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Original Article

Effects of multimodal pain management in patients with long bone fracture

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Abstract: Objective: To explore the effects of multimodal pain management on pain degree, sleep quality and psychological states of patients with long bone fracture. Methods: Ninety-eight patients with long bone fracture who were treated by internal fixation were enrolled and, according to random number table, divided into a control group (n = 49) receiving routine nursing and an experimental group (n = 49) receiving multimodal pain management based on routine nursing. The two groups of patients were compared in terms of pain degree, sleep quality, psychological states, coping styles, the number of postoperative patient-controlled analgesia (PCA) uses and nursing satisfaction. Results: At 1 and 3 days after operation, the Numerical Rating Scale (NRS) scores of resting and active states in the experimental group were significantly lower than those in the control group (all P = 0.000). At 4 weeks after intervention, the Pittsburgh Sleep Quality Index (PSQI), the Self-Rating Scale of Sleep (SRSS), the Self-Rating Anxiety Scale (SAS) and the Self-Rating Depression Scale (SDS) scores in the experimental group were significantly lower than those in the control group (all P = 0.000). Compared with the control group, patients in the experimental group had a significantly higher positive coping score (P = 0.000), but a significantly lower negative coping score (P = 0.000). The number of PCA uses within postoperative 6, 24 and 48 hours were lower in the experimental than those in the control group (P = 0.002, P = 0.000 and P = 0.000 respectively). Pain education, perception of pain control and overall nursing satisfaction in the experimental group were significantly higher than those in the control group (P = 0.025, P = 0.029 and P = 0.004 respectively). Conclusion: Multimodal pain management for patients with long bone fracture is conducive to pain relief, sleep quality improvement, negative emotion regulation, relationship improvement between patients and nurses, promoting patients' positive response to disease and reduced number of postoperative PCA uses.

Keywords: Long bone fracture, multimodal, pain management, sleep quality, psychological state

Introduction

Long bone fracture, as a common disease in orthopaedics, is caused by severe primary injuries, local bone infections, fixation of unstable fractures and poor restoration. Patients with long bone fracture disease are clinically treated by internal fixation, which aims to promote the restoration of the original anatomical structures and improve health-related functional status [1]. However, invasive operation easily causes physiological stress responses, among which pain is a common symptom of orthopedic patients, accompanied by potential and actual tissue damage. Pain causes increases of respiratory and heart rates, blood pressure, as well as a decrease of sleep quality. If the patients are not given intervention treatment, it will increase the risk of postoperative deep vein thrombosis and other complications, and even turns into chronic pain [2, 3]. Therefore, postoperative pain management is of great significance for pain relief and subjective feeling of improvement in patients undergoing orthopedic surgery [4]. Multimodal pain management refers to, under the supervision of a multimodal pain management team, improving pain threshold through psychological intervention, refining perioperative work and combining drugs (opioids, local anesthetics, magnesia mixture, etc.) with different mechanisms of action for analgesia. It improves patients' pain tolerance, plays an analgesic effect through the synergistic effect of drugs and reduces peripheral and cen-

tral sensitization, thereby relieving pain and improving sleep quality. Based on this, the effects of multimodal pain management on the pain degree, sleep quality and psychological state of patients with long bone fracture were explored in this study.

Materials and methods

General information

Ninety-eight patients with long bone fracture of the lower limbs who were treated by internal fixation in Tongji Hospital of Tongji Medical College, Huazhong University of Science and Technology from February 2016 to May 2018 were enrolled and divided into the control and experimental groups (n = 49) according to the random number table. The patients included 56 males and 42 females, aged 21-79 years old with an average age of 42.5 ± 6.3 years old and 3-17 years of schooling. This study was approved by the Ethics Committee of Tongji Hospital of Tongji Medical College, Huazhong University of Science and Technology.

Inclusion and exclusion criteria

Inclusion criteria: Patients ≥ 18 years old; patients who were diagnosed with closed long bone fracture of the lower limbs by X-ray; patients who were admitted to Tongji Hospital of Tongji Medical College, Huazhong University of Science and Technology within 24 hours of injury; patients who voluntarily signed an informed consent form.

Exclusion criteria: Those with open fractures and fractures complicated with compound injuries; those with previous complications affecting postoperative healing; those complicated with dislocation of joint, distal limb destruction and neurovascular injury; those accompanied by coagulation disorders and dysfunction of important organs (heart, lung, kidney, etc.).

Methods

Routine nursing was carried out on patients in the control group. Before operation, routine visits were conducted by anesthesiologists. After operation, bedside nurses evaluated the pain degree of the patients and timely reported to the doctor in charge or the anesthesiologists in case of abnormalities. Disease monitoring, observation of disease changes, health education and other nursing interventions were performed at the same time. After operation, the patients were treated with patient-controlled analgesia (PCA) with tramadol hydrochloride injection as the main component for 48-72 hours. According to the doctors' advice, patients who complained about pain were symptomatically treated, and orally administrated with 0.2 g celecoxib capsules at the 1st day after operation, twice/d for 5 consecutive days.

Multimodal pain management on the basis of routine nursing was carried out on patients in the experimental group. First, the organizational structure of multimodal pain management was established. A multimodal pain management team was formed after the approval of the Pain Management Committee in Tongji Hospital of Tongji Medical College, Huazhong University of Science and Technology, consisting of 2 orthopedic clinicians, 1 project chief, 1 head nurse who served as a team leader, 1 anesthesiologist, 5 bedside nurses, patients and their families. Each member had a clear division of labor and did his or her own duties. Meanwhile, incentive mechanisms and learning platforms were established and improved. The head nurse regularly organized the members to carry out systematic training and assessment in order to strengthen management knowledge and operation skills, master analgesic methods, effects and adverse reactions and follow procedures. Under the guidance of the institutions, multimodal pain management was performed on the patients whose pain degree was then evaluated according to the Numerical Rating Scale (NRS) [5]. Measures were as follows: (1) preoperative educational cognition and psychological intervention in pain management. Brochures about pain were designed and distributed. Based on patients' ability to accept things and level of education, health education was carried out to deepen their understanding of pain, including operation methods, intra-operative precautions, physiological mechanisms and harm of pain. Communication with patients and their families were strengthened and a good family support system was established. In order to create a comfortable environment for rest, proper temperature and humidity in the ward was maintained, and number of visitors and visiting hour

were controlled. (2) Pain management without drugs: Treatment and nursing work was refined to relieve pain. For instance, after operation, the patients were placed in a horizontal position without pillows for 6 hours, and the trapezoid pillow and the soft pillow were respectively placed between the legs and under the affected limb, in order to keep the affected limb in an abduction and neutral position. The head of the bed was raised by approximately 30° and static contraction training of the affected limb was carried out to accelerate incision healing and relieve pain. Centripetal massage was given to the affected limb in order to promote local blood circulation and prevent lower limb venous thrombosis. According to the patients' hobbies, their favorite music was used to divert their attention from pain and improve pain threshold. (3) Drug intervention: 50 mg of flurbiprofen axetil injection was intravenously injected and 0.15 μg/kg of sufentanil citrate injection (0.9% sodium chloride injection diluted to 6 mL) was epidurally injected before and after operation. After operation, PCA with tramadol hydrochloride injection as the main component was used to relieve pain, and family members were instructed to use control keys. After operation, the incision was iced for 24 hours; on the 1st and 2nd days after operation, 40 mg of parecoxib sodium was intravenously injected, twice/d; from day 1 to 14 after the operation, 0.2 g of celecoxib capsules were orally administrated, twice/d. During the treatment, the head nurse evaluated the nursing effect on pain through spot check and organized all members to participate in the meeting, in order to give timely feedback and summarize prominent problems for management and put forward improvement measures, so as to improve the overall nursing care.

Observational indexes

(1) Pain degree: The pain degree during resting state and continuous passive motion (CPM) in bed was evaluated through NRS on the 1st day before operation, the 1st and 3rd days after operation. Zero represented no pain while 10 points represented severe pain [6]. (2) Sleep quality: The sleep quality was assessed through the Pittsburgh Sleep Quality Index (PSQI) and the Self-Rating Scale of Sleep (SRSS) before and at 4 weeks after intervention [7]. PSQI included sleep efficiency, sleep disturbance, sleep duration, sleep latency, daytime dysfunction, sleep quality and use of sleep medication. Each item had 0-3 points with a total of 21 points. The sleep quality was negatively correlated with the PSQI score and the SRSS score which had 10-50 points. (3) Psychological states: Depression and anxiety were respectively assessed through the Self-Rating Depression Scale (SDS) and the Self-Rating Anxiety Scale (SAS) before and at 4 weeks after intervention [8, 9]. Each scale had 0-100 points and 20 items. The higher the score was, the more obvious the depression and anxiety. (4) Coping styles: Coping styles including positive and negative coping skills were evaluated through the Trait Coping Style Questionnaire (TCSQ) before and at 4 weeks after intervention. Each style had 10 items with a total of 50 points, and each item was scored on a scale of 1-5. A high score indicated that the patients were more likely to choose the corresponding coping style. (5) Number of PCA uses within 48 hours after operation: The number of PCA uses within 6, 24 and 48 hours after operation in the two groups was counted. (6) Nursing satisfaction: The Chinese version of Houston Pain Outcome Instrument (HPQI) was used to assess the patients' nursing satisfaction after discharge, including pain education, perception of pain control and overall nursing satisfaction [10]. Each item had 0-10 points and a score ≥ 7 points was considered to be satisfactory.

Statistical methods

SPSS 24.0 was used for data processing. Measurement data were expressed as $\bar{x} \pm sd$, and comparison between groups was conducted through two-factor analysis of variance with repeated measures. Count data were expressed as % and tested by χ^2. $P < 0.05$ indicates a statistically significant difference.

Results

Comparison of general information

There was no statistically significant difference in general data between the two groups (both $P > 0.05$). More details are shown in **Table 1**.

Comparison of pain degree

There was no statistically significant difference in the NRS score between the experimental

Table 1. Comparison of general information

Group	Control group (n = 49)	Experimental group (n = 49)	χ^2/t	P
Male/female	29/20	27/22	0.167	0.683
Age (year)	43.3 ± 6.1	42.8 ± 6.4	0.396	0.693
Years of education (year)	11.32 ± 3.54	11.75 ± 3.87	1.757	0.079
Fracture reason			0.178	0.915
Traffic accident injury	19	17		
Pressure bruise	12	13		
Fall injury	18	19		
Fracture site				0.179
Tibia	36	36		
Thighbone	19	17		0.914

Table 2. Comparison of NRS score ($\bar{x}$ ± sd)

Group	Control group (n = 49)	Experimental group (n = 49)	t	P
1st day before operation				
Resting state	7.02 ± 1.44	7.19 ± 1.35	0.603	0.548
CPM state	8.45 ± 1.31	8.39 ± 1.42	0.217	0.828
1st day after operation				
Resting state	4.26 ± 0.84	2.75 ± 0.73	9.498	0.000
CPM state	6.35 ± 1.14	4.51 ± 0.95	8.680	0.000
3rd days after operation				
Resting state	3.72 ± 0.81	1.24 ± 0.33	19.848	0.000
CPM state	5.06 ± 0.94	2.87 ± 0.69	13.147	0.000

Note: NRS, numerical rating scale; CPM, continuous passive motion.

and control groups at the 1st day before operation (both P > 0.05). At the 1st and 3rd days after operation, the NRS scores of resting state and CPM in the experimental group were lower than those in the control group (P < 0.001). More details are shown in **Table 2** and **Figure 1**.

Comparison of sleep quality

Before intervention, there were no statistically significant differences between the experimental and control groups in terms of PSQI and SRSS scores (both P > 0.05). However, the experimental group had lower scores than those in the control group at 4 weeks after intervention (P < 0.001). More details are shown in **Table 3** and **Figure 2**.

Comparison of psychological states

Before intervention, there were no statistically significant differences between the experimental and control groups in terms of SAS and SDS scores (both P > 0.05). At 4 weeks after intervention the experimental group had lower scores than those in the control group (P < 0.001). More details are shown in **Table 4** and **Figure 3**.

Comparison of coping styles

Before intervention, there was no statistically significant difference in coping styles between the experimental and control groups (both P > 0.05). At 4 weeks after intervention, the positive coping score in the experimental group was higher than that in the control group, while the negative coping score was lower than that in the control group (P < 0.001). More details are shown in **Table 5** and **Figure 4**.

Comparison of number of PCA uses

The number of PCA uses in the experimental group was lower than that in the control group within 6, 24 and 48 hours after operation (P < 0.01). More details are shown in **Table 6**.

Comparison of nursing satisfaction

The pain education, perception of pain control and overall nursing satisfaction in the experimental group were higher than those in the control group (P < 0.05). More details are shown in **Table 7**.

Discussion

Importance and necessity of pain management: Pain is a complex physiological response produced when the body experiences operative trauma-induced stress, and its generation and transmission form a behavioral system of cognition and senses with dynamism and complexity. The system detects, coordinates and integrates harmful stimuli threatening the survival of the body and causing tissue damage, as well as inducing protective responses [11, 12]. The pathogenesis of postoperative pain is different

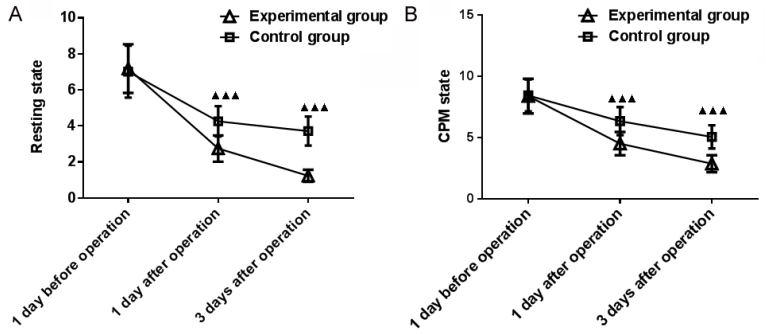

Figure 1. Comparison of NRS scores between the two groups. A. Resting state; B. CPM state. Compared with the experimental group, ▲▲▲P < 0.001. NRS, numerical rating scale; CPM, continuous passive motion.

Table 3. Comparison of sleep quality ($\bar{x}$ ± sd)

Group	Control group (n = 49)	Experimental group (n = 49)	t	P
PSQI score				
Before intervention	12.81 ± 3.23	12.56 ± 3.36	0.376	0.708
4 weeks after intervention	9.47 ± 2.04	7.16 ± 1.81	5.929	0.000
t	6.120	9.904		
P	0.000	0.000		
SRSS score				
Before intervention	41.54 ± 5.02	40.62 ± 6.28	0.801	0.425
4 weeks after intervention	32.14 ± 4.74	24.65 ± 3.81	8.621	0.000
t	9.530	15.219		
P	0.000	0.000		

Note: PSQI, Pittsburgh Sleep Quality Index; SRSS, Self-Rating Scale of Sleep.

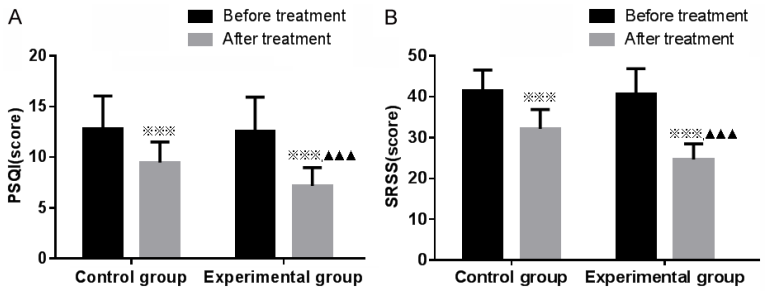

Figure 2. Comparison of sleep quality between the two groups. A. PSQI score; B. SRSS score. Compared with the control group, ▲▲▲P < 0.001; compared with before treatment, ※※※P < 0.001. PSQI, Pittsburgh Sleep Quality Index; SRSS, Self-Rating Scale of Sleep.

from neuropathic and inflammatory pain and related to osteoarticular injuries. When it comes to tissue damage, central sensitization and peripheral sensitization occur in the nociceptive system, changing the levels of pain regulation and treatment and reducing pain threshold [13]. According to clinical studies, patients with long bone fracture are usually accompanied by pain, which reduces their postoperative activity and sleep quality, increases complications and affects postoperative functional status, all of which are not conducive to a patients' recovery [14, 15]. Therefore, it is of great significance to explore the effects of an all-around and standardized pain management scheme in relieving the pain and improving the quality of life of patients with long bone fracture.

Connotation of multimodal pain management: Previous clinical pain nursing for long bone fracture, such as position nursing, attention diversion, physical pain relief and analgesia through painkillers according to doctor's advice, has alleviated the degree of pain in patients to some extent. However, nurses and patients dominated the nursing process. Nursing personnel are limited by outdated concepts and short of correct knowledge of pain management and inaccurate evaluation of the pain degree, so their measures for nursing intervention at times lack comprehensiveness and integrity [16]. With the development of modern nursing concepts, multimodal pain management emerges at the right moment. Taking patients' rehabilitation as the core, it combines mechanisms, approaches and analgesics for analgesic treatment to obtain the best analgesic effect while minimizing adverse reactions, aimed at minimizing the pain degree and accelerating the postoperative rehabilitation [17].

Effects of multimodal pain management: In this study, compared with the control group, patients in the experimental group had lower NRS scores of resting and active states on the 1st and 3rd days after operation, significantly

Table 4. Comparison of psychological states ($\bar{x}$ ± sd)

Group	Control group (n = 49)	Experimental group (n = 49)	t	P
SAS score				
Before intervention	52.83 ± 6.83	53.26 ± 6.94	0.309	0.758
4 weeks after intervention	45.47 ± 5.04	32.16 ± 4.24	14.146	0.000
t	6.070	18.161		
P	0.000	0.000		
SDS score				
Before intervention	50.28 ± 6.32	51.16 ± 6.17	0.670	0.487
4 weeks after intervention	42.26 ± 4.53	31.38 ± 3.92	12.713	0.000
t	7.220	18.941		
P	0.000	0.000		

Note: SAS, self-rating anxiety scale; SDS, self-rating depression scale.

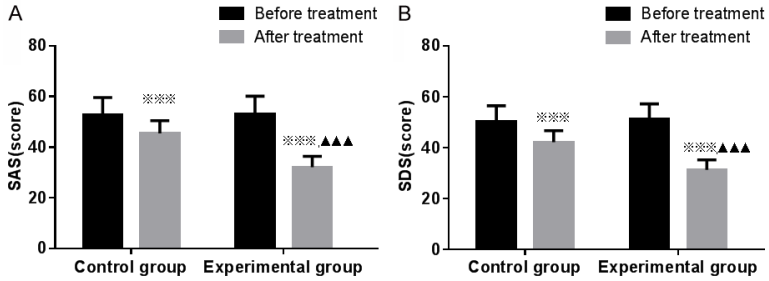

Figure 3. Comparison of psychological states between the two groups. A. SAS score; B. SDS score. Compared with the control group, ▲▲▲P < 0.001, compared with before treatment, ※※※P < 0.001. SAS, self-rating anxiety scale; SDS, self-rating depression scale.

Table 5. Comparison of coping styles ($\bar{x}$ ± sd)

Group	Control group (n = 49)	Experimental group (n = 49)	t	P
Positive coping score				
Before intervention	15.28 ± 3.52	14.26 ± 3.24	1.492	0.139
4 weeks after intervention	19.17 ± 3.82	26.24 ± 4.63	8.245	0.000
t	5.242	14.840		
P	0.000	0.000		
Negative coping score				
Before intervention	20.42 ± 3.98	21.27 ± 4.02	1.052	0.296
4 weeks after intervention	16.37 ± 3.28	11.54 ± 2.81	7.828	0.000
t	5.497	13.887		
P	0.000	0.000		

lower PSQI, SRSS, SAS, SDS and negative coping scores at 4 weeks after intervention, significantly higher positive coping score and nursing satisfaction, and lower number of PCA uses within 6, 24 and 48 hours after operation. Therefore, multimodal pain management is superior to routine nursing in pain management for patients with long bone fracture. (1) Reduction of postoperative pain degree and number of PCA uses, and improvement of sleep quality. Timely postoperative identification and evaluation of pain and measures for multimodal pain management (position placement, massotherapy, music relaxation therapy, etc.) can cause swelling of affected limbs to subside, relax tense muscles and accelerate local blood circulation, as well as divert attention from pain, thereby relieving pain. In addition, patients with obvious pain are given multimodal analgesia. Two or more analgesic methods and drugs with different mechanisms act on pain receptors or different layers of conductive pathways, which effectively inhibits central and peripheral sensitization, further improves the analgesic effect and reduces PCA usage rate, as well as improves sleep quality [18, 19]. (2) Improvement of psychological states and coping styles. Explanation of pain-related knowledge through distribution of health booklets and other means to patients and their families corrects their understanding, builds their treatment confidence and reduces their doubt, anxiety and other adverse psychological states. Besides, the importance of patients' chief complaints in pain management is emphasized, to keep their personal goals highly consistent with team goals and mobilize their subjective initiative while relieving pain, thereby improving coping styles [20]. (3) Improvement of nursing satisfaction and reduction of medical disputes. Multimodal pain management is attended by project chiefs, doctors, nurses, patients and their families who are coordinated and supervised according

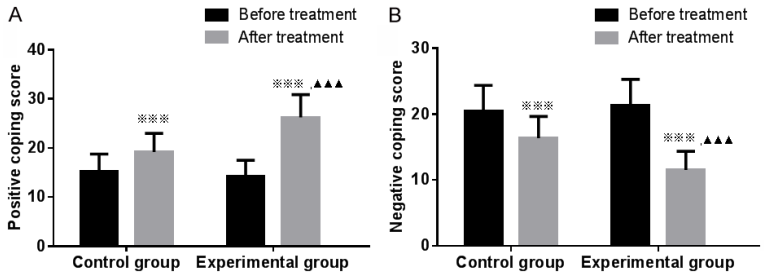

Figure 4. Comparison of coping styles between the two groups. A. Positive coping score; B. Negative coping score. Compared with the control group, ▲▲▲P < 0.001; compared with before treatment, ※※※P < 0.001.

Table 6. Comparison of number of PCA uses ($\bar{x}$ ± sd)

Group	Control group (n = 49)	Experimental group (n = 49)	t	P
6 hours after operation	3.63 ± 1.89	2.46 ± 1.76	3.171	0.002
24 hours after operation	5.84 ± 2.07	4.12 ± 1.94	4.244	0.000
48 hours after operation	9.42 ± 3.85	7.47 ± 3.14	2.748	0.000

Note: PCA, patient-controlled analgesia.

Table 7. Comparison of nursing satisfaction (n, %)

Group	Control group (n = 49)	Experimental group (n = 49)	χ^2	P
Pain education	40 (81.63)	47 (95.92)	5.018	0.025
Perception of pain control	37 (75.51)	45 (91.84)	4.781	0.029
Overall nursing satisfaction	39 (79.59)	48 (97.96)	8.295	0.004

to its procedures. Conducive to the multi-level, multi-faceted and multi-angle development of nursing work, this management coordinates patient-nurse relationships, realizes the multimodal participation of management team personnel and prolongs service cycles, as well as expands service fields, thus shortening the distance between patients and nurses and improving their mutual trust [21, 22].

In conclusion, multimodal pain management for patients with long bone fracture is conducive to pain relief, sleep quality improvement, negative emotion regulation, relationship improvement between patients and nurses, promotes patients' positive response to disease and reduces the number of postoperative PCA uses.

Disclosure of conflict of interest

None.

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