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Original Research Article

Analgesic and safety analysis of dexmedetomidine combined with ropivacaine in ultrasound-guided brachial plexus nerve block

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Abstract

Purpose: *To investigate analgesic effect and safety of dexmedetomidine combined with ropivacaine in ultrasound-guided brachial plexus block in intercostal space.*
Methods: *A total of 90 patients were scheduled to undergo upper limb surgery and divided into control and study groups, respectively. Patients in control group were given ropivacaine nerve block, while those in study group were given ropivacaine combined with dexmedetomidine mixture nerve block. The efficiency of sensory and motor block, secondary evaluation of block effect, visual analogue scale (VAS) scores at different postoperative moments, remedial analgesia and adverse reactions were compared between the two groups after 30 min of drug injection.*
Results: *The success rate of sensory block was not significantly different between control group (91.11 %) and study group (93.33 %; $\chi^2 = 0.155$, $p > 0.05$) but success rate of the motor block was significantly higher in study group (93.33 %) than in control group (71.11 %; $\chi^2 = 7.601$, $p < 0.05$). Compared with control group, onset of sensory block and motor block were significantly shorter in study group, while the duration of sensory block and motor block was significantly longer ($p < 0.05$). The VAS scores at 12, 24, and 48 h postoperatively were significantly lower in study group than control group ($p < 0.05$). The number of self-administered analgesia, number of patients, dose used, and overall incidence of adverse reactions in study group were significantly lower than in control group ($p < 0.05$).*
Conclusion: *Dexmedetomidine and ropivacaine, when administered together, have a significant anesthetic effect during nerve block, which is safe and enhances their analgesic effect. However, the mechanism of improving analgesic effect of the combined plan, using a larger number of samples should be further investigated.*

Keywords: *Ropivacaine, Dexmedetomidine, Nerve block, Analgesic effect, Safety*

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INTRODUCTION

In recent years, with the development of agricultural mechanization in China and its wide application, the number of patients with traumatic hand injuries such as broken fingers, broken arms, skin defects, etc. caused by the unregulated use of agricultural machinery has increased significantly. These patients not only have to suffer from the physical pain caused by

trauma but also from very serious postoperative pain, which seriously threatens patients' physical and psychological health [1]. A brachial plexus nerve block is one of the most important anesthetic methods in regional anesthesia, and is an indispensable anesthetic modality for upper limb and shoulder surgery in critically ill patients, with different anesthetic protocols, differences in blocking effects, and complications [2].

In clinical anesthesia, the use of ultrasound technology has a significant effect, which can effectively improve the puncture rate of nerve block, reduce risk of neurovascular injury, dosage of local anesthesia drugs [3]. Good postoperative analgesia is effective for patients with postoperative pain, increases patients' commitment to treatment, improves patient satisfaction, and contributes more to patients' postoperative recovery [4]. Ropivacaine has low toxicity to central system and heart, sensorimotor dissociation, peripheral vasoconstriction, and long-time peripheral nerve block. Thus, it is the best anesthetic for peripheral nerve block in current clinical studies [5].

Studies have found that ropivacaine has limited analgesic duration when used independently, and increasing the anesthetic dose to achieve durable and highly effective block increases risk of toxicity and subsequent adverse effects [6]. Recent research has revealed that regional block combined with adjuvants (such as dexmedetomidine, opioids, dexamethasone, etc.) effectively shortens onset of anesthesia, prolongs duration of anesthesia, and significantly enhances blocking effect [7]. The purpose of this study was to investigate analgesic efficacy and safety of dexmedetomidine in ultrasound-guided brachial plexus block in the intercostal space, relative to ropivacaine alone.

METHODS

Subjects

Patients admitted in The Affiliated Hospital of Beihua University, Jilin City, Jilin Province, China for proposed upper extremity surgery from January 2021 to January 2023 were selected for this study.

Inclusion criteria

Patients that met indications for brachial plexus block, expected surgical time of less than 4 h, classified as I to II by American Society of Anesthesiologists (ASA), completed clinical information, and voluntarily signed an informed consent form were included in this study.

Exclusion criteria

Patients with hand injuries or other serious injuries, or patients with serious cardiovascular or coagulation disorders, mental illnesses or long-term use of opioids and other psychotropic drugs, allergy to either dexmedetomidine or ropivacaine and patients with incomplete clinical data were excluded from this study.

A total of 90 patients were screened as study sample, and all subjects were randomly divided into a control group and a study group. All procedures performed in studies involving human participants were approved by Ethics Committee of The Affiliated Hospital of Beihua University (approval no. BH-2020-13) and complied with the guidelines of the 1964 Helsinki Declaration and its later amendments for ethical research involving human subjects [8]. The general information on the two groups is presented in Table 1.

Table 1: Comparison of general information of 90 subjects (n = 45)

Group	Mean age	Male to female ratio	BMI	ASA (I/II)
Control Group	38.80± 7.72	23/22	22.14± 2.71	32/13
Study Group	39.21± 8.21	29/16	23.21± 3.24	35/10
t/χ^2 value	0.249	1.640	1.691	0.526
P-value	0.804	0.200	0.094	0.468

Note: *P* > 0.05 indicates no significant difference

Surgical procedure

All patients were in a fasted state and frequently drank water before surgery. No analgesic nor sedative was administered before admission to the operating room. After admission, peripheral venous access to upper extremities of non-operative side was opened, and patients were routinely given oxygen via a mask and underwent routine tests, including ECG, pulse oxygen saturation SPO_2, non-invasive blood pressure, respiratory rate, and temperature. Patients were placed on their or her backs, with the limb abducting at 90 degrees and the head slightly inclined to the other side. An anesthesiologist attached the ultrasound device and probe to middle of the medial, lateral, and posterior bundles of the brachial plexus lateral to the axillary artery in the intercostal space, and other end of the catheter was connected to the electronic pain pump. Control group used 20 mL of 0.25 % ropivacaine for intraoperative nerve block and 300 mL of 0.2 % ropivacaine for continuous postoperative pain. Research protocol involves 0.25 % ropivacaine plus 1

μg/Kg dexmedetomidine mixture for intraoperative nerve block, and 0.2 % ropivacaine plus 2 μg/Kg of dexmedetomidine for continuous postoperative pain.

Evaluation of parameters/indices

Nerve block assessment

Sensory block assessment was carried out on patient's ipsilateral musculocutaneous nerve (radial side of the forearm), median nerve (palmar side of the thumb), the ulnar nerve (palmar side of the little finger), radial nerve (radial side of the dorsal hand), and other innervated areas. The areas were cold-stimulated with alcohol swab or ice every 5 min within 30 min after end of block. Block effect was recorded using a 3-point scale, 0- no obstruction, 1- tactile sensation but no cold sensation, 2- without tactile sensation; (2) Motor block assessment: Similarly, muscle strength tests were performed on the musculocutaneous nerve (bent elbow), median nerve (thumb to palm), the ulnar nerve (thumb adduction), radial nerve (thumb abduction) and other innervated areas of the patient. Block effect was recorded using a 3-point scale, with 0 points representing no block, 1 point of reduced muscle strength, and 2 points of muscle paralysis. The maximum block effect score was 18, and a total score of > 16 achieved block effect.

Sensory and motor block efficiency

Block success rate (B) was assessed within 30 min of drug injection (Eq 1). It is block effect reached comparable to the standard after 30 min of drug injection, and the operation was completed without additional local anesthesia, sedative and analgesic drugs, or general anesthesia.

$$B = (nB/N)100 \quad \ldots\ldots\ldots\ldots \quad (1)$$

Where nB is number of successful block cases and N is total number of block cases.

Secondary indices

Onset time (i.e., the time required for the total block score to be greater than or equal to 16), and sensory and motor block duration were assessed. Duration of sensory block was the time from end of drug injection to time when postoperative area felt pain or sensation similar to that of healthy side. Duration of motor block is the time from the end of drug injection until the hands, elbows, and wrists can move autonomously and normally.

Pain level

The visual analog scoring method (VAS score) was used to assess patients' VAS scores at 12, 24, and 48 h after surgery, with scores from 0 to 10, and higher scores indicating stronger pain.

Remedial analgesia

Number and dose of analgesics and tramadol used by patients in two groups were compared.

Adverse reactions

The incidence of nausea, vomiting, dizziness, drowsiness, and pruritus were counted between the two groups.

Statistical analysis

Data was processed and analyzed with Statistical Packages for Social Sciences (SPSS, version 23.0). Counting data was expressed using number of cases and percentages. Comparison was done using chi-square test. Measurement data was verified to conform to a normal distribution, expressed using sample mean, and analyzed using independent sample t-test. $P < 0.05$ was considered statistically significant.

RESULTS

Nerve block efficiency

Among the 45 patients in the control group, 41 patients had successful sensory blocks, with a block success rate of 91.11 %, and 32 patients had successful motor blocks, with a block success rate of 71.11 %. In the study group, 42 patients had successful sensory blocks and motor blocks, with a block success rate of 93.33 %. Compared with control group, there was no significant difference in the success rate of sensory blocks in study group ($p > 0.05$). However, success rate of motor block in study group was significantly higher than control group, and the difference was statistically significant ($p < 0.05$).

Secondary assessment

Compared with control group, onset of sensory block and moor block were significantly shorter in study group ($p < 0.05$). Duration of sensory and motor block were both significantly higher in study group than control group ($p < 0.05$) (Table 2).

Pain levels at different times after surgery

The VAS scores of study group at 12, 24, and 48 h postoperatively were significantly lower than control group at same period ($p < 0.05$).

Remedial analgesia

Compared with control group, number of self-administered analgesia, number of patient cases used and dose used were significantly lower in study group ($p < 0.05$).

Adverse reactions

There were no serious complications such as vascular nerve injury, local anesthetic poisoning, Horner syndrome, pneumothorax, and postoperative sensorimotor abnormalities during treatment in both groups. Incidence of adverse reactions such as nausea and vomiting, skin pruritus, and hypotension were similar in study group ($p > 0.05$). Number of cases of vertigo in study group was significantly lower than control group, and total adverse reaction rate in study group was significantly lower than control group ($p < 0.05$).

DISCUSSION

A brachial plexus nerve block is one of the most important anesthetic modalities for traumatic hand surgery because it provides perfect anesthesia and has little effect on the systemic system, in addition to being a regional nerve block [9]. The traditional brachial plexus block approaches are mainly interosseous sulcus brachial plexus block, supraclavicular brachial plexus block, sub-clavicular brachial plexus block, and axillary brachial plexus block, each of which has its advantages and disadvantages. The combined effect of ultrasound and anesthesia has been confirmed in numerous studies[10]. However, due to different blocking schemes, even under ultrasound, there may be a high mutation rate and incomplete or failed blocking [11]. Intercostal locking block has the characteristics of simple operation and low variability and has been widely used in brachial plexus block, which has been proven to effectively reduce risk of complications [12].

Table 2: Comparison of secondary assessment indicators (n = 45)

Group	Onset of action (min)		Duration (min)	
	Sensory block	***Motor block***	***Sensory block***	***Motor block***
Control group	10.97±2.65	13.87±2.58	500.62±69.91	481.45±45.88
Study group	9.70±2.46	11.40±2.22	670.33±83.03	588.11±68.31
t	2.349	4.871	10.489	8.696
P-value	0.021	0.000	0.000	0.000

Table 3: Comparison of VAS scores (mean ± SD, n = 45)

Group	Postoperative 12 h	Postoperative 24 h	Postoperative 48 h
Control group	3.23±0.45	3.49±0.48	2.39±0.54
Study group	2.73±0.41	2.65±0.44	2.18±0.31
T	5.471	8.577	2.221
P-value	0.000	0.000	0.029

Table 4: Comparison of remedial analgesia between two groups (n = 45)

Group	Number of self-administered analgesia	Number of patients used	Dose used
Control group	3 (2-7)	15	0.3 (0.1-0.4)
Study group	5 (2- 6)	6	0.1 (0.1- 0.2)
Z/*t*	2.161	5.031	2.652
P-value	0.036	0.025	0.008

Table 5: Comparison of adverse reactions between the two groups (n = 45)

Group	Nausea and vomiting	Dizziness	Skin pruritus	Hypotension	Total adverse reaction rate
Control	5 (11.11)	6 (13.33)	4 (8.89)	1 (2.22)	35.56 %
Study	2 (4.44)	1 (2.22)	2 (4.44)	2 (4.44)	15.56 %
χ^2	1.394	3.873	0.714	0.345	4.731
P-value	0.238	0.049	0.398	0.557	0.030

Although the feasibility and advantages of ultrasound-guided inter-costoclavicular space block have been confirmed by numerous foreign studies, there is still a significant gap in clinical

application of adult ultrasound-guided inter-costoclavicular space brachial plexus block and use of related anesthetic drugs. Ropivacaine is currently one of the most commonly used local anesthetic drugs for peripheral nerve block. However, pharmacological studies have found that due to its low lipophilicity and slow metabolism in patients, it causes certain toxic damage to the heart and central nervous system. Therefore, selection of drug concentration is particularly important [13]. Dexmedetomidine is a highly selective α_2-adrenoceptor agonist with sedative effects and low toxicity. Therefore, ropivacaine is often used in combination with dexmedetomidine in clinical practice to improve intraoperative anesthesia. Analgesic effect of this combined regimen in epidural delivery analgesia, lumbar surgery, and some radical tumor surgeries has been confirmed [14,15]. This study used ropivacaine as control group and dexmedetomidine combined with ropivacaine as study group to investigate effects of two different anesthesia schemes on ultrasound-guided brachial plexus block in intercostal space.

Results of this study showed that success rate of motor block in study group was significantly higher than control group, while there was no significant difference in success rate of sensory block between the two groups. By comparing secondary evaluation indices of anesthesia between two groups, it was found that onset time of sensory block and motor block in study group was significantly shortened, and duration of sensory block and motor block was significantly prolonged. Results of this present study showed that combined anesthesia plan effectively improves anesthetic effect on patients, which is consistent with some previously reported results, and this is related to a decrease in peripheral nerve potential and prolongation of action time of ropivacaine caused by inhibition of overactivated cationic current [16]. Postoperative analgesia is an important content of rapid rehabilitation medicine. Postoperative pain not only affects quality of life of patients, it also has a great impact on postoperative recovery [17].

This study compared VAS scores at 12, 24, and 48 h after surgery and found that VAS scores of study group patients were significantly lower than those of the control group at same time interval. Comparison of remedial pain relief between two groups also found that a number of patient-controlled analgesia, dosage of tramadol users, and number of cases in study group were significantly lower than those of control group. Results confirmed that combined anesthesia regimen effectively improves analgesic effect. The reason may be related to factors such as dexmedetomidine activating descending inhibitory system and inhibiting nociceptive input [18]. Surgical trauma and postoperative pain affect secretion of hormones in patient's body and homeostasis of internal environment, leading to strong stress reactions and adverse timing [19]. Therefore, to determine safety of anesthesia protocol, incidence of perioperative complications and adverse reactions were compared between two groups. Results showed that there were no serious complications such as nerve injury, intoxication of local anesthetic, Horner's syndrome, pneumothorax, and postoperative sensorimotor abnormalities in both groups. The total incidence of adverse reactions such as vertigo, pruritus, and hypotension, was significantly reduced. Results suggest that a combination of dexmedetomidine with ropivacaine is effective in reducing incidence of postoperative adverse reactions, which may be related to factors such as better analgesic effect and reduced use of remedial anesthetics.

Limitations of this study

The small sample size used may not be adequate to generalize the conclusions of this study.

CONCLUSION

The combination of dexmedetomidine and ropivacaine has a significant anesthetic effect in ultrasound-guided brachial plexus block in intercostal space, improves postoperative analgesic effect, reduces the use of remedial analgesic drugs, and has high safety margin. The mechanism of improving analgesic effect of the combined plan, number of samples should be further investigated in the future to enhance the understanding of inflammatory mechanisms and investigate levels of stress hormones.

DECLARATIONS

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Ethical approval

This work was approved by the approved by Ethics Committee of The Affiliated Hospital of

Beihua University, China (approval no. BH-2020-13).

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflict of Interest

No conflict of interest associated with this work.

Contribution of Authors

We declare that this work was done by the authors named in this article and all liabilities pertaining to claims relating to the content of this article will be borne by the authors. Jiayu Lu and Wei He designed the study and carried them out. Jiayu Lu, Taihao Cui, Zhaoxiang Yu, Wei Zheng supervised the data collection, analyzed and interpreted the data, prepared the manuscript for publication and reviewed a draft of the manuscript. All authors read and approved the manuscript for publication.

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