at day 3 post-operatively, and plasma D-dimer content measurement at day 3 pre-operatively and day 3 post-operatively [3]. Colour Doppler ultrasound DVT screening and examination were performed for the 2 groups prior to and after the operation.

1.4 Statistical Methods SPSS 20.0 statistical software was used for analysis, the count data were analysed using χ^2 test, and the measurement data were analysed using t-test; the difference was statistically significant, with P<0.05.

2 Results

The observation group had one case of DVT, with an incidence rate of 2.7%; the control group had six cases, with an incidence rate of 16.7%. The DVT incidence rate of the observation group was lower than the control group, and the difference was statistically significant (χ^2=3.956, P=0.047). There was no occurrence of post-operative PTE in these two groups. Pre-operative and post-operative plasma D-dimer content measurement was carried out for the two groups. The comparative difference between the two groups in plasma D-dimer content at day 1 pre-operatively was not statistically significant (P>0.05); plasma D-dimer content at day 3 post-operatively in the observation group was lower than the control group, with a statistically significant difference (P<0.05). See Table 1.

Table 1 Comparison of plasma D-dimer (g/L) content measurements prior to and after THA operation for the two groups of femoral head necrosis patients

Group	n	Day 1 pre-op	Day 3 post-op
Observation group	36	0.62±0.49	1.70±0.85
Control group	36	0.57±0.65	2.55±1.90
t value		0.356	-2.449
P value		0.723	0.018

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The negative pressure drainage tubes for the two groups were pulled out 24 hours after the operation. Of the two groups, the negative pressure drainage of the observation group was 150-928 (355.4±186.2) ml, and that of the control group was 42-688(331.7±177.4) ml. The comparative difference of the two groups in THA post-operative 24 hour negative pressure drainage was not statistically significant (t=0.553, P=0.582). The VAS scoring at 3 days post-operatively in the two groups: observation group 0-5 (2.4±1.1), control group 2-7 (4.1±1.5). The difference was statistically significant (t=5.537, P=0.001). No adverse events such as skin damage, irritation, insomnia or rise in blood pressure were found in the observation group.

3 Discussion

Venous blood stasis and hypercoagulation status within lower limb deep vein blood vessels are two important contributing factors to DVT[4]. Femoral head necrosis patients with long-term pre-operative disability of movement or prolonged bed rest causes lower limb venous blood stasis. In response to the more serious trauma caused by patient THA operations, the human body will generate procoagulant factors, and other blood coagulants may change, so that the blood is in a hypercoagulable state, which is more conducive to the occurrence of DVT. Hence, more pro-active and comprehensive measures should be taken for THA patients to prevent the formation of DVT[5].

The GEKO neuromuscular electrical stimulator could stimulate the nervus peroneus communis of the lower limbs through NMES, inducing regular contraction of leg muscle groups and generating rhythmic foot dorsiflexion activity; furthermore, this will lead to blood vessel expansion of the lower limbs and enable drainage of blood in the deep and superficial vein system, increasing the venous blood flow and volume of the lower limbs and improving the venous stasis[6]. It could also promote blood circulation, accelerate the metabolism of trauma tissue, prevent the aggregation of blood coagulation components, reduce the reactive adhesion of blood platelets on venous intima of the lower limbs, and reduce the hypercoagulable state of the blood. This would thereby prevent the formation of DVT and help reduce post-operative pain and speed up the metabolic rate of the D-dimer without increasing THA post-operative negative pressure drainage[7-8]. Compared to other physical DVT prevention instruments and basic preventative methods, the GEKO neuromuscular electrical stimulator features a small size, ease of operation and flexibility in self-installation by patients, and shows obvious advantages in terms of electrical safety, portability and patient compliance.

Prior to the NMES treatment by use of GEKO, Colour Doppler ultrasound examination of both lower limb arteries/veins is required to screen if the patient is already suffering from peripheral arterial disease and deep venous thrombosis before the surgical operation; once such contraindications are identified, NMES treatment is not allowed. The device is worn on the outside of the lower leg, and applied to the skin's nervus peroneus communis, with the arrow indicator aligning to the centre of the caput fibulae below the knees. Generally, the working intensity level is set to 3-4 depending on the tolerance of the patient to the stimulation. According to the feedback of most patients in the observation group, the sensation of contraction of the lower leg and foot muscles is obvious, without affecting sleep, and the patients' reactions after continuous NMES treatment indicate the pain of the injured limbs has been alleviated. The VAS scoring difference is statistically significant, and patients can actively receive NMES treatment.

According to foreign literature, the incidence rate of post-operative VTE reaches up to 42%-57%[4]. In preventing DVT for post-operative THA patients by combining basic preventative methods with the NMES physical prevention method, the DVT incidence rate of the observation group was 2.7%, which was lower than the control group, and the difference was statistically significant, pointing toward NMES physical prevention being conducive to reducing the post-operative incidence of DVT.

Plasma D-dimer content is an indicator reflecting the blood's hypercoagulable or prethrombotic state within the human body. In the event of hyperfunction of fibrous protein dissolution and thrombosis in the human body, plasma D-dimer content will rise accordingly. Plasma D-dimer features a high measurement sensitivity, rapid speed and cost-effectiveness. Through monitoring plasma D-dimer content, it can play a positive role in effectively assessing the incidence of deep venous thrombosis. In this study, D-dimer content and the difference between the post-operative day 3 observation group are lower than the control group, showing that the difference is statistically significant.

DVT frequently occurs 1-14 days after operation, with the peak time at 1-3 days after operation[1]. It is recommended that NMES physical preventive measures be performed as soon as possible after bandaging the wound, and that NMES be maintained for 2 weeks after the operation, during which time patient activity should be restored to the pre-operative level as early as possible. Through retrospective analysis, it is clear that immediate use of NMES to prevent DVT after operation does not affect wound healing, and the difference in post-operative negative pressure drainage between these two groups is not statistically significant. In the event of peripheral arterial occlusion, deep venous thrombosis and varicosity during NMES, use is not suitable for patients already connected to high-frequency surgical equipment and equipped with electrocardiograph electrodes.

For femoral head necrosis patients after THA operation, the basic preventive methods for DVT plus NMES treatment present ease of operation and safety, helping to increase the lower limb deep vein blood flow, expand blood vessel diameter and effectively reduce the incidence of DVT, showing better application value. Yet, due to the relatively small sample in this study, further expanding the sample size and validation through a multi-centre comparative study are required.

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