Randomized Controlled Trial

Ultrasound-Guided Transversus Abdominis Plane Block in Treating Abdominal Skin Tension Pain After Kyphosis Surgery: A Pilot Study in Enhanced Recovery After Surgery Setting

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Background: The postsurgical management of patients with ankylosing spondylitis is often only focused on the incision pain, and the pain caused by abdominal skin traction is paid little attention.

Objectives: To explore the effectiveness of ultrasound-guided transversus abdominis plane block (TAPB) in treating abdominal skin tension pain after kyphosis surgery.

Study Design: Randomized controlled trial.

Setting: This prospective study consecutively enrolled patients scheduled to undergo kyphosis correction surgery at the Department of Orthopedics of Xijing Hospital from March 2021 to December 2021.

Methods: The patients were randomized 1:1 to the TAPB and control groups. The Visual Analog Scale (VAS) for abdominal pain, Bruggrmann Comfort Scale (BCS), abdominal skin tension blisters, bed rest duration, length of hospitalization, and the use of patient-controlled analgesia pumps (PCAPs) were compared. The primary endpoint was pain alleviation at 24 hours after surgery.

Results: Thirty-one patients were enrolled, without differences between the 2 groups regarding age, body mass index, preoperative kyphosis severity, operation duration, and blood loss. The TAPB group (n = 16) had lower abdominal VAS scores than the control group (n = 15) at 2, 4, 6, 8, and 12 hours after surgery ($P < 0.05$). The TAPB group had higher BCS scores than the control group at 4, 6, 8, and 12 hours after surgery ($P < 0.05$). The TAPB group used PCAPs less frequently than the control group after surgery ($P < 0.001$). The incidence of tension blisters in the TAPB group was numerically lower than that of the control group, but the difference was not statistically significant (18.8% vs 33.3%, $P > 0.05$).

Limitations: The sample size of this study is small and a single-center study, there might be data bias.

Conclusions: In the first 24 hours after severe kyphosis surgery, TAPB can reduce the pain from abdominal skin tension and increase the comfort scores, but its effects on tension blisters remain to be further studied.

Key words: Kyphosis, abdominal skin traction, abdominal skin pain, tension blisters, anesthesia, transversus abdominis plane block, visual analog scale, Bruggrmann comfort scale

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Ankylosing spondylitis (AS) is a chronic inflammatory rheumatic disease primarily involving the sacroiliac joints and spine (1-3). The peak age of onset of AS is 20-30 years, with 80% developing first symptoms before age 30 years (1,2). The reported incidence is between 0.5 and 14 per 100,000 persons/year (1,2). The men to women ratio is 2-3:1 (1,2). Genetic factors, particularly the human leukocyte antigen-B27 gene, play a major role in the pathogenesis of AS (1,2). Significant comorbidities of AS include osteoporosis, spinal fracture, hypertension, kidney stones, sleep apnea, cardiovascular disease, apical pulmonary fibrosis, immunoglobulin A nephropathy, and rarely secondary renal amyloidosis (1,2,4).

Kyphosis is a common spinal deformity that develops from AS (5-7). Severe kyphosis affects the life of patients and requires surgical correction in the late stage (3,8,9). Most patients who had undergone surgical correction had satisfactory outcomes (10). Severe kyphosis causes lasting trunk flexion and deformity and abdominal skin folds, and some patients might have abdominal skin tension after surgery, which causes pain and even painful tension blisters (Figs. 1A,1B) (11). The postsurgical management of patients with AS is often only focused on the incision pain, and the pain caused by abdominal skin traction is paid little attention.

Ultrasound (US)-guided transversus abdominis plane block (TAPB) is being more widely applied in clinical practice in recent years as anesthesiologists can use US guidance to inject long-acting local anesthetics into the TAP after surgery to manage pain after abdominal surgeries (12-15). Nevertheless, the application of TAPB to manage abdominal skin tension pain after kyphosis surgery has never been reported.

Therefore, this study aimed to examine the effectiveness of US-guided TAPB in treating abdominal skin tension pain after kyphosis surgery. The results could provide an additional method to manage skin tension pain in such patients.

Methods

Study Design and Patients

This prospective study consecutively enrolled patients scheduled to undergo kyphosis correction surgery at the Department of Orthopedics of Xijing Hospital from March 2021 to December 2021. The inclusion criteria were 1) 30-60 years of age, 2) kyphosis and total kyphosis ≥ 60°, 3) requiring surgical treatment, and 4) underwent a single-level pedicle subtraction osteotomy (PSO). The exclusion criteria were 1) history of dependence on alcohol, opioids, and other analgesic drugs, 2) coagulation disorders, peripheral neuropathy, or abnormal innervation skin sensation, or 3) history of abdominal surgery or trauma. The study was approved by the Medical Ethics Committee of Xijing Hospital Hospital (KY20212166-C-1). This study has been registered with the Clinical Trial Management Public Platform (Registration Number: ChiCTR2100044709. Registration date: February 28, 2021; Register URL: www.medresman.org.cn/login.aspx. All patients signed the written informed consent for this study.

Randomization and Blinding

Using the random number table method, the patients were randomly grouped 1:1 into the TAPB and control groups. The randomization code was prepared in sequential sealed envelopes that were opened right after the surgery. The patients and data assessors were blind to the grouping.

Intervention Process

All surgeries were performed by the same surgeon with 10 years of clinical experience. All patients were not given drugs before surgery and received general anesthesia (propofol [1.5~2.5 mg/kg], midazolam [0.05~0.2 mg/kg], rocuronium [0.6~1.0 mg/kg], and sulfentanil [2~8 ug/kg] for induction intravenously. Intravenous injection of remifentanil 0.25~2 ug/kg, and inhalation of sevoflurane 2%~3% to maintain anesthesia). All patients underwent a single-level PSO.

After surgery, the TAPB group patients were given bilateral TAPB according to the method suggested by Hebbard et al (16). In this method, the patients were placed in the horizontal position, the puncture site was disinfected and draped, and the surgeon stood by the right side of the patients with a needle in the right hand and an ultrasonic probe (L15-16, GE, Healthcare, Waukesha, WI, United States) in the left hand. The ultrasonic probe was moved along the costal margin from the xiphoid process to the midaxillary line. Three stripe-like hypoechoic structures, namely the external oblique, internal oblique, transversus abdominis, and their surface fascia layer, were observed successively in the rectus abdominis and its lateral sides. For the TAPB group, 20 mL of 0.375% ropivacaine was injected under ultrasonic guidance after the needle tip reached the designated position and was close to the internal oblique muscle

Fig. 1. *Comparison of abdominal skin before and after surgery in one patient with kyphosis from AS. (A) Flexion trunk and abdominal skin folds in a patient with kyphosis from AS. (B) Epigastric skin folds in a patient in the lying position. (C) Abdominal pulling, tension, and gloss in a patient after the correction surgery. AS: ankylosing spondylitis.*

and transverse abdominal muscle, and no blood or air was aspirated back (16). For the control group, conventional perioperative treatment and nursing were given. Both groups were given intravenous patient-controlled analgesia pumps (PCAPs), sufentanil (1 μg/mL), tropisetron (0.1 mg/mL), and infiltration anesthesia to the surgical incision surface (with 20 mL of 0.375% ropivacaine subcutaneously injected around the incision) for 48 hours after surgery.

Assessment of Visual Analog Scale and Bruggrmann Comfort Scale

The data assessors visited the patients at 2, 4, 6, 12, and 24 hours after surgery to assess abdominal skin tension pain. At each time point, the Visual Analog Scale (VAS) for pain (17) and the Bruggrmann Comfort Scale (BCS) scores (18) were assessed. Abdominal VAS scores were used to evaluate the degree of abdominal pain, with 0 points for no pain, 1-3 points for mild and tolerable pain, 4-6 points for tolerable pain affecting sleep, and 7-10 points for intolerable pain affecting appetite and sleep. BCS scores were also recorded, with 0 points for no pain when resting and severe pain when taking deep breaths or coughing, 2 points for no pain when lying and resting and mild pain when taking deep breaths or coughing, 3 points for no pain when taking deep breaths, and 4 points for no pain when coughing.

Endpoints and Indicators

The primary endpoint of the study was pain alleviation within 24 hours after surgery. The secondary endpoint was the complications after surgery. Nausea, vomiting, respiratory depression, and other complications in the 2 groups were recorded, as well as TAPB-related complications (puncture site infection, local hematoma, local anesthetic poisoning, organ injury, and nerve injury) and abdominal skin tension blisters.

Data Collection and Follow-up

The patients' basic information (age, gender, and weight) was collected from the hospital's medical report system. The use of PCAPs (number of uses) was recorded directly from the pumps. The bed rest duration, first exhaust time after removing the drainage tube, and the average length of hospitalization after surgery were recorded. The patients were followed for one month after the operation to confirm skin infection at the puncture site.

Statistical Analysis

SPSS 19.0 (IBM Corporation, Armonk, NY) was used to analyze the data based on the full analysis set. Continuous data conforming to the normal distribution (according to the Kolmogorov-Smirnov test) are expressed as means ± standard deviations and were analyzed using Student's t test; otherwise, the data are presented as medians (Q25, Q75) and were analyzed using the Mann-Whitney U test. Categorical data are presented as count (percentage) and were analyzed using Fisher's exact test. Two-sided P values < 0.05 were deemed statistically significant.

Results

Characteristics of the Patients

Thirty-one patients were enrolled in this trial and randomized to the TAPB (n = 16) and control (n = 15) groups. All patients are men. In the TAPB group, the patients were all men of 34.9 ± 8.1 years of age, and with a body mass index (BMI) of 24.3 ± 2.3 kg/m^2, preoperative kyphosis of 80.7 ± 13.4°, operation duration of 310.3 ± 30.1 minutes, and blood loss of 1,668 ± 261 mL (Table 1). Fifteen patients of the control group, all of whom were men, 38.5 ± 6.3 years old, and with a BMI of 23.1 ± 2.0, preoperative kyphosis of 84.5 ± 17.2°, operation duration of 326.7 ± 26.9 minutes, and blood loss of 1,489 ± 310 mL (Table 1). There were no differences in age, preoperative kyphosis severity, operation duration, blood loss, and BMI between the 2 groups (all $P > 0.05$) (Table 1). The bed rest duration in the TAPB group was 1.2 ± 0.3 days after removing the drainage tubes, and that of the control group was 2.1 ± 0.6 days ($P < 0.05$). The difference in the length of hospitalization after surgery between the 2 groups was not significant ($P > 0.05$) (Table 1).

Comparison of Pain Between the Two Groups

The TAPB group had fewer intravenous PCAP uses than the control group after surgery ($P < 0.05$) (Table 1). The TAPB group had lower abdominal VAS scores than the control group at 2, 4, 6, 8, and 12 hours after surgery ($P < 0.05$), but not at 24 hours ($P > 0.05$). The TAPB group had higher BCS scores than the control group at 4, 6, 8, and 12 hours after surgery ($P < 0.05$), but not at 2 and 24 hours ($P > 0.05$) (Fig. 2).

Complications and Abdominal Skin Blisters Between the Two Groups

All patients had no nerve injury, infection, and other surgery-related complications. In the TAPB group, 3 patients had nausea and vomiting, compared with 2 in the control group ($P > 0.05$). No patients in the TAPB group had abdominal puncture complications. The incidence of tension blisters in the TAPB group was numerically lower than that of the control group, but the difference was not statistically significant (18.8% vs 33.3%, $P > 0.05$) (Table 2).

Discussion

This study aimed to examine the effectiveness of US-guided TAPB in treating abdominal skin tension pain after kyphosis surgery. The results suggest that in the first 24 hours after surgery, TAPB can reduce the pain from abdominal skin tension of severe kyphosis operation. Nevertheless, its effects on tension blisters remain to be further studied in larger studies.

AS is a common spinal joint inflammatory disease that mostly occurs in young adults. At the late stage, it may develop into kyphosis that affects the life of patients. Kyphosis can be corrected by surgical treatment, but due to the trunk's long-term flexion, abdominal, and gastrointestinal complications, such as intestinal tympanites and intestinal obstruction, are more likely to occur after compulsory surgical correction of the trunk (19-21). Little attention has been paid to pain caused by abdominal skin tension. As shown in the patient depicted in Fig. 1, the kyphosis angle was severe, leading to abdominal skin folds. Abdominal skin

pulling, tension, and gloss were all observed after correction surgery (Fig. 1C). As in that representative case, all patients in the control group had red and glossy abdominal skin after surgery. In addition, 14 of the 15 (93.3%) patients reported pain, and 10 complained of abdominal skin discomfort that interfered with standing up. This difficulty in mobilization might affect the postoperative outcomes. Indeed, the lasting flexion position makes the epigastric skin always folded, up to 10 years in many patients, leading to mild adherence to epigastric skin folds. Because the skin at the folds is difficult to clean and the skin hygiene is poor, some patients have developed ulcers. After kyphosis correction, the abdominal skin is pulled instantaneously, causing tension pain. Besides, all patients in this study had severe kyphosis (degree > 60°), leading to severe skin folds. Skin microvascular dysfunction, poor blood flow, and reduced skin toughness are observed in patients with AS (22), causing severe pain from skin tension. In addition, the skin is under high tension for a long time, causing tension blisters to occur (23). One of the causes might be subcutaneous tissue edema and epidermis-dermis separation due to great skin tension (24). On the other hand, because of severe abdominal soft tissue injury and vascular intima injury, blood and lymphatic return obstruction, increased capillary permeability in the tissue, increased tissue fluid exudation, and endogenous water produced by liquefaction and necrosis accumulate in the epidermis and the weak point between the dermis (24). The pain at the operating site is the focus in postoperative analgesia for patients with kyphosis, but the pain caused by abdominal skin tension is usually ignored. Both abdominal pain and tension blisters will cause physical and psychological pain in patients with AS who have undergone surgery and bring challenges to treatment and nursing.

The nerves that innervate the anterior abdominal wall include the inferior pectoral nerves (T7-12) and the superior haunch, which branch off between the transversus abdominis and the internal oblique and then to the lateral abdominal wall. Such a muscle plane is known as the TAP. Injection of long-acting local anesthetics into

Table 1. *Baseline information between 2 groups.*

Variable	TAPB (n = 16)	Control (n = 15)	*P* value
Age (y)	34.9 ± 8.1	38.5 ± 6.3	0.146
BMI (kg/m^2)	24.3 ± 2.3	23.1 ± 2.0	0.106
Kyphosis (°)	80.7 ± 13.4	84.5 ± 17.2	0.461
Operation Duration (min)	310.3 ± 30.1	326.7 ± 26.9	0.088
Blood Loss (mL)	1,668 ± 261	1,489 ± 310	0.068
Number of PCAP Presses (uses)	5.7 ± 2.2	16.6 ± 2.3	<0.001
Bed Rest Duration (d)	1.2 ± 0.3	2.1 ± 0.6	<0.001
Average Length of Hospitalization After Surgery (d)	6.5 ± 1.2	7.1 ± 1.0	0.123

Note: All data were expressed as mean ± standard deviation. TAPB: transversus abdominis plane block; y: year(s); BMI: body mass index; PCAP: patient-controlled analgesia pump; d: day(s).

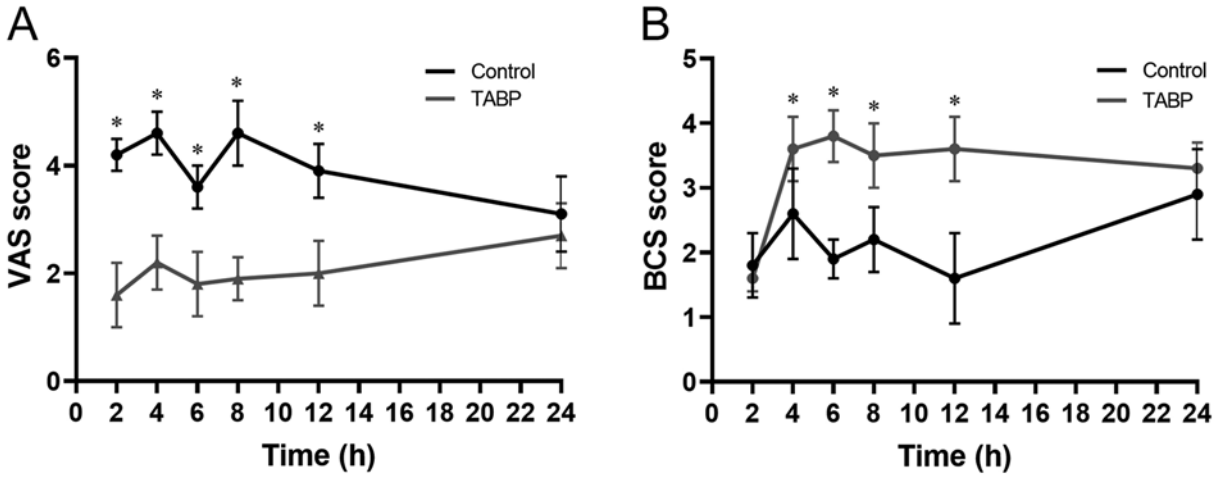

Fig. 2. *VAS and BCS scores were obtained within 24 hours after surgery. (A) VAS and (B) BCS scores at 2 hours, 4 hours, 6 hours, 8 hours, 12 hours, and 24 hours postoperatively. *P < 0.05 vs control group. VAS: Visual Analog Scale; BCS: Bruggrmann Comfort Scale.*

Table 2. *Comparison of the incidence of analgesic complications and abdominal skin tension blisters between the 2 groups.*

Variables	TAPB (n = 16) (%)	Control (n = 15) (%)	*P* value
Nausea and Vomiting	18.8% (3/16)	13.3% (2/15)	0.682
Respiratory Depression	0	0	-
Abdominal Puncture Complications	0	0	-
Incidence of Tension Blisters	18.8% (3/16)	33.3% (5/15)	0.354

Note: The data are presented as percentage. TAPB: transversus abdominis plane block.

this plane can effectively block the skin, muscular, and parietal peritoneum of the unilateral anterior abdominal wall (12-15). In the conventional TAPB, a blind puncture is performed following body surface anatomical markers, in which a puncture needle is used to break through the sensory localization of the TAP. Still, a blind puncture can cause multiple complications, including abdominal organ injury and nerve injury (25,26). In 2010, Hebbard et al (16) proposed US-guided TAPB that first made possible visualized operations with accurate positioning and reduced the incidence of puncture complications. In the present study, US-guided TAPB was performed by experienced anesthesiologists. There were no puncture complications, suggesting the safety of US-guided TAPB. Most patients with abdominal skin tension pain after AS surgery had pain in the epigastrium of the costal margin-navel level, which was within the coverage of the TAP and provided an anatomical basis for TAPB management of abdominal skin tension pain.

In the present study, the control group was treated with magnesium sulfate wet dressing after the occurrence of abdominal skin tension pain, which usually took effect within 1-2 weeks in the event of blisters. The TAPB group underwent bilateral TAPB, resulting in lower VAS scores at 2, 4, 6, 8, and 12 hours, as well as higher BCS scores at 4, 6, 8, and 12 hours after surgery, indicating that TAPB did have an analgesic effect on the abdominal skin (Fig. 2). This is supported by previous studies (12-15) about the use of TAPB for various abdominal interventions. In this study, ropivacaine was used, and it can act for 24 consecutive hours (27). Still, there were no differences at 24 hours between the 2 groups. The difference in the BCS score between the 2 groups was not significant at 2 hours after surgery, which might be due to coughs from anesthetic drugs during postoperative resuscitation that hindered the patients' appropriate BCS scoring. PCAP analgesia was given to both groups after surgery, and the TAPB group showed a lower use, suggesting that TAPB alleviated the abdominal pain. Nevertheless, all patients had surgical incisions in their back, which might interfere with evaluating the abdominal pain. Almost all TAPB group patients got out of bed on day 1 after removing the drainage tube, except one due to leakage of cerebrospinal fluid. Of the control group patients, 7 failed to get out of bed promptly, mainly because of fear of abdominal pain. The difference in length of hospitalization after surgery between the 2 groups was not statistically significant.

Regarding local anesthetic toxicity, the difference in postoperative complications, such as nausea, vomiting, and respiratory depression, was not statistically significant between the 2 groups, mainly because ropivacaine was used for local nerve block and did not increase systemic anesthetic accumulation or increase local anesthetic toxic responses. The TAPB group had a lower incidence of tension blisters than the control group, but the difference was not significant, possibly because of the small sample size. Nevertheless, ropivacaine can reduce the inflammatory responses and promote wound healing (28-30), explaining the fewer patients with blisters in the TAPB group. Still, it remains to be verified.

There are some limitations to this study. Because the sample size of this study is small and a single-center study, there might be data bias. The observational indicators in this study might be affected by other indicators, such as the bed rest duration and average postoperative hospital stay, which may be affected by pain tolerance and the pain caused by the surgical incision. These also affect the study results, but a larger sample size would be needed for multivariable analyses.

Conclusions

After kyphosis surgery, abdominal skin tension pain in patients with AS can delay the postoperative recovery but is usually paid little attention to. US-guided bilateral TAPB provides a method to manage abdominal skin pain in patients undergoing kyphosis surgery. TAPB could alleviate abdominal pain and help rapid recovery in patients. Still, the effects of TAPB on tension blisters require further studies due to the small sample size.

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