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Original Article

Assessment of skin temperature change in determining success of transversus abdominis plane block

Hai Xie[1], Yan Li[2], Qi Zhou[1], Naiquan Ma[1], Bingyu Gao[1], Linghui Pan[3]

[1]*Department of Anesthesiology, The First Affiliated Hospital of Hainan Medical College, Haikou 570102, China;* [2]*Department of Anesthesiology, Hainan Provincial Maternal and Child Health Hospital, Haikou 570206, China;* [3]*Department of Anesthesiology, Affiliated Tumor Hospital of Guangxi Medical University, Nanning 530021, China*

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Abstract: Background: To observe the skin temperature changes on the blocked area and its response to pinprick testing in ultrasound-guided transversus abdominis plane block (TAP block), and to explore the accurate predictor of the temperature measurement for TAP block success. Methods: A total of 30 patients underwent lower abdominal surgery were enrolled. Bilateral ultrasound-guided TAP blocks were performed before the surgery, after obtaining the view of transversus abdominis plane and the needle tip, 30 mL of 0.25% ropivacaine was injected for each side. Two measuring points in each unilateral TAP blocked area were randomly selected, where the results of pinprick testing and skin temperature at the time of 10 minutes before and after local anesthetics injection were collected. Based on defined standard (pinprick testing results), the sensitivity and specificity, the area under the receiver operating characteristic curve (AUC) and the diagnostic cut-off value of skin temperature change responding to TAP block success were assessed by analyzing the receiver operating characteristic curve (ROC curve). The correlation between the skin temperature changes and the pinprick testing results was assessed by Pearson correlation analysis. Results: The AUC value of skin temperature change upon the blocked area to TAP block success was 0.909 (95% *CI* 0.832-0.985). Importantly, the ROC analysis displayed that the diagnostic cut-off value was 0.55°C, with a sensitivity of 86.3% and specificity of 88.9%. The value of Pearson's correlation coefficient (*r*) was 0.588 (95% *CI* 0.403-0.723). Conclusions: Our study suggests that the skin temperature change is a strong predictor for a successful TAP block. We can conclude that a TAP block is probable success if value of skin temperature change is more than or equal to 0.55°C, and TAP block failure if less than 0.55°C with a sensitivity of 86.3% and specificity of 88.9%. Skin temperature measurement is a valuable predictor in determining TAP block effect when sensory testing is impossible.

Keywords: Transversus abdominis plane block, skin temperature measurement, analgesia, ultrasound guided nerve block

Introduction

Analgesia for acute postoperative pain is an important part of perioperative care beyond just comfort medicine. Multimodal analgesic approach including transversus abdominis plane block (TAP block) can offer a better analgesia, minimize the side-effects of parental pain medications [1-3]. TAP block technique was first described by Rafi in 2001 [4] and has gained a breakthrough progress with the development of ultrasound guided nerve block technology.

TAP block is a peripheral nerve block of anterior abdominal wall. It allows the injection of local anesthetic into the fascial plane between the transversus abdominis muscle and the internal oblique muscle, provide the analgesia from T_7 to L_1 [5, 6]. This technique was verified that it can offer an excellent analgesia for abdominal procedures, while significantly decreases the intraoperative and postoperative dosage of analgesics [2] and reduce the incidence of postoperative delirium, pneumonia, urinary retention, and falls [7].

Ultrasound guided techniques increase the success rate and efficiency of TAP blocks. Sensory stimulation such as pinprick or ice cold testing, is an easy and common method to assess

Table 1. Baseline patient characteristics

Variable	N = 30
Age, y	42.0 ± 13.9
Gender, n (F/M)	14/16
Height, cm	164.2 ± 7.7
Weight, kg	58.0 ± 10.4
ASA, I/II/III	18/8/4

Data are expressed as mean ± SD or number.

nerve block success by however, pain is a complex subjective experience, when sensory testing is impossible or causing unpleasant experience in some special cases or situations including pediatric, mental disorders, general anesthesia, incapable coordination and so on, the assessment for TAP block success become difficult. Thus, it is necessary to search a better parameter for assessment in those situations. Skin temperature measurement is a simple useful and reliable predictor for assessment of nerve block success [8-10]. Our hypothesis is that a successful nerve block can changed block area skin temperature which mediated by the blood vessels dilation [11].

Thus, our trial aims to testify the association between skin temperature changes and TAP block effect, distinguish the sensitivity and specificity of skin temperature measurement in determining TAP block effect, and explore skin temperature measurement as a useful parameter for TAP block success when sensory testing is impossible.

Materials and methods

General data

This clinical trial was a prospective observational study and its protocol was approved by the ethics committee in the affiliated hospital of Hainan medical college (No. XF20140013). Thirty patients underwent selective lower abdominal surgery, aged from 19 to 66 years old, American Society of Anesthesiologists (ASA) Grade I-III, were randomly selected for the trial from August 2014 to July 2015. Exclusion criteria including patients with nervous system disorders, allergy to local anesthetics, abnormal coagulative disorders, skin defects or infection, history of mental illness, hypothermia or hyperthermia, etc.

Methods

General anesthesia: Premedication wasn't administrated before anesthesia. Operating room temperature was maintained at 22°C, air humidity 60%. After preoperative fasting for 10-12 h, patients were received examinations in the operation room by monitoring electrocardiogram, blood oxygen saturation and blood pressure. Venous access was established with a 22 G or 24 G needle puncture, 1 mg of midazolam (Jiangsu Nhwa Pharmaceutical Corporation Ltd., batch No. 20140622) was administered intravenously, and facemask oxygen was inhaled synchronously. Before and after nerve block puncture procedure, blankets were used to cover on the patients especial on the nerve blocked area to prevent from heat loss.

Ultrasonic procedures

A portable ultrasound instrument (Siemens, ACUSON X500, Germany) and high-frequency ultrasound linear probe (7-12 MHz) were selected for TAP block. Anterior axillary line approach and in-plane ultrasound puncture technique were adopted. Ultrasound probe was placed horizontally on the unilateral side of the intersection between the horizontal line of umbilicus and the anterior axillary line. Following puncture needle removal, probe was continually moved outward to mid-axillary line and explicitly revealed external oblique abdominal muscle, internal oblique abdominal muscle and transverse abdominal muscle.

Obtaining the distance from skin to transverse abdominal plane in the ultrasound images, which the puncture point according to was set from the medial side of the probe. After skin preparation and draping, 20 G size puncture needle was almost parallel to the probe and towards to dorsal direction. Needle tip was clearly revealed through the axial plane between internal oblique abdominal muscle and transverse abdominal muscle. After water separation technology was performed to confirm the needle tip locating below the transverse abdominal muscle fascia, 30 mL of 0.25% ropivacaine (AstraZeneca, 2014040) was injected. Each patient was underwent bilateral TAP block and the same approach.

Two measuring points randomly were selected and marked in each unilateral TAP blocked area. The results of pinprick testing and temperature measurement were obtained in those points at the time of 10 minutes before and after local anesthetics injection. Our pinprick

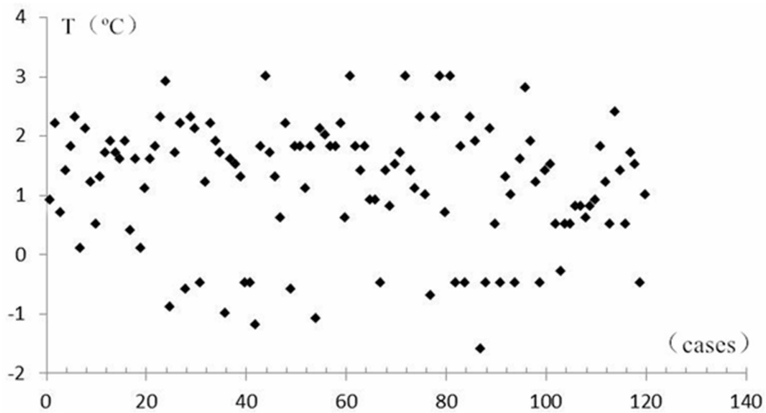

Figure 1. Scatter plot of skin temperature change in each case.

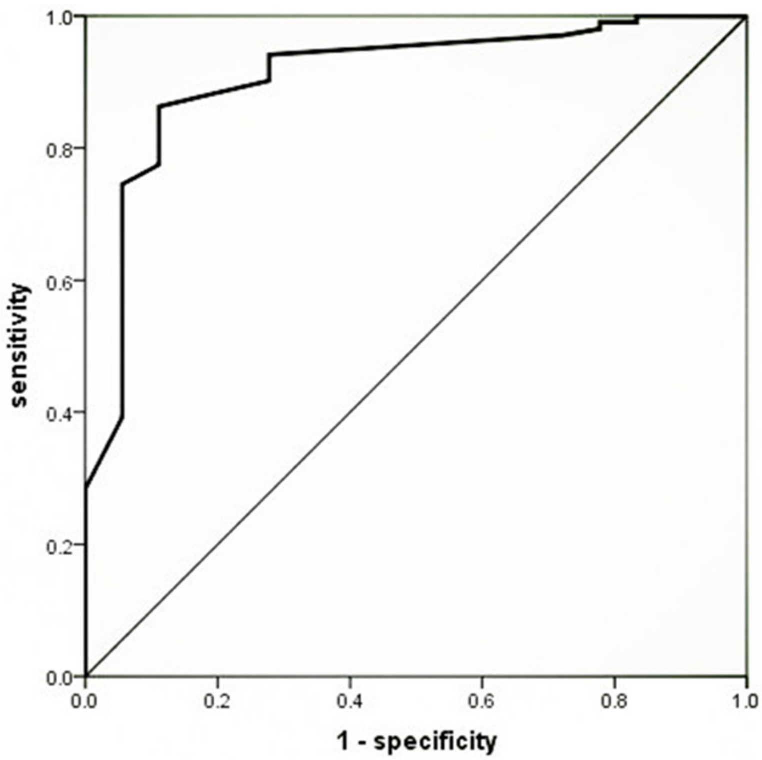

Figure 2. ROC of skin temperature change on blocked area responding to TAP block effect.

testing tool was a sterile 24 G needle tip. In order to determine whether nerve block success or not, patients was required to answer their feeling of 'pain' or 'no pain' responding to needle skin testing. Data of skin temperature on the measuring points was obtained by infrared thermometer (Dali Technology Corporation Ltd., T8, China), which performs accurate measurements with a resolution of up to 0.1°C. During measurement, the infrared thermometer was placed perpendicular to the surface of the blocked area and set a 5 cm according to the distance from the thermometer to the patient. Three measured temperature values were obtained in one selected point, from which the average value was calculated and defined as an effective one. Skin temperature changes were calculated with the formula of ($Value_{after}$-$Value_{before}$). '$Value_{before}$' was the data of the base temperature at the time of 10 minutes before local anesthetics injection and '$Value_{after}$' was 10 minutes after injection.

Statistical analysis

Statistical software SPSS-22.00 was utilized for measured data analysis. The data were presented as 'mean ± standard deviation (\d\fo1(± s)' or 'mean [95% confidence interval (*CI*)]'. Differences between $Value_{after}$ and $Value_{before}$ were analyzed by using a paired samples student's *t*-test, $P < 0.05$ was considered statistically significant. In order to estimate a receiver operating characteristic curve (ROC) analysis, 'diagnostic standard' was defined, included that patients feel pain in pinprick testing (negative) or patients feel numb in pinprick testing (positive). 'Negative result is equal to 0' and 'positive result is equal to 1' were set in ROC curve analysis, the reactivity of skin temperature change responding to TAP block effect was analyzed, with calculating the area under the receiver operating characteristic curve (AUC) and the diagnostic cut-off value via the formula of 'the highest value of specificity + sensitivity'.

Results

No adverse event was occurred in the trial. Thirty patients were screened for eligibility and fulfilled the inclusion criteria in the study. Baseline patient characteristics were present-

Table 2. Skin temperature changes with specificity and sensitivity

Temperature changes (°C)	Specificity (%)	Sensitivity (%)	Specificity + Sensitivity
-2.60	100.0	0.0	1.000
-1.40	100.0	5.6	1.056
-1.15	100.0	11.1	1.111
-1.05	100.0	16.7	1.167
-0.95	99.0	16.7	1.157
-0.80	99.0	22.2	1.212
-0.65	98.0	22.2	1.203
-0.55	97.1	27.8	1.248
-0.40	94.1	72.2	1.663
-0.10	93.1	72.2	1.654
0.25	91.2	72.2	1.634
0.45	90.2	72.2	1.624
0.55	86.3	88.9	1.752*
0.65	83.3	88.9	1.722
0.75	81.4	88.9	1.703
0.85	77.5	88.9	1.663
0.95	74.5	94.4	1.690
1.05	71.6	94.4	1.660
1.15	68.6	94.4	1.631
1.25	64.7	94.4	1.592
1.35	60.8	94.4	1.552
1.45	54.9	94.4	1.493
1.55	51.0	94.4	1.454
1.65	46.1	94.4	1.405
1.75	39.2	94.4	1.337
1.85	28.4	100.0	1.284
1.95	23.5	100.0	1.235
2.05	22.5	100.0	1.225
2.15	18.6	100.0	1.186
2.25	13.7	100.0	1.137
2.35	7.8	100.0	1.078
2.60	6.9	100.0	1.069
2.85	5.9	100.0	1.059
2.95	4.9	100.0	1.049
4.00	0.0	100.0	1.000

*The highest value of specificity + sensitivity.

ed as mean ± standard deviation or number (**Table 1**).

There were one-hundred and one 'positive' results and nineteen 'negative' results in the total of one-hundred and twenty pinprick testing points (**Figure 1**). The ROC curve of skin temperature change responding to TAP block success was analyzed (**Figure 2**).

The baseline temperature ($Value_{before}$) of (36.53 ± 0.22)°C was presented versus after puncture temperature ($Value_{after}$) of (37.70 ± 1.04)°C. No statistically significant was considered between $Value_{before}$ and $Value_{after}$ ($P > 0.05$). The values of skin temperature changes in blocked area were calculated with the formula of ($Value_{after}$-$Value_{before}$) and presented as (1.17 ± 1.04)°C . Based on defined standard, analysis of the ROC curve demonstrated that the cut-off value of ≥ 0.55°C for predicting TAP block success, with a sensitivity of 86.3% and specificity of 88.9% (**Table 2**), and the value of AUC was 0.909 (95% *CI* 0.832-0.985).

Pearson's correlation coefficient [r = 0.588 (95% *CI* 0.403-0.723)] demonstrated that a strong correlation between skin temperature and pinprick testing (whereas $r \geq 0.5$ means a strong correlation in Pearson's correlation analysis).

Discussion

This is one of the prospective observational studies, which investigates the relationship between skin temperature change and nerve block success. Pinprick testing has been adopted to verify the accuracy of skin temperature change in TAP block success, which demonstrates that skin temperature measurement is a strong predictor for nerve block effect.

In a total of 120 points, there were 19 pinprick testing points where patients felt pain due to TAP block failure in this study. However, those defined as 'negative' results could satisfy the demand of sensitivity and specificity analysis in the ROC curve. With high reactivity in the ROC curve, AUC of 0.909 is considered to represent an 'excellent' outcome, whereas more than 90% is an 'excellent' outcome. Furthermore, strong correlation between the pinprick testing result and skin temperature change were displayed. Both suggested that in blocked area, skin temperature change was sensitive to TAP block success, which could be a predictive parameter for TAP block. In the ROC curve, the sensitivity value of 86.3% is calculated with a missed diagnosis rate of 13.7%, a specificity of 88.9% and a misdiagnosis rate of 11.1%. In addition, the diagnostic threshold value of skin temperature change responding to TAP block effect was 0.55°C. Provided that the value of skin temperature change was not less than

0.55°C, TAP block was likely to succeed. Otherwise, TAP block failure was probably indicated.

In this study, a hypothesis has been made, that is, tension cold sensation is considered as the dominant portion among afferent impulses transferred from skin temperature sensation to body thermoregulatory center in a typical operating room environment, which dominates peripheral blood vessel contraction though nervous reflex [12]. However, when regional nerve block is performed, afferent impulses of skin temperature sensory nerve sensory nerve will be blocked, including tension cold. Therefore, body thermoregulatory center weakens and blood vessels dilate in blocked area [13], then local blood flow increased, by which body central heat transfers to the outer peripheral blocked area. Without being affected by other factors, such as environment temperature, skin temperature will be elevated in the outer peripheral blocked area. However, the temperature commonly falls in clinical practice due to the explosion in a typical operating room environment and heat loss [14]. In our study, blankets were employed to cover the blocked area before and after TAP block procedure to prevent from heat loss. Therefore, limitations in the study should be taken into account. It was found that some temperature change data were calculated into a result of negative values, which suggested that after local anesthetics injection, skin temperature had dropped inversely. Skin heat loss could not be avoided and eventually led to a differential result with deviation data. Although those low deviation data were calculated into a differential result, which might increase the false negative rate, decrease the true positive rate and lower sensitivity value, specificity value and diagnostic threshold value. In other words, exact values of sensitivity, specificity and diagnostic threshold might be higher. Therefore, it was enough for skin temperature measurement as a valuable predictor in TAP block success determination.

Our finding is consistent with Van [15] who found that foot temperatures increased significantly after ultrasound-guided subgluteal blockade of sciatic nerve. There was a good correlation between pinprick testing and infrared temperature measurement. Furthermore, the diagnostic cut-off value was 0.65°C with a sensitivity of 85.5% and a specificity of 79.8% in their study, which suggested that infrared skin temperature measurement was a good test in block success determination when sensory testing was impossible. When compared with differential diagnostic threshold values in the ROC curve, their results might be partially explained by different parts of body and different measure methods [16] and it was hypothesized that the cut-off value in our study was lower than that in their study, since bigger body surface area in our study would result in quicker heat loss, although our temperature protection in the patients from operating room environment was confirmed.

Skin temperature measurement is a valuable parameter in TAP block determination, which can be a predictor when sensory testing is impossible in some circumstances, such as pediatric, mental disorders, general anesthesia and incapable coordination. However, it may be difficult to appoint skin temperature measurement in some regional areas, including autonomic nervous dysfunction and vasomotor disorder. In future, further studies focusing on those special cases are expected, such as TAP block in paraplegic patients.

In conclusion, our study demonstrated the good relationship between skin temperature and TAP block effect. The diagnostic threshold value is 0.55°C. With a sensitivity of 86.3% and a specificity of 88.9%, it can be concluded that TAP block is probably successful if the skin temperature change value is more than or equal to 0.55°C. Otherwise, TAP block failure occurs. When sensory testing is impossible, skin temperature measurement is a valuable predictor in determining TAP success.

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Disclosure of conflict of interest

None.

Abbreviations

AUC, the area under the receiver operating characteristic curve; ROC, the receiver operating characteristic curve; ASA, American Society of Anesthesiologists; TAP, Transversus abdominis plane.

Address correspondence to: Yan Li, Department of Anesthesiology, Hainan Provincial Maternal and Child Health Hospital, NO. 75, South Longkun Road, Haikou 570206, China. Tel: +8618608909045; Fax: +8689866776593; E-mail: hnxh2003@163.com

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