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Original Article

Application of ultrasound-guided subcostal transversus abdominis plane block in gastric cancer patients undergoing open gastrectomy

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Abstract: Background: To observe intraoperative and postoperative analgesic effect of ultrasound-guided subcostal transversus abdominis plane (TAP) block in gastric cancer patients undergoing open gastrectomy. Material and Methods: Forty patients with gastric cancer underwent open gastrectomy were randomly assigned into groups R and S. All patients received ultrasound-guided subcostal bilateral TAP under general anesthesia, and then were injected with 40 ml of 0.375% ropivacaine (group R) or equivalent amount of normal saline (group S). The surgery was performed in 30 min following the blocking. Intraoperatively, BIS value was maintained between 45 and 65. Patient-controlled intravenous analgesia pump was properly connected after the operation. Intraoperative changes in systolic blood pressure (SBP), diastolic blood pressure (DBP) and heart rate (HR) were observed and the dosage of sufentanil and alternative drugs was closely monitored during the surgery. Visual analogue scale (VAS) scores and related surgical complications were recorded at 2, 4, 6, 12, 24 and 48 h following the operation. Results: The SBP, DBP and HR changes in the group R were significantly decreased compared with those in the group S (all $P<0.01$). In both groups, desirable analgesic effect was obtained. The VAS scores at postoperative 2, 4, 6 and 12 h after the surgery in the group R were significantly lower than those in the group S (all $P<0.05$). No TAP puncture-induced adverse reaction was observed in both groups. Conclusion: Ultrasound-guided subcostal transversus abdominis plane block has the advantages of accurate localization and high success rate. Clinical application of this technique in open gastrectomy can significantly decrease intraoperative and postoperative dosage of analgesics and exert desirable analgesic effect.

Keywords: Transversus abdominis plane, nerve block, gastric cancer, subcostal

Introduction

As an emerging technique, transversus abdominis plane (TAP) block not only decreases intraoperative and postoperative dosage of opiod drugs, but also exert high efficacy upon maintaining intraoperative hemodynamics stable and postoperative analgesia. Open gastrectomy may cause severe pain in the incision of abdominal wall. Patients' responses towards surgical pain are likely to lead to unstable hemodynamics and negatively affect postoperative recovery and patients' degree of satisfaction. TAP block can effectively block the regulation of sensory nerve at the anterior abdominal wall and achieve satisfactory analgesic effect in clinical settings. In conventional blocking methods, blind insertion was performed via the triangle of Petit, which was merely applicable to lower abdominal operation and probably induced puncture failure and postoperative complications.

TAP block could block the conduction of pain sensation of anterior abdominal wall [1], exert mild effect upon respiratory, circulating and vegetative nervous systems with high safety and effect. Due to the reason of anatomy, the identified indications during puncture and drug administration were lacking, which was likely to yield low effect resulting from inaccurate site of administration and cause organ damages and relevant complications of the needle were inserted accidentally into the blood vessels [2]. Ultrasound technique has gained breakthrough progress in nerve block. Sola et al. utilized ultra-

sound-guided TAP block for herniorrhaphy in pediatric patients and demonstrated that ultrasound-guided TAP block with 0.2 ml/kg of 20% levobupivacaine offers efficacious analgesia in 95% of enrolled children undergoing herniorrhaphy [3]. In 2013, Sahin et al. reported that ultrasound-guided TAP block with 0.5 ml/kg of 0.25% levobupivacaine could prolong postoperative analgesia and reduce analgesic use with no clinical side-effects after unilateral hernia repair in children [4].

Consequently, this study aims to adopt ultrasound-guided TAP block and perform bilateral multi-point block on the basis of subcostal TAP block by Hebard et al. [5] and preliminarily assess the analgesic effect during open gastrectomy.

Materials and methods

General data

A total of 40 patients undergwent open gastrectomy in our hospital between March 1 and July 1, 2014 were enrolled in this clinical trial, patients' ages were between 45 to 72 years and the weighing were 55-75 kg. Those with allergy to topical anesthetics, severe heart, brain, lung diseases, mental illness, abnormal coagulation, skin defects or infection, etc. were excluded from this study. The patients were voluntary to accept TAP block analgesia and signed the informed consents. All participants were randomly divided into ropivacaine (group R) and NS groups (group S), 20 patients for each group. Patients in the group R were injected with 20 ml of 0.375% ropivacaine via bilateral TAP, while those in the group S were administered with equivalent amount of NS via bilateral TAP.

Methods

General anesthesia via intravenous administration combined with inhalation: After entering the operation room, patients received routine examinations including electrocardiogram and measurement of arterial blood pressure and pulse oxygen saturation. Anesthesia induction was performed by combined use of 0.02 mg/kg midazolam (Jiangsu Nhwa Pharmaceutical Corporation Ltd., batch No. 20130514), 0.15 mg/kg cisatracurium besylate (Jiangsu Hengrui Medicine Co., Ltd., batch No. 14072422), 0.3 μg/kg sufentanil (Humanwell Healthcare (Group) Co., batch No. 1140511) and 2.0-2.5 mg/kg propofol (Frensenius Kabi Austria Gmb, batch No. 16HA0081). Following tracheal intubation, mechanical ventilation was conducted with a tidal volume of 6-8 ml/kg and $PetCO_2$ of 35-45 mmHg. The status of anesthesia was maintained by inhalation of sevoflurane and the BIS value was set between 45 and 60. Approximately 5-10 μg sufentanil was supplemented if heart rate and blood pressure exceeded normal value by 20%. If it failed to take effect, a proper quantity of nicardipine (Liaoning Hisen Pharma, batch No. 1403281) and esmolol (Qilu Pharmaceutical, batch No. 2010022EF) were administered.

Ultrasonic procedures: All patients underwent ultrasound-guided bilateral subcostal TAP block under general anesthesia using portable ultrasound instrument with 5-10 MHZ probe (TITAN: Sonosite Inc TM, Bothell, WA, USA). Ultrasound puncture was adopted by in-plane technique. The scope of block was modified enlarged on the technique of subcostal nerve block proposed by Hebbard and his colleagues [5]. After skin sterilization, sterile ultrasound probe was placed at unilateral subcostal position (close to costal margin) and proceeded outward starting from abdominal white line. Following puncture needle removal, ultrasound probe was moved outward to anterior axillary line and explicitly revealed external oblique muscle of abdomen, internal abdominal oblique muscle and internal abdominal oblique muscle and the another needle insertion was delivered.

Bilateral subcostal TAP block: Twice needle insertion along subcostal positions was adopted for subcostal nerve block. The migration position of rectus abdominis and internal abdominal oblique muscle was located. 20 G puncture needle was inserted between rectus abdominis and internal abdominal oblique muscle along the vertical axial plane and then gradually injected 20 ml of drugs laterally by using water isolation technique. By utilizing the same technique, 20 mL of medication was evenly injected into subcostal TAP to construct a continuous plane after twice injection, covering from the medial upper pole of rectus abdominis to the midaxillary line of TAP. Patients in both groups were randomly injected with an equivalent amount of 0.375% ropivacaine

Table 1. Demographic data in patients between two groups

	Age	Gender (male/female)	BMI	Operative time
Group S	57.64±7.34	15/5	46.14±9.26	233±34.34
Group R	61.26±8.19	16/4	48.52±10.39	219.34±40.39
P	0.76	0.79	0.65	0.29

Table 2. Changes in SBP (mmHg), DBP (mmHg) and HR (beats/min) before and after skin incision between two groups

Group	No. of cases	ΔSBPa	ΔDBPb	ΔHRc
Group S	20	33.567±11.794*	20.583±9.748*	20.183±6.691*
Group R	20	-0.950±5.674	-0.167±5.557	2.383±9.10

Note: *denotes statistical significance.

(Astrazeneca 2012006) or NS. The surgery was initiated 30 min after the block. No analgesic drugs were supplemented during skin incision. Intraoperatively, sufentanil and alternative vasoactive agonists were administered based upon the changes in blood pressure and heart rate.

Observation indexes: The SBP, DBP and HR were detected at 2, 4 and 6 min before and after skin incision. The mean value was calculated to represent blood pressure and heart rate before and after skin incision. Dose of sufentanil and alternative vasoactive agonists supplemented intraoperatively. VAS scores at resting state at postoperative 2, 4, 6, 12, 24 and 48 h. Whether nausea, vomiting and other adverse reactions and complications occurred were recorded.

Statistical analysis

Measurement data were statistically analyzed by student's t-test or Fisher's test. Normal distribution of test data was assessed by Kolmogorov-Smirnov test. Normally distributed measurement data were expressed as means ± standard deviation. Non-normally distributed measurement data were denoted as the median (quartile). SPSS 19.0 statistical software package was utilized for data analysis. P<0.05 was considered as statistical significance.

Results

In this study, 40 patients successfully underwent puncture and subsequent operation. No statistical significance was observed between two groups regarding to age, gender and weight (**Table 1**). Measurement data were expressed as mean ± standard deviation.

Intraoperative changes in hemodynamics before and after skin incision.

The changes in ΔSBP, ΔDBP and ΔHR in the group R were significantly less compared with those in the group S (all P<0.01), as illustrated in **Table 2**.

The dose of sufentanil dosage and alternative vasoactive agonists supplemented intraoperatively in the group R were significantly less than that in the group S (all P<0.01), as indicated in **Table 3**.

The VAS score at postoperative 4, 6, 12 and 24 h in the group R weres lower compared with those in the group S by 2 points. No significant difference was observed between two groups regarding VAS score (**Table 4**). No other postoperative complications were observed in both groups.

Discussion

The skin, muscle and parietal peritoneum of anterior abdominal wall is innervated by segments T6-L1. The anterior nerve trunk derives from intervertebral foramen, stretches along the cross section of vertebra and subsequently releases musculocutaneous branches of lateral abdominal wall and penetrates nervous fascial plane between internal abdominal oblique muscle and internal abdominal oblique muscle. Initially, sensory nerve branches release lateral cutaneous branch at midaxillary line and penetrate through the branches and functions to innervate the skin [6]. If the topical anesthetics were administered into the transversus abdominis plane, the nerve branches innervating the skin may be blocked, thereby inhibiting the sensation of abdominal wall. Rafi [7] proposed TAP block in 2001 for the first time. McDonnell et al. [8] conducted autopsy and demonstrated that the nerves innervating anterior abdominal wall mainly entered the anterior abdominal wall via the fascial plane between internal abdominal oblique muscle and internal abdominal oblique muscle. Ultrasound-guided nerve block had been widely applied in lower abdominal surgery

Table 3. The dose of sufentanil (μg), nicardipine (mg) and esmolol (mg) supplemented intraoperatively between two groups

Group	No.of cases	Sufentanild	Nicardipinee	Esmololf
Group S	20	10.900±0.607*	5.400±0.380*	19.700±2.628*
Group R	20	2.300±0.105	0.955±0.223	5.250±2.160

Note: *denotes statistical significance.

globally [9, 10] and good analgesic effect was obtained. Tran et al. [11] conducted TAP block on fresh corpse and injected the aniline dye into the transversus abdominis plane above iliac crest. The results revealed that only nerve roots of segments T10-L1 were stained, hinting that this technique was probably merely applicable to lower abdominal operation. However, Hebbard et al. [5] proposed that subcostal transversus abdominis plane block could be applied to upper abdominal operation. Barrington et al. [12] compared single and multiple injections of block drugs and demonstrated that multi-injection can prevent more nerve segments and increase the area of drug diffusion. Anja Ulrike Mitchel [13] conducted experiment in awakening volunteers and found that ultrasound-guided subcostal TAP block covered a scope of T4-L4 segments with maximal pain sensation after 30 min. At present, subcostal TAP block has been applied in postoperative analgesia after laparoscope gallbladder surgery [14], whereas few studies have been conducted to evaluate its application value during and following gastric cancer surgery. Therefore, this study was designed to adopt bilateral multiple subcostal nerve block by twice needle insertion. The outer margin of sheath of rectus was chosen as the first injection site and the junction of anterior axillary line and costal margin as the second injection site. Multi-injection was administered during each needle insertion to form continuous plane surface and submerge the anterior branches of 7-12 thoracic nerves completely into the local anesthetics. In this study, the changes in SBP, DBP and HR of patients in group R were significantly less compared with their counterparts in group S before and after skin incision, and intraoperative dose of sufentanil, nicardipine and esmolol in group R was significantly less than that in group S, indicating that bilateral subcostal TAP block yielded high clinical efficacy. Albeit the scope of block was not measured before surgery, relevant evidence demonstrated that the sense of anaesthesia was observed at 30 min after drug injection [15], which offered reliable evidence to support the results in our experiment. These outcomes revealed that TAP block had yielded effective analgesic effect during skin incision. Moreover, although the projection system of cerebral cortex, limbic system or hypothalamus towards cerebral cortex was suppressed by medication under general anesthesia, harmful surgical stimulation still existed. The sympathetic nerve-adrenal medulla axis still responded under stimulation and could not block the reflection of central nerve system. In this study, TAP block under general anesthesia could effectively inhibit the excitation of area neuron, compensate for the insufficiency of general anesthesia and prevent the sudden elevation of blood catecholamine during skin incision, which plays an extremely role in maintaining the stable hemodynamics during skin incision and throughout the surgery. In this study, the blood pressure and HR through the surgery were extremely stable and no alternative vasoactive agonists were supplemented, suggesting that the blocking efficacy is proven to be high.

Abdominal operation pain originated from abdominal incision and splanchnodynia. Diffuse dull pain was induced by intraoperative traction or postoperative cough. The degree of incisional pain played a vital role in intraoperative stress and postoperative recovery. Venous and epidural analgesia were commonly adopted. Albeit the venous analgesia effect of opiod drugs has been explicitly proven, it is likely to cause respiratory depression, nausea, vomiting, urine retention, postoperative intestinal obstruction and other side effect. Epidural analgesia has a high degree of selectivity for patients. It not only blocks sensation, but also blocks movement. In addition, the incidence of serious nerve system symptoms is high and the application is relatively limited. Recently, multimodal analgesia has been gradually applied to enhance analgesic effect and decrease side effects. Multimodal analgesia, equally known as balance analgesia, refers to analgesia medication or different analgesia methods of varying phases and targets, aiming to improve analgesia effect and decrease adverse reaction,

Table 4. VAS score at different postoperative time points between two groups

Group	2 h	4 h	6 h	12 h	24 h	48 h
Group S	2.13±0.11	3.09±0.14	4.00±0.36	5.78±0.19	3.59±0.25	1.31±0.0
Group R	0.55±0.17	0.57±0.17	0.91±0.25	2.61±0.22	1.49±0.15	0.96±0.63

compensate for the limitations of single drug as possible, alleviate pain, reduce the influence of medication upon nerve, immunity and endocrine secretion system, maintain the stability of inner environment and lower the incidence of complications.

In recent studies, ultrasound-guided TAP block has been applied in postoperative analgesia after abdominal surgery [16-19] including rectal cancer and uterus, *etc*. High clinical efficacy has been also achieved. This study demonstrated that ultrasound-guided bilateral subcostal TAP block using 40 ml of 0.375% ropivacaine could yield effective analgesic effect during and following gastric surgery. The difference of VAS scores achieved two points within postoperative 2-24 h between two groups, suggesting that 0.375% ropivacaine could induce 24 h effective analgesia. McDonnell et al. [20] demonstrated that the most significant hypoesthesia of anterior abdominal wall was observed at postoperative 90 min, steadily decreased at 4 h and the sensation restored at 24 h, collectively proving the reliability of this study. Wu et al. [21] the postoperative analgesic effect of general anesthesia in combination with subcostal nerve block was higher compared with that of simple general anesthesia, which is consistent with the findings of our study. The difference of VAS scores within postoperative 2 h did not significantly differ between two groups, probably because the 40 mg parecoxib sodium delivered 30 min before the end of surgery and alternative anesthetics given intraoperatively were not fully metabolized.

To sum up, compared with conventional TAP technique, ultrasound-guided TAP could yield higher analgesic effectiveness, free from use of opioid, have the potential of prolong the analgesic duration and associated with a lower incidence of hypotension and motor blockade by clearly directly revealing the anatomical morphology of the target organs to the physicians, letting them insert the needle under direct vision, accurately reach the injection site and clearly show the continuous plane after drug injection into TAP, ensuring the efficacy of medication and the continuity of level of anesthesia.

In this study, all patients in two groups successfully received puncture. The analgesic effect in group R was higher, which significantly enhanced success rate of puncture and reduced the risk of surgical complications of blind insertion. At present, most studies focus upon the application of TAP block in lower abdominal surgery mainly by Petie triangle puncture. This study was designed to extend the application of TAP block in upper abdominal surgery. In previous studies, subcostal TAP block has been utilized in postoperative analgesia after upper abdominal operation. However, in this study, ultrasound-guided bilateral subcostal TAP block was employed to maintain intraoperative hemodynamic stability, decrease intraoperative dosage of sufentanil and alternative drugs and yield high analgesic effect, which is consistent with the findings of recent studies [22-24].

Study limitations: First, only the block efficacy of 0.375% ropivacaine was evaluated. Next, the drug efficacy of different volume, concentration and compatibility should be subsequently analyzed. Second, only single drug administration was performed under ultrasound. The long-term analgesic effect after transversus abdominis plane intubation remains to be elucidated. Third, the surgery was initiated 30 min after TAP block to ensure the normal operation. The time and extent of onset of the medication should be investigated in our next studies.

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Disclosure of conflict of interest

None.

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