

World Journal of *Clinical Cases*

World J Clin Cases 2023 October 16; 11(29): 6974-7260



MINIREVIEWS

- 6974** Applications of time series analysis in epidemiology: Literature review and our experience during COVID-19 pandemic

Tomov L, Chervenkov L, Miteva DG, Batselova H, Velikova T

ORIGINAL ARTICLE**Retrospective Cohort Study**

- 6984** Acute cholangitis: Does malignant biliary obstruction *vs* choledocholithiasis etiology change the clinical presentation and outcomes?

Tsou YK, Su YT, Lin CH, Liu NJ

Retrospective Study

- 6995** Usefulness of analyzing endoscopic features in identifying the colorectal serrated sessile lesions with and without dysplasia

Wang RG, Ren YT, Jiang X, Wei L, Zhang XF, Liu H, Jiang B

- 7004** Roles of biochemistry data, lifestyle, and inflammation in identifying abnormal renal function in old Chinese

Chen CH, Wang CK, Wang CY, Chang CF, Chu TW

- 7017** Clinical efficacy and safety of Guipi decoction combined with escitalopram oxalate tablets in patients with depression

Yu J, Xu FQ

- 7026** Artificial intelligence technology and ultrasound-guided nerve block for analgesia in total knee arthroplasty

Tong SX, Li RS, Wang D, Xie XM, Ruan Y, Huang L

- 7034** Axenfeld-Reiger syndrome: A search for the missing links

Morya AK, Ramesh PV, Sinha S, Nishant P, Nain N, Ramavath RN, Gone C, Prasad R

Observational Study

- 7043** Self-management of osteoarthritis while waiting for total knee arthroplasty during the COVID-19 pandemic among older Malaysians

Mahdzir ANK, Mat S, Seow SR, Abdul Rani R, Che Hasan MK, Mohamad Yahaya NH

- 7053** "In situ bone flap" combined with vascular pedicled mucous flap to reconstruction of skull base defect

Qian M, Chen X, Zhang LY, Wang ZF, Zhang Y, Wang XJ

- 7061** Reference values of gait parameters in healthy Chinese university students: A cross-sectional observational study

Yu JS, Zhuang C, Guo WX, Chen JJ, Wu XK, Xie W, Zhou X, Su H, Chen YX, Wang LK, Li WK, Tian K, Zhuang RJ

- 7075** Effect of T-regulatory cells and interleukin-35, interleukin-10, and transforming growth factor-beta on diffuse large B-cell lymphoma

Wu H, Sun HC, Ouyang GF

META-ANALYSIS

- 7082** Meta-analysis on the effectiveness of parent education for children with disabilities

Jang J, Kim G, Jeong H, Lee N, Oh S

- 7091** Meta-analysis of the efficacy and safety of daratumumab in the treatment of multiple myeloma

Wang P, Jin SY

CASE REPORT

- 7101** Varicella-zoster virus meningitis with hypoglycorrhachia: A case report

Cao LJ, Zheng YM, Li F, Hao HJ, Gao F

- 7107** Unusual presentation of penile giant condyloma acuminatum with spontaneous prepuce perforation: A case report

Hsu FC, Yu DS, Pu TW, Wu MJ, Meng E

- 7113** Primary renal lymphoma presenting as renal failure: A case report and review of literature from 1989

Lee SB, Yoon YM, Hong R

- 7127** Intravascular ultrasonography assisted carotid artery stenting for treatment of carotid stenosis: Two case reports

Fu PC, Wang JY, Su Y, Liao YQ, Li SL, Xu GL, Huang YJ, Hu MH, Cao LM

- 7136** Mucoepidermoid carcinoma of the lung with hemoptysis as initial symptom: A case report

Xie WX, Liu R, Li Z, Zhou PL, Duan LN, Fu DD

- 7144** Co-infection of *Chlamydia psittaci* and *Tropheryma whippelii*: A case report

Du ZM, Chen P

- 7150** Surgical treatment of severe anterior capsular organized hard core cataract: A case report

Wang LW, Fang SF

- 7156** First platelet transfusion refractoriness in a patient with acute myelocytic leukemia: A case report

Tu SK, Fan HJ, Shi ZW, Li XL, Li M, Song K

- 7162** Rare finding of primary aortoduodenal fistula on single-photon emission computed tomography/computed tomography of gastrointestinal bleeding: A case report

Kuo CL, Chen CF, Su WK, Yang RH, Chang YH

- 7170** Rituximab combined with Bruton tyrosine kinase inhibitor to treat elderly diffuse large B-cell lymphoma patients: Two case reports

Zhang CJ, Zhao ML

- 7179** Use of Ilizarov technique for bilateral knees flexion contracture in Juvenile-onset ankylosing spondylitis: A case report
Xia LW, Xu C, Huang JH
- 7187** Case of takotsubo cardiomyopathy after surgical treatment of liver hydatid cyst: A case report
Altaş Y, Abdullayeva Ü
- 7193** Laparoscopic choledocholithotomy and transductal T-tube insertion with indocyanine green fluorescence imaging and laparoscopic ultrasound: A case report
Yoo D
- 7200** Hematopoietic stem cell transplantation of aplastic anemia by relative with mutations and normal telomere length: A case report
Yan J, Jin T, Wang L
- 7207** Emphysematous thrombophlebitis caused by a misplaced central venous catheter: A case report
Chen N, Chen HJ, Chen T, Zhang W, Fu XY, Xing ZX
- 7214** Aggressive angiomyxoma of the epididymis: A case report
Liu XJ, Su JH, Fu QZ, Liu Y
- 7221** Gastric and intestinal ectopic pancreas: Two case reports
Zhang H, Zhao HY, Zhang FH, Liang W
- 7227** Congenital leukemia: A case report and review of literature
Yang CX, Yang Y, Zhang FL, Wang DH, Bian QH, Zhou M, Zhou MX, Yang XY
- 7234** Imaging misdiagnosis and clinical analysis of significant hepatic atrophy after bilioenteric anastomosis: A case report
Liang SY, Lu JG, Wang ZD
- 7242** Surgical treatment of mixed cervical spondylosis with spontaneous cerebrospinal fluid leakage: A case report
Yu Z, Zhang HFZ, Wang YJ
- 7248** Simultaneous thyroglossal duct cyst with parathyroid cyst: A case report
Chen GY, Li T
- 7253** Submandibular solid-cystic mass as the first and sole manifestation of occult thyroid papillary carcinoma: A case report
Chen GY, Li T

LETTER TO THE EDITOR

- 7258** Artificial intelligence and machine learning in motor recovery: A rehabilitation medicine perspective
Swarnakar R, Yadav SL

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Retrospective Study

Artificial intelligence technology and ultrasound-guided nerve block for analgesia in total knee arthroplasty

Sheng-Xiong Tong, Ren-Song Li, Dan Wang, Xiao-Meng Xie, Yuan Ruan, Lin Huang

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Abstract

BACKGROUND

Knee diseases are more common in middle-aged and elderly people, so artificial knee replacement is also more used in middle-aged and elderly people. Although the patient's pain can be reduced through surgery, often accompanied by moderate pain after surgery and neutralization, which not only increases the psychological burden of the patient, but also greatly reduces the postoperative recovery effect, and may also lead to the occurrence of postoperative adverse events in severe cases.

AIM

To investigate the analgesic effect of artificial intelligence (AI) and ultrasound-guided nerve block in total knee arthroplasty (TKA).

METHODS

A total of 92 patients with TKA admitted to our hospital from January 2021 to January 2022 were opted and divided into two groups according to the treatment regimen. The control group received combined spinal-epidural anesthesia. The research group received AI technique combined with ultrasound-guided nerve

block anesthesia. The sensory block time, motor block time, visual analogue scale (VAS) at different time points and complications were contrasted between the two groups.

RESULTS

The time of sensory block onset and sensory block perfection in the research group was shorter than those in the control group, but the results had no significant difference ($P > 0.05$). Duration of sensory block in the research group was significantly longer than those in the control group ($P < 0.05$). The time of motor block onset and motor block perfection in the research group was shorter than those in the control group, but the results had no significant difference ($P > 0.05$). Duration of motor block in the research group was significantly longer than those in the control group. The VAS scales of the research group were significantly lower than that of the control group at different time points ($P < 0.05$). The postoperative hip flexion and abduction range of motion in the research group were significantly better than those in the control group at different time points ($P < 0.05$). The incidence of complications was significantly lower in the research group than in the control group ($P = 0.049$).

CONCLUSION

In TKA, the combination of AI technology and ultrasound-guided nerve block has a significantly effect, with fewer postoperative complications and significantly analgesic effect, which is worthy of application.

Key Words: Artificial intelligence technology; Ultrasound guidance; Nerve blocks; Total knee arthroplasty; Analgesia effects

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Core Tip: Entering the century of rapid development, the phenomenon of aging population is also increasing, aging problems have received widespread social attention, middle-aged and elderly people are prone to knee joint lesions, the most important feature of knee joint lesions is its multiple, this disease affects the motor function of the elderly. This study aimed to investigate the analgesic effect of artificial intelligence (AI) and ultrasound-guided nerve block in total knee arthroplasty (TKA). The authors found that in TKA, the combination of AI technology and ultrasound-guided nerve block has a significantly effect, with fewer postoperative complications and significantly analgesic effect, which is worthy of application.

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INTRODUCTION

Entering the century of rapid development, the phenomenon of aging population is also increasing, aging problems have received widespread social attention, middle-aged and elderly people are prone to knee joint lesions, the most important feature of knee joint lesions is its multiple, this disease affects the motor function of the elderly[1,2]. Among the disabling chronic diseases, gonarthrosis also accounts for a considerable part, and only knee replacement by surgery can minimize the patient's pain, help the patient get rid of the disease distress as much as possible, help them establish a new outlook on life, and enhance the quality of life[3]. However, surgery in the treatment of diseases at the same time, will bring a greater degree of trauma to patients, the most ideal anesthesia is perioperative analgesia. This anesthesia method is not only aimed at the surgical process, but also includes the postoperative period. If reasonable nursing is given in the perioperative period, the incidence rate of postoperative complications will be greatly reduced. This management not only includes providing a good method for the patient with labor pain, but also includes the guidance and help for the patient postoperative exercise and improving the patient's comfort level[4].

Knee joint diseases are mostly seen in middle-aged and elderly people, so artificial knee arthroplasty is also mostly used in middle-aged and elderly people[5]. Although the pain of patients can be reduced through surgery, it is often accompanied by more than moderate pain during and after surgery, which not only aggravates the psychological burden of patients, but also greatly reduces the postoperative recovery effect, and may also lead to the occurrence of postoperative adverse events in serious cases[6]. Therefore, the most important purpose of medical staff is to do a good job of preoperative as well as postoperative anesthesia and minimize the patient's pain[7]. The use of artificial intelligence (AI) technology combined with ultrasound-guided nerve block anesthesia has achieved ideal results, reducing the pain of patients while reducing the incidence of postoperative complications.

MATERIALS AND METHODS

General information

A total of 92 patients with total knee arthroplasty (TKA) who were treated in our hospital from January 2021 to January 2022 were opted, and the patients were divided into two groups according to the treatment regimen. Inclusion criteria: (1) All meet the relevant standards for TKA; (2) Clear consciousness and normal communication; (3) Normal spirit; (4) Normal blood coagulation function; and (5) All know and agree to this study. Exclusion criteria: (1) Patients with allergic reactions to anesthetics; (2) Patients with infection at the puncture site; (3) Patients with severe abnormal coagulation function; and (4) Patients with nerve damage in the bottom extremity on the operating side or abnormal skin sensation patient. Ethics approval was provided by the ethical committee of Wuhan First Hospital. Written informed consent was obtained from all participants. The research group included 31 males and 15 females, with a mean age of 74.7 ± 1.4 years and a mean weight of 64.6 ± 2.1 kg. The control group included 27 males and 19 females, with a mean age of 74.5 ± 1.3 years and a mean weight of 64.3 ± 2.0 kg. No statistically significant difference was found between the two groups.

Intervention methods

Control group: The control group was given combined spinal-epidural anesthesia, and L2-3 was used as the puncture point for puncture anesthesia. Glucose (10%, approved by Chinese medicine: H13022457, produced by CSPC) was mixed for anesthesia for the patient, and 8-10 mL of lidocaine (1.5%, approved by Chinese medicine: H35020528) was added to the epidural during the operation.

Research group: The research group performed nerve block anesthesia guided by ultrasound, and used a portable ultrasound instrument (S-NERVE, Solo Sound) to perform nerve block anesthesia on the patients. After opting a good position for the patient, let the patient flex their knees and flex their hips. After disinfection, mark points are made. The data is imported into the AI KNEE system to quickly and intelligently generate and automatically segment the three-dimensional bone anatomy of the patient's knee joint. The software automatically identifies anatomical landmarks and measures key knee parameters. After the image was obtained, 25 mL of ropivacaine (0.5%, approved by the State Drug Administration: H20113463, produced by Hebei Yipin Company) was injected into the sciatic nerve using a spinal anesthesia needle; A short-axis view was performed while 20 mL of ropivacaine was injected near the nerve using a spinal needle.

Observation indicators

Sensory block time: Observe and record the sensory block time of the two clusters of patients, including the onset time, perfection time, and duration.

Motor block time: Mainly include onset time, perfection time, and duration.

Visual analog scale: Contrasted the pain conditions of the two clusters of patients at different time points, the score is 10 points, 0 points: No pain; < 3 points: Slight pain, but tolerable; 4-6 points: Pain affects sleep, but can be tolerated; 7-10 points: Pain is intense, unbearable, affects sleep, and affects appetite.

The range of motion of hip flexion and abduction: The changes in the range of motion of hip flexion and abduction after surgery were contrasted between the two clusters.

Complications: Mainly headache, low back pain, nausea and vomiting.

Statistical analysis

The count data was expressed as n (%) and compared using the χ^2 test. The measurement data was expressed as mean \pm SD and compared using the t -test. $P < 0.05$ was considered as significant differences.

RESULTS

Comparative of sensory block time between the two groups

The time of sensory block onset and sensory block perfection in the research group was shorter than those in the control group, but the results had no significant difference ($P > 0.05$) (Figure 1). Duration of sensory block in the research group was significantly longer than those in the control group ($P < 0.05$).

Comparative of motor block time between the two groups

The time of motor block onset and motor block perfection in the research group was shorter than those in the control group, but the results had no significant difference ($P > 0.05$) (Figure 2). Duration of motor block in the research group was significantly longer than those in the control group ($P < 0.05$) (Figure 2).

Comparative of visual analogue scales between the two clusters

The visual analogue scale (VAS) scales of the research group were bottom than that of the control group at different time points, and the variance was significant difference ($P < 0.05$) (Table 1, Figure 3).

Table 1 Comparative of visual analogue scale scores (points, mean \pm SD)

Group	2 h post-operation	4 h post-operation	12 h post-operation	24 h post-operation	48 h post-operation
Control group (<i>n</i> = 46)	3.1 \pm 1.0	3.3 \pm 0.3	3.7 \pm 0.6	3.5 \pm 1.0	3.2 \pm 0.3
Research group (<i>n</i> = 46)	1.0 \pm 0.4	1.3 \pm 0.4	1.6 \pm 0.8	1.2 \pm 0.6	1.5 \pm 0.4
<i>T</i> value	13.224	27.129	14.243	13.376	23.060
<i>P</i> value	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05

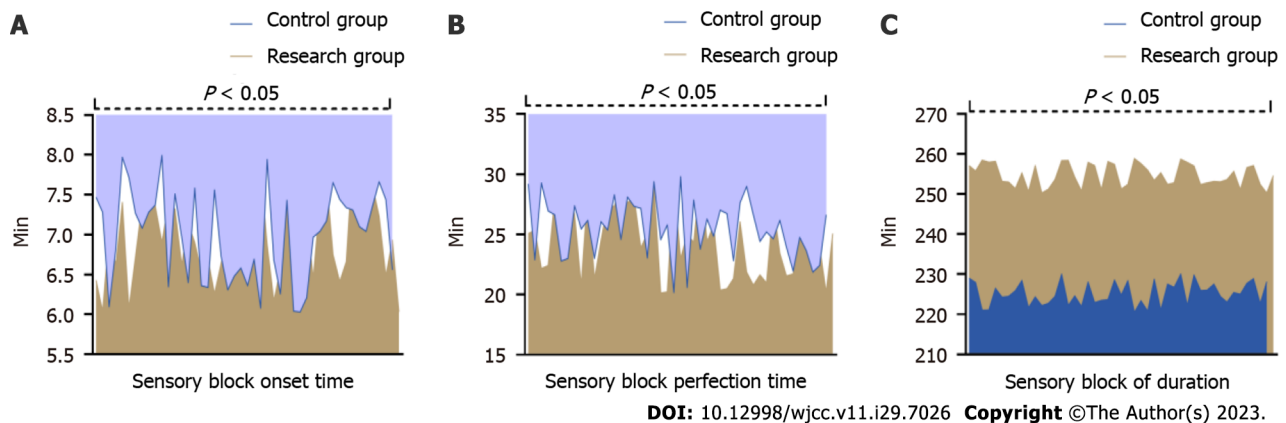


Figure 1 Comparative of sensory block time (mean \pm SD). A: Sensory block onset time; B: Sensory block perfection time; C: Sensory block of duration. The duration of sensation in the research group is longer than that in the control group. $P < 0.05$ indicates that there is a significant difference in the duration of sensation between the control group and the research group.

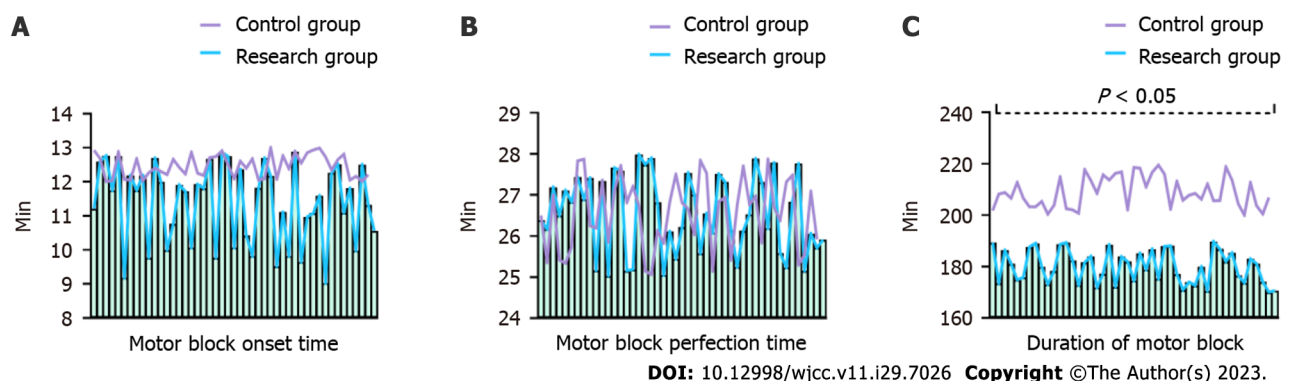


Figure 2 Comparative of motor block time (mean \pm SD). A: Motor block onset time; B: Motor block perfection time; C: Duration of motor block. The exercise duration of the research group was shorter than that of the control group. $P < 0.05$ indicates that there was a significant difference in the exercise duration between the control group and the research group.

Comparative of postoperative hip flexion and abduction range of motion

The postoperative hip flexion and abduction range of motion in the research group were better than those in the control group at different time points, and the variance was significant difference ($P < 0.05$) (Figure 4).

Comparative of complications between the two clusters

The number of patients with headache, back pain, nausea and vomiting in the research group were 1, 2, and 3 respectively, and the complication rate was 2.2%; while those of the control group were 0, 0, and 1, respectively, with a complication rate of 13.0%. The incidence of complications was significantly lower in the research group than in the control group ($P = 0.049$, Table 2).

Table 2 Comparative of complications, *n* (%)

Group	Headache	Back pain	Nausea and vomiting	Incidence
Control group (<i>n</i> = 46)	1 (2.2)	2 (4.3)	3 (6.5)	13.0%
Research group (<i>n</i> = 46)	0 (0)	0 (0)	1 (2.2)	2.2%
χ^2 value				3.867
<i>P</i> value				< 0.05

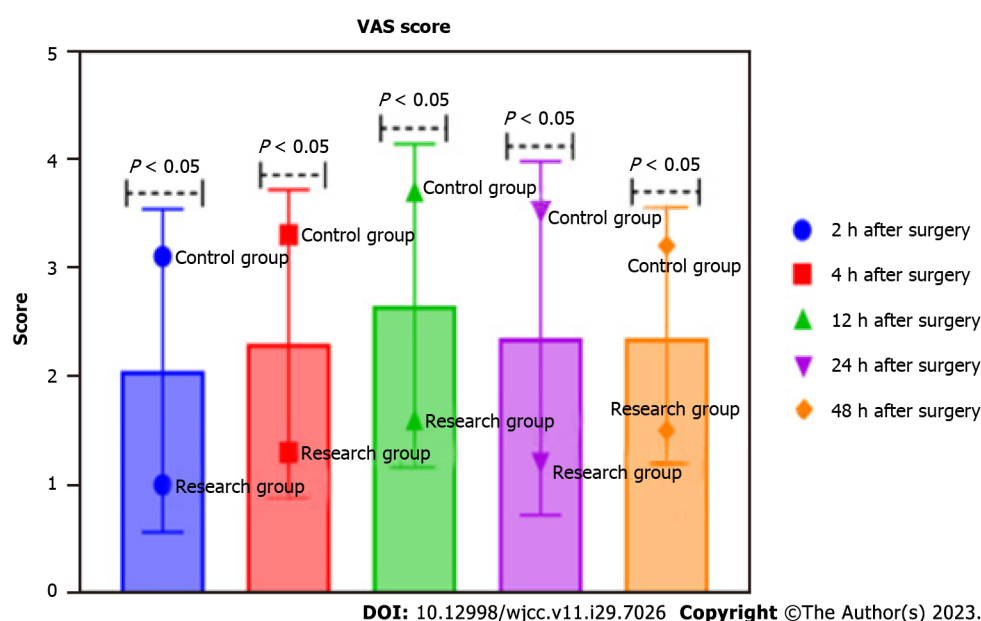


Figure 3 Comparative of visual analogue scale scores (points, mean ± SD). The visual analogue scale (VAS) score of the research group is lower than that of the control group after surgery. *P* < 0.05 means that the VAS score of the control group and the research group at different time points (2 h, 4 h, 12 h, 24 h, 48 h) after surgery, the variance is significant difference. VAS: Visual analogue scale.

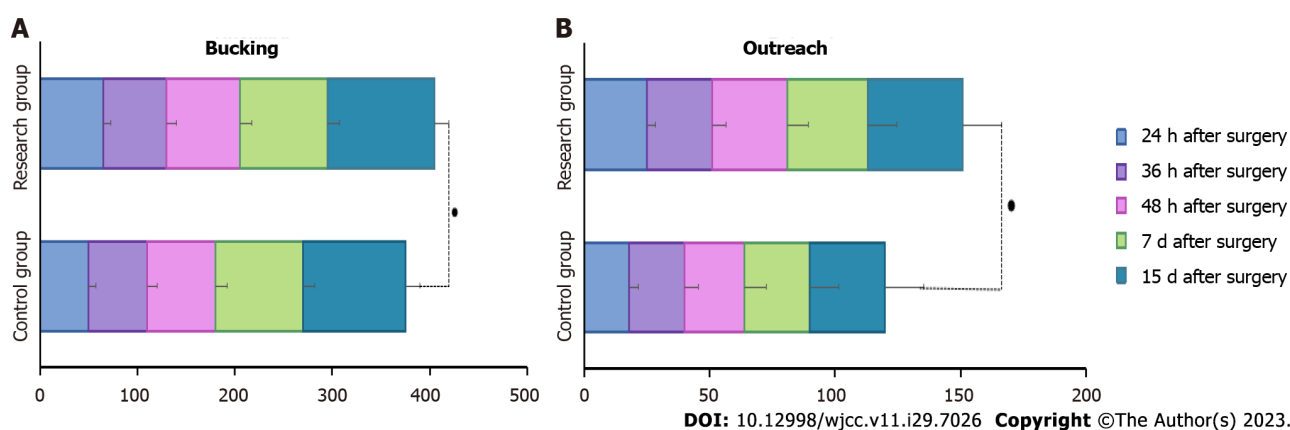


Figure 4 Comparative of hip flexion and abduction range of motion between the two groups after surgery (°, mean ± SD). A: Bucking; B: Outreach. Contrasted with the control group, the research group has greater degree of hip flexion and abduction after surgery. *P* < 0.05 means that the control group and the research group at different time points (24 h, 36 h, 48 h, 7 d, 15 d after the surgery) hip flexion contrasted with abduction activity, the variance was significant difference.

DISCUSSION

Osteoarthritis is a common joint disease, mainly characterized by joint deformity, dysfunction and deformity[8-10]. At present, TKA is mainly used to treat patients with osteoarthritis, which can relieve joint pain and restore normal function of some joints[11]. However, the operation process of TKA is relatively complex, causing great harm to patients[12], which can easily lead to stress reactions in patients[13]. Pain is the most common postoperative complication of TKA.

Excessive pain will have a certain impact on the quality of postoperative joint training. Reasonable and effective postoperative analgesia for patients can enhance postoperative joint function training treatment, reduce the risk of complications[14].

Nerve block is to inject drugs directly into nerve trunks, nerve plexuses and other places where nerves gather, or to block nerve pathways through physical stimulation, and block the use of ultrasound-guided knee replacement surgery [15]. The main function of this pump is to transfer the effective concentration of drugs are introduced into the epidural space through a catheter, so that the pain transmitted from the spinal cord is blocked in the process of being transmitted to the nervous system, increased the speed and strength of venous blood return, in this way can greatly reduce the complications of surgery[16,17].

The AI-based three-dimensional planning system for TKA surgery is used for preoperative planning[18,19]. The system can accurately segment the skeletal bone fragments based on the preoperative computed tomography images of the patient, using a pixel-level segmentation network and edge smoothing technology based on a recurrent neural network. In nerve block, the concentration of ropivacaine is controlled between 0.2% and 0.5%, and the total amount is less than 3 mg/kg[20]. Mixing ropivacaine with lidocaine can effectively make up for the lack of slow onset of ropivacaine, and can also effectively expand the area of drug diffusion and block a wider range of[21]. Our results showed the time of sensory block onset and sensory block perfection in the research group was shorter than those in the control group, but the results had no significant difference[22]. However, duration of sensory block in the research group was significantly longer than those in the control group[23].

With the continuous advancement of medical technology, ultrasound guidance has been widely used in anesthesia, which can effectively make up for the shortcomings of conventional nerve block anesthesia[24]. Our results showed that the complications in the research group was significantly lower than those in the control group, which means that in TKA, the combination of AI technology and ultrasound-guided nerve block can significantly reduce the probability of complications in patients. The VAS scales of the research group were significantly lower than that of the control group at different time points, which indicated that the combination of AI technology and ultrasound-guided nerve block in TKA was more feasible, and the method has no obvious effect on the circulatory system of patients and is easy to be widely used[25]. The most important thing is that it can significantly reduce the occurrence of various complications in the patient[24,25]. Although the feasibility of ultrasound-guided nerve block is high, this study also has certain shortcomings. Therefore, in the future research process, we will conduct more in-depth research and discussion in order to confirm the accuracy of the results and provide a certain scientific basis for the development of TKA. Provide some reference for other researchers.

CONCLUSION

In TKA, the combination of AI technology and ultrasound-guided nerve block has a significantly effect. The AI-based three-dimensional planning system for TKA surgery performs preoperative planning, reduces the risk of complications, and speeds up patient recovery. The analgesic effect is obvious and it is worth applying.

ARTICLE HIGHLIGHTS

Research background

Knee joint disease, as one of the common diseases of middle-aged and elderly people, has increased greatly with the aging population. Conventional total knee arthroplasty (TKA) has a high risk of postoperative pain.

Research motivation

Artificial intelligence (AI) combined with ultrasound-guided nerve block anesthesia has achieved ideal results in TKA, effectively reducing the incidence of postoperative complications.

Research objectives

This study aimed to explore the clinical analgesic effect of artificial intelligence and ultrasound-guided nerve block in TKA, and to provide expected clinical guidance for TKA.

Research methods

Patients were randomly divided into two groups: combined spinal-epidural anesthesia and AI combined with ultrasound-guided nerve block anesthesia. The different clinical effects of the two groups were compared.

Research results

Ultrasound-guided nerve block in TKA has longer duration of sensory block and longer duration of motor block in the research group, better postoperative complications and better clinical effect.

Research conclusions

The combination of AI technology and ultrasound-guided nerve block is effective in the treatment of knee lesions in the

elderly, with few postoperative complications and significantly analgesic effect, which is worth popularizing and applying.

Research perspectives

The combination of AI technology and ultrasound-guided nerve block is an effective clinical practice method, which provides a certain clinical guidance for postoperative analgesia of knee diseases in middle-aged and elderly people.

FOOTNOTES

Author contributions: Tong SX and Li RS contributed equally to this work; Tong SX and Huang L contributed to the conceptualization, methodology, software of the study; Tong SX and Li RS contributed to the data curation and the drafted the manuscript; Wang D, Xie XM, Li RS and Ruan Y contributed the validation of the study, and the writing, reviewing and editing of the manuscript.

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