Predicting successful stellate ganglion block using laser speckle contrast imaging

Xi Wu[1], Jun-Wei Xia[2], Shang-Long Yao[1], Ning An[1]

[1]Department of Anesthesiology, Institute of Anesthesiology and Critical Care Medicine, Union Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, Hubei 430022, China;
[2]Department of Anesthesiology, Ezhou Central Hospital, Ezhou, Hubei 436000, China.

Stellate ganglion block (SGB) is highly beneficial when used for treating pain syndromes, including acute herpes zoster of the face, postherpetic neuralgia, and sympathetically mediated pain of the head. Horner's syndrome is not reliable as a traditional indicator of successful SGB because of ambiguous and subjective judgment.[1] Cutaneous temperature change was reported to be a simple and objective method for assessing successful SGB.[2] However, temperature increase was only observed at least 10 min after successful SGB, demonstrating that the assessment of skin temperature cannot predict the efficacy of SGB in the early stage.[3] Laser speckle contrast imaging (LSCI) provides a powerful tool for quantitative assessment of flow dynamics for microcirculation over large areas with high spatiotemporal resolution.[4,5] According to our knowledge, LSCI has not been studied as an indicator of successful SGB.

The study was approved by Institutional Ethical Committee (No. S147) and written informed consent was obtained. Fifty-four adult patients with facial postherpetic neuralgia were enrolled at Union Hospital, Tongji Medical College, Huazhong University of Science and Technology between April 2019 and September 2020. Inclusion criteria were: (1) Age of 18–75 years; (2) American Society of Anesthesiologists (ASA) physical status I to II; and (3) body mass index <35 kg/m^2. Exclusion criteria included contraindication to regional anesthesia, peripheral neurological or vascular disease, or preoperative anti-hypertensive medication treatment. We recorded the blood flow images of the fingers in the ipsilateral upper limb using LSCI technique and performed numerical rating scale (NRS) tests 3 min before SGB ($t = 0$) as baseline measurements. Temperature measurement was performed at the tip of the index finger by touch thermometer. The high-frequency linear array probe was placed to identify the carotid artery, vertebral artery, longus colli muscle, and the anterior tubercle of the sixth cervical vertebra. The needle was inserted from the lateral edge of the probe toward the stellate ganglion with an in-plane approach. Correct needle position was confirmed when the local anesthetics spread as an expanding hypoechoic area in the space anterior and lateral to the longus colli muscle. Subsequently, 5 mL of 0.5% ropivacaine was injected after negative aspiration. Blood flow and cutaneous temperature measurements were repeated at 3-min intervals ($t = 3$, $t = 6$, $t = 9$, $t = 12$, $t = 15$, respectively) after local anesthetic injection. Blood flow index (BFI) was obtained by calculating perfusion over regions of interests with LSCI software, which expresses recorded values in perfusion unit (PU). SGB was defined as successful if NRS score achieved was 4 or less.

Continuous data were presented as mean ± standard deviation. Comparisons of normally distributed data between two groups were made using the independent sample t test. Comparisons of BFI and skin temperature between the groups and different time points were compared using repeated-measures analysis of variance followed by multiple paired t test. A P value <0.05 was considered statistically significant. The predictive power of the BFI for deciding the block success was determined by a receiver operator characteristics (ROC) curve, which presented sensitivity, specificity, and the optimal cut-off point.

SGB was successful in 47 patients and failed in seven patients. For successful SGB, patients achieved effective

Xi Wu and Jun-Wei Xia contributed equally to this work.

Correspondence to: Dr Ning An, Department of Anesthesiology, Institute of Anesthesiology and Critical Care Medicine, Union Hospital, Tongji Medical College, Huazhong University of Science and Technology, 1277 Jiefang Avenue, Wuhan, Hubei 430022, China
E-Mail: anning1005@163.com

pain relief with NRS score decreased to below 4. Among these patients, 45 out of 47 (95.7%) developed ipsilateral Horner's sign. Seven patients had no significant pain relief, whereas Horner's sign occurred in four patients. We were surprised to note that temperature at the tip of the index finger was not significantly increased after successful SGB when compared with the baseline value. Moreover, the baseline skin temperature in the area of the finger was decreased in two adult patients who had a long history of cigarette smoking for 30 years or more. The baseline temperature and BFI value of the finger were found to be significantly lower in one female patient with type 2 diabetes mellitus.

As shown in Figure 1, an initial significant increase of BFI value at each finger was observed within the first 3 min after successful SGB. For successful SGB, there was a significant increase in BFI values at each time point after the block compared to the same area before the procedure. At 3 min after successful SGB, the most pronounced rise of the BFI value was for the thumb compared with the baseline value (36.19 ± 7.83 vs. 88.49 ± 9.41 PU, $t = 46.310$, $P < 0.001$). Meanwhile, BFI value of the index finger, middle finger, ring finger, and little finger were increased by 2.37-fold, 2.37-fold, 1.78-fold, and 1.31-fold, respectively [Figure 1 and Supplementary Figure 1, http://links.lww.com/CM9/A470]. Six patients were over 65 years old. Among patients over 65 years old, a 2.38-time increase of BFI occurred at the thumb at 3 min after successful SGB, as compared to the baseline measurement. Compared with the population younger than 65 years old, average BFI value of the thumb at 3 min after successful SGB was lower in patients over 65 years old, but there was no significant difference (86.17 ± 4.17 vs. 88.77 ± 7.15 PU, $t = -0.870$, $P = 0.389$). However, failed SGB was associated with no significant difference in

BFI values of the tested fingers after the block. At 3 min after SGB, both the sensitivity and specificity of BFI value at the thumb to predict block outcome were 100%. The area under the ROC curve was 1.00 (95% confidence interval: 0.95–1.00, $P < 0.05$), demonstrating excellent ability of LSCI technique to discriminate successful block. Also, the optimal cut-off point was found to be 57.65 PU based on the ROC analysis.

A small temperature increase was only observed in 70% of the patients receiving SGB, which indicated that skin temperature is constantly maintained within a narrow range.[3] Thermography converts infrared radiation emitted from the skin surface into electrical impulses that are visualized in terms of color, and thus cannot provide quantitative analyzed microcirculation perfusion. So, as far as SGB is concerned, thermography measurement of skin temperature might not be a reliable diagnostic tool to predict the block success. Different from traditional assessment tools, the advantages of LSCI technique are excellent especially in real-time and wide-field monitoring and quantification of microcirculation blood flow changes. Further studies are needed to compare the ability of laser Doppler flowmetry and LSCI to detect changes in perfusion index during SGB.

In clinical practice, identification of a failed block could be always time-consuming. Early and accurate assessment of block outcome would be valuable and allow supplemental measures. Compared with the temperature measurement, the novel LSCI technique is an effective tool for early evaluation of successful SGB. We suggested that LSCI could well predict block outcome for SGB in an objective and non-invasive way. A BFI value of >57.65 PU at the thumb within 3 min after SGB is a great predictor for block success.
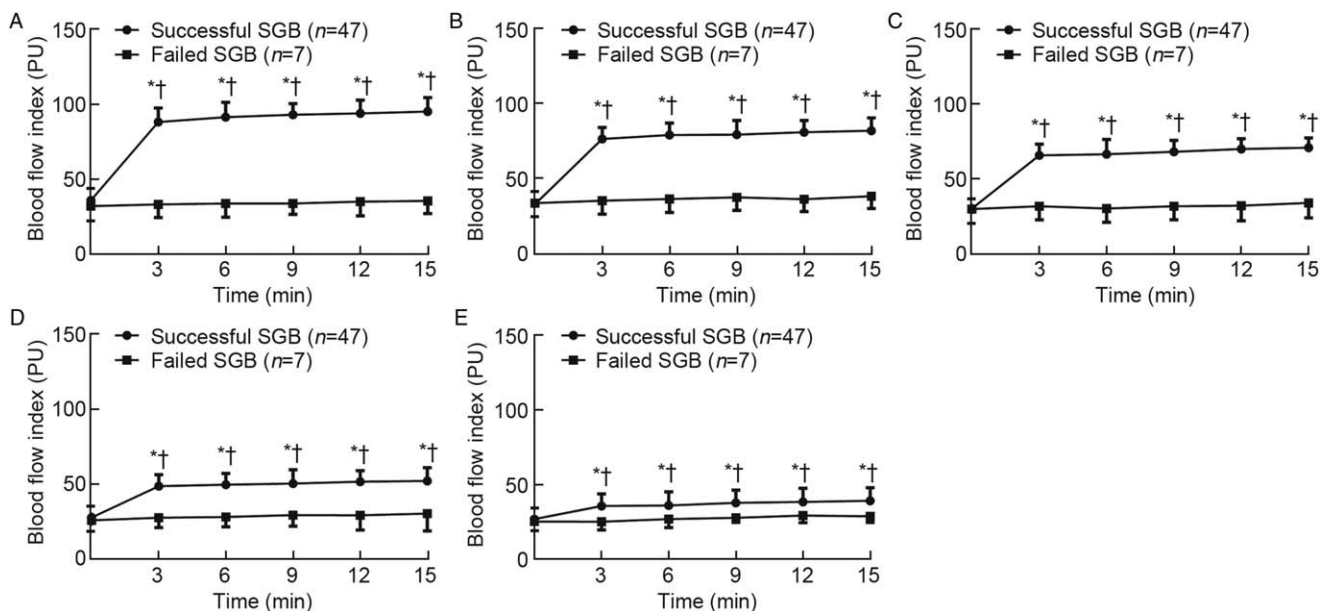

Figure 1: BFI values of the fingers in patients that underwent SGB. (A) BFI value of the thumb; (B) BFI value of the index finger; (C) BFI value of the middle finger; (D) BFI value of the ring finger; and (E) BFI value of the little finger. *$P < 0.05$ compared to failed SGB at each time point. †$P < 0.001$ compared to the baseline value. BFI: Blood flow index; SGB: Stellate ganglion block; PU: Perfusion unit.

Conflicts of interest

None.

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