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The skin-traction method increases the cross-sectional area of the internal jugular vein by increasing its anteroposterior diameter

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Abstract
Purpose. We developed a novel "skin-traction method" in which the puncture point of the skin over the internal jugular vein (IJV) is stretched upward with several pieces of surgical tape in the cephalad and caudad directions to facilitate cannulation of the IJV. We investigated whether this method increases the cross-sectional area of the IJV.
Methods. In 11 healthy volunteers, the cross-sectional area, anteroposterior diameter, and transverse diameter of the right IJV (RIJV) were recorded by ultrasound echo at head tilts of +10°, +5°, 0°, –5°, and –10° with and without the skin-traction method.
Results. The skin-traction method significantly increased the cross-sectional areas of the RIJV at head tilts of +10°, +5°, and 0°. In the flat position, the skin-traction method increased the cross-sectional area of the RIJV from $1.21 \pm 0.44\,cm^2$ to $1.75 \pm 0.60\,cm^2$ (44.6% increase), which is almost the same as that in the Trendelenburg position without this method ($1.60 \pm 0.54\,cm^2$ at –5° and $1.83 \pm 0.56\,cm^2$ at –10°). The anteroposterior diameter of the RIJV was significantly increased in all positions with this method, although the transverse diameter was not.
Conclusion. This method significantly increased the cross-sectional area of the RIJV by increasing the anteroposterior diameter of the RIJV. Even in the flat position, this method was almost as efficacious as the Trendelenburg position. This method thus appears to facilitate IJV cannulation.

Key words Skin-traction method · Internal jugular vein · Cannulation · Cross-sectional area

Introduction

The cannulation of central veins is an important technique for major surgery as well as for critically ill patients in the intensive care unit and the emergency department for the administration of drugs, the measurement of central venous pressure, the administration of fluids and blood, and the supply of intravenous nutrition. The internal jugular vein (IJV) is frequently used for central venous catheterization. However, IJV cannulation is sometimes difficult even for skilled physicians, especially in patients with hypovolemia and in pediatric patients [1].

A significant positive correlation has been found between IJV diameter and the rate of success of IJV cannulation [2]. The Trendelenburg position is known to be one effective method for increasing the diameter of the IJV [3–5], and thereby improving the rate of success of cannulation and reducing complications. However, it can be dangerous in patients with increased intracranial pressure or heart failure.

Although several reports have shown the usefulness and safety of ultrasound echo as a guide for IJV cannulation, we have often observed that the IJV collapsed when we pressed the skin with an echo probe or when we inserted a needle. However, we also noticed that the IJV collapse could be prevented to some extent by stretching the skin over the IJV in both the cephalad and caudad directions. From these observations, we speculated that this method might increase the cross-sectional area of the IJV.

We have developed a novel "skin-traction method" in which the puncture point of the skin over the IJV is stretched upward with several pieces of surgical tape in the cephalad and caudad directions in order to increase the cross-sectional area of the IJV during vein puncture.

The purpose of this study was to examine how the skin-traction method increases the cross-sectional area and diameter of the IJV in various head positions.

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Materials and methods

Eleven healthy volunteers (all were male physicians in our department) were enrolled in this study. The research protocol was reviewed and approved by the Ethics Committee of our hospital, and informed consent was obtained from each subject. Their mean age was 35.1 years (range 27–47 years). Their body weight ranged from 56 to 80 kg, with a mean weight of 67.4 kg. Their height ranged from 165 to 178 cm, with a mean height of 172.1 cm.

The volunteers had no previous history of IJV cannulation or disease of the neck. All studies were performed while the volunteers were in a supine position.

The head was rotated 30° [6] to the left while keeping the neck flat. No pillow was used under the shoulder in order to prevent the neck from excessive distension and to retain the angle made by two lines, that between the center of the clavicle and the puncture point, and that between the mandibular angle and the puncture point, about 135°, which makes it easy to lift up the skin with the skin-traction method. The skin over the right IJV (RIJV) was stretched with several pieces of 5-cm-wide surgical tape (Nichiban H50, Nichiban, Tokyo, Japan) in the cephalad and caudad directions. The skin cephalic to the RIJV was stretched cephalad, while the skin caudal to the RIJV was stretched caudad. Three pieces of tape were used in each direction. The other ends of the tape were firmly stuck to the metal edge of the operating table so that sufficient skin traction could be maintained (Fig. 1).

The body position was changed in order to examine the effect of head-tilt on the RIJV. The volunteers were placed in head tilts of +10°, +5°, 0°, −5° (Trendelenburg 5), and −10° (Trendelenburg 10).

The cross-sectional area, anteroposterior diameter, and transverse diameter of the RIJV were recorded (Fig. 2) with real-time two-dimensional ultrasound imaging (iLOOK25, SonoSite, WA, USA) in each head tilt position with and without the skin-traction method. A 7.5-MHz transducer (L38/10-5) was placed perpendicularly on the skin surface of the neck in order to identify the RIJV. Care was taken not to press the neck too strongly in order not to compress the RIJV [3].

The point of measurement was the lesser supraclavicular fossa at the level of the cricoid cartilage [7]. The images obtained using 2D ultrasound were recorded on a videotape recorder and transferred to a computer, where the recorded area and diameter of the RIJV at the end-expiratory phase of spontaneous respiration were measured using ImageJ [8] (Image Processing and Analysis in Java) version 1.34 s image analysis software.

All results are presented as the mean ± standard deviation. Two-way repeated-measures ANOVA was used to test for significance. P values <0.05 were considered to be significant.

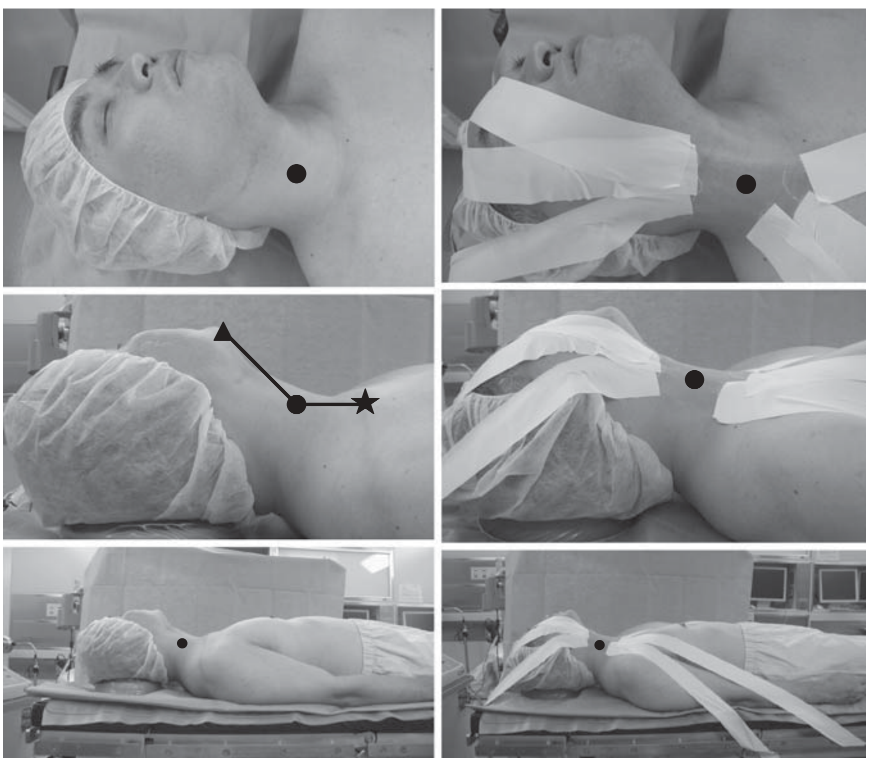

Fig. 1. Difference in the surface of the neck with (*right*) and without (*left*) the skin-traction method. The skin over the right interior jugular vein (RIJV) is stretched upward, and the puncture point (*black spot*) is lifted up with the skin-traction method (*right*). The angle made by two lines, that between the center of the clavicle (*star*) and the puncture point, and that between the mandibular angle (*triangle*) and the puncture point, was kept at about 135°

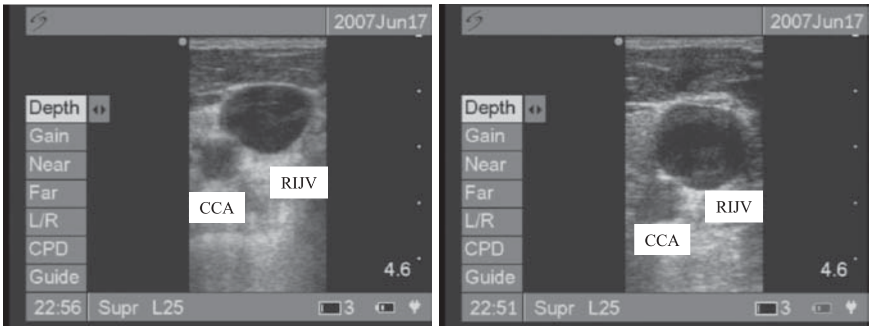

Fig. 2. Difference in the cross-sectional area of the RIJV with (*right*) and without (*left*) the skin-traction method. The cross-sectional area of the RIJV increased mainly as a result of an increase in the anteroposterior diameter. The distance between the skin and the RIJV also increased with this method. *CCA*, common carotid artery; *RIJV*, right internal jugular vein

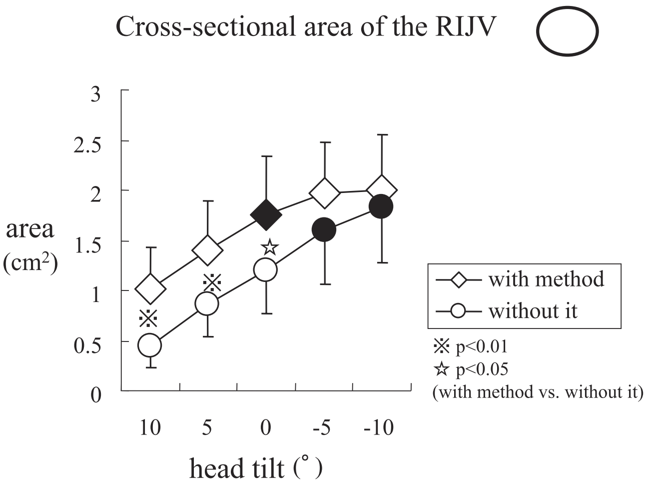

Fig. 3. Relationship between the head-tilt angle (+10°, +5°, 0°, –5°, –10°) and the cross-sectional area of the RIJV. *Open diamonds*, with skin-traction method; *Open circles*, without the skin-traction method. The cross-sectional area with the skin-traction method in the flat postion (0°) (*solid diamond*) is almost the same as that without this method at –5° or –10° (*solid circles*)

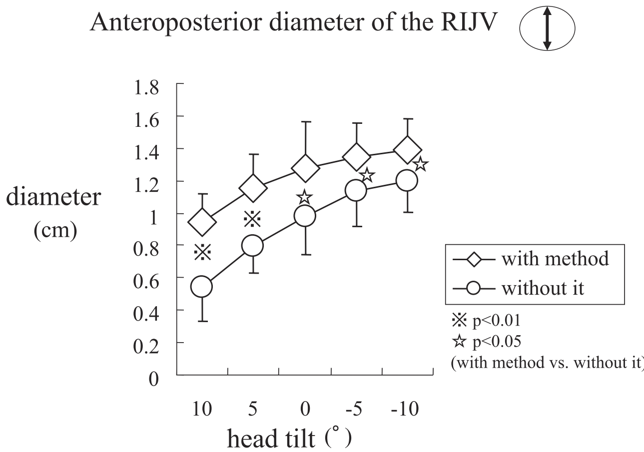

Fig. 4. Relationship between the head-tilt angle (+10°, +5°, 0°, –5°, –10°) and the anteroposterior diameter of the RIJV. The skin-traction method increased the anteroposterior diameter of the RIJV in all positions

Results

Figure 3 shows the changes in cross-sectional area of the RIJV at each head tilt position with and without the skin-traction method. With the skin-traction method, the cross-sectional area of the RIJV significantly increased at head tilts of +10°, +5°, and 0°. In the flat position, the skin-traction method increased the cross-sectional area of the RIJV from 1.21± 0.44 cm^2 to 1.75 ± 0.60 cm^2 (44.6% increase). In the Trendelenburg positon, the cross-sectional area of the RIJV without the skin-traction method was 1.60 ± 0.54 cm^2 at –5° and 1.83 ± 0.56 cm^2 at –10°, which is almost the same as the value of 1.75 ± 0.60 cm^2 obtained in the flat position with the skin-traction method. Without the skin-traction method, the lower the head position, the larger the cross-sectional area of the RIJV, showing that the Trendelenburg position is effective in increasing the cross-sectional area of the RIJV [2–4]. On the other hand, with the skin-traction method, there was no significant difference in the cross-sectional area of the RIJV between –5° and –10°.

Figure 4 shows changes in the anteroposterior diameter of the RIJV. Our method significantly increased the anteroposterior diameter in all positions. Figure 5 shows changes in the transverse diameter of the RIJV. In contrast to the anteroposterior diameter, the transverse diameter did not differ significantly in any position.

Discussion

Many efforts have been made to increase the IJV diameter in order to facilitate cannulation [3–5]. Gordon et al. [2] reported that success at first pass was significantly correlated with the diameter of the IJV, and that higher success rate at first pass contributes to reduction of the incidence of complications. The Trendelenburg position is known to be effective in increasing the diameter of the IJV. However, this position can be dangerous in patients with increased intracranial pressure or heart failure.

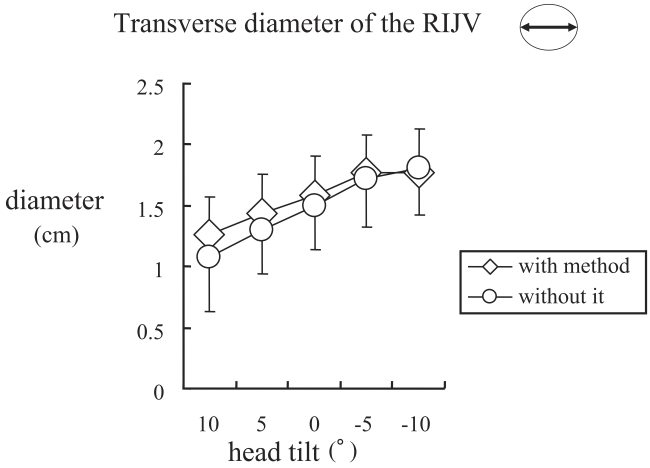

Fig. 5. Relationship between the head-tilt angle (+10°, +5°, 0°, –5°, –10°) and the transverse diameter of the RIJV. The skin-traction method did not increase the transverse diameter of the RIJV

Several recent reports have demonstrated the usefulness and safety of ultrasound echo for guidance in IJV cannulation. We have also used ultrasound echo, and have often observed that the IJV collapsed when we pressed the skin with an echo probe or when we inserted a needle. However, we also noticed that IJV collapse could be prevented to some extent by stretching the skin over the IJV in both the cephalad and caudad directions. Based on these observations, we speculated that this method might be able to increase the cross-sectional area of the IJV.

We developed a novel skin-traction method for cannulation of the IJV, and investigated how it increased the cross-sectional area of the RIJV in various head-tilt positions. It increased the cross-sectional area of the RIJV significantly in the head-up position and the flat position. Even in the flat position, the cross-sectional area of the RIJV with the skin-traction method was almost the same as that in the Trendelenburg position without the method. This method may therefore be especially effective for patients who cannot be placed in Trendelenburg position due to increased intracranial pressure or cardiac failure.

Our results showed that with this method the anteroposterior diameter of the RIJV significantly increased at all positions, whereas the transverse diameter did not. The mechanism of dilation of the RIJV in the anteroposterior direction with the skin-traction method seems to involve lifting the skin over the RIJV and then stretching the RIJV in the anteroposterior direction. The increase in distance between the skin and the RIJV on ultrasound echo with the skin-traction method (see Fig. 2) shows that this method stretches not only the RIJV, but also tissue such as muscle over the RIJV, thus releasing pressure on the RIJV.

An increase in the anteroposterior diameter of the RIJV helps prevent penetration of the posterior wall of the IJV [1]. Performing a single-wall puncture will also reduce the rate of inadvertent puncture of the common carotid artery, since the RIJV sometimes overlaps the common carotid artery partially or completely [2].

Our skin-traction method might have a risk of skin injury due to the force of traction applied. After skin traction, the skin of some subjects became red. However, there were no cases of lasting skin injury. Notably, though, attention should be paid to selection of the appropriate type of tape, which should be harmless to the skin and stretch it without damaging it. Furthermore, air-embolisms must be carefully avoided during cannulation of the catheter under the skin-traction method, since this method prevents the IJV from collapsing, causing intravascular negative pressure, especially in the head-up position.

One of the limitations of our study is that observers were not blinded to the subjects' condition. In addition, the sequence of body positions and interventions was not randomized. However, even if blinded, an observer could easily deduce which position and intervention were used for testing, thus introducing bias. Another limitation is that we did not study patients of greater interest, e.g., hypovolemic patients, patients with increased intracranial pressure, excessively obese patients, or pediatric patients [1,7,9].

Although there are several limitations to this study, the increases in cross-sectional area of the IJV obtained with our method may facilitate IJV cannulation. We expect this method not only to increase the diameter of the IJV, but also to prevent the IJV from collapsing during cannulation or handling of the ultrasound probe. Further study of this method is needed.

In conclusion, we have developed a skin-traction method for cannulation of the IJV in which the skin over the IJV is stretched in the cephalad and caudad directions with several pieces of surgical tape. This method significantly increased the cross-sectional area of the RIJV in healthy volunteers by increasing the anteroposterior diameter of the RIJV. This method thus appears to facilitate IJV cannulation.

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