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Lower-extremity venous stasis during laparoscopic cholecystectomy as assessed using color Doppler ultrasound

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Abstract. Lower-extremity venous stasis during laparoscopic cholecystectomy was evaluated in 16 patients by monitoring the blood velocity in the femoral vein and the femoral vein size (cross-sectional area) using color Doppler ultrasonography. The blood velocity in the femoral vein decreased significantly after the start of 10-mmHg abdominal insufflation in the supine position. When the patients were placed in a reverse Trendelenburg position during 10-mmHg insufflation, blood velocity in the femoral vein further decreased. However, velocity returned to the baseline after deflation. The cross-sectional area of the femoral vein was significantly elevated after the start of 10 mm Hg insufflation in the supine position. When patients were placed in the reverse Trendelenburg position during 10-mmHg insufflation, this parameter was further elevated, but returned to the baseline soon after deflation.

These results indicate that femoral vein stasis during laparoscopic cholecystectomy can be minimized by reducing the pressure of abdominal insufflation and avoiding elevation of the patient's head as much as possible.

Key words: Laparoscopic cholecystectomy — Color doppler ultrasound — Lower-extremity venous stasis — Deep vein thrombosis

Postoperative deep-vein thrombosis (DVT) and subsequent pulmonary embolism are one of the most severe complications after operation. Kakkar et al. reported that DVT in the legs developed in 30% of postoperative patients and pulmonary embolism in 10% of these patients [1]. According to previous studies, this complication could not be completely prevented even when anticoagulants were used during surgery, and DVT occurred in 25–50% of all patients after surgery [2].

Recently, laparoscopic surgery such as laparoscopic cholecystectomy has been with increasing frequency performed. To date, several deaths from pulmonary embolism, which developed after such surgery, have been reported [3]. In our department, laparoscopic cholecystectomy has been performed on 850 patients since 1990 [5, 9, 14]. Of these patients, one developed postoperative DVT in the bilateral femoral veins and a subsequent bilateral pulmonary embolism; fortunately, the patient recovered with medical treatment. Due to the experience with this patient, we undertook this study.

Laparoscopic cholecystectomy involves a specific manipulation called abdominal insufflation in addition to the routine procedure of general anesthesia. Furthermore, the patient is placed in the reverse Trendelenburg position during this surgery. Therefore, we hypothesized that these features during laparoscopic cholecystectomy may be more likely to induce lower-extremity stasis than is the case in supine position without abdominal insufflation. In other words, abdominal insufflation and the reverse Trendelenburg position, which are used for laparoscopic cholecystectomy, can elevate the incidence of venous stasis in the lower extremities. Thus, we recently examined changes in femoral vein blood flow caused by abdominal insufflation and the reverse Trendelenburg position, using color Doppler ultrasonography.

Materials and methods

The subjects were 16 consecutive patients who underwent laparoscopic cholecystectomy in our department between June and July

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Table 1. Character of patients

Number of patients	16
Age (years old)	51.8 (24–78)
Sex	
male	6
female	10
ASA[a] class	
I	10
II	6
Height (cm)	158.3 (144–175)
Body weight (kg)	58.4 (46–85)

[a] ASA: American Society of Anesthesiologists.

1993. The background profiles of these patients are shown in Table 1. According to the ASA classification, these patients were PS1 or PS2. Their ages ranged from 24 to 78 years (mean: 50.8 years). None of them had concomitant diseases or past histories which were considered risk factors for venous thromboembolic complications—for example, severe obesity, thrombocytosis, thrombophlebitis, cerebral infarction, myocardial infarction, or diabetes mellitus.

After premedication (intramuscular injection of atropine sulfate and hydroxyzine 25 mg), the patients were anesthetized with sodium thiopental (4 mg/kg) and vecuronium bromide (0.1 mg/kg). Anesthesia was maintained, using nitrous oxide (3 l/min), oxygen (3 l/min), and sevoflurane (1.5%). After induction of anesthesia, the concentration of inhaled anesthetics was maintained at constant levels and ventilation was mechanically assisted, with a tidal volume of 10 ml/kg and a ventilation frequency of 12/min. During surgery, solution was intravenously infused at a rate of 6 ml/kg/h. Abdominal insufflation with carbon dioxide was attained at a pressure of 10 mmHg, using an automated insufflator.

Color Doppler ultrasonography was performed by placing a 7.5-MHz probe (PLF-703NT, Toshiba Medical Company) on the right inguinal region. Color Doppler ultrasound images of the longitudinal section of the femoral vein were obtained at its segment proximal to the bifurcation of the deep femoral artery from the femoral artery. The probe position was selected so that its location, angle, and anatomical relationship with surrounding structures would not change during the course of measurement (Fig. 1). Cluster components of the Doppler information were sent to the built-in FFT (fast Fourier transform) circuit, and the time-axial data were converted into axial frequency components; then the FFT spectrum was displayed and converted to a velocity value. Mean blood velocity was automatically calculated by tracing the frequency spectrum and the direction of blood flow was corrected when its angle was set on the cross-sectional image. Mean blood velocity through the femoral vein and the femoral vein size were measured five times: (1) after induction of anesthesia in the supine position (baseline level), (2) after the start of abdominal insufflation (5 mmHg) in supine position, (3) at 10-mmHg insufflation in the supine position, (4) after attaining insufflation and tilting the patient to the reverse Trendelenburg position, and (5) after the release of insufflation and return to the supine position. The body angle during the reverse Trendelenburg's position was 20° from the horizontal level.

Each parameter was expressed as mean ± SE. The data were analyzed using the Wilcoxon test.

Results

The blood velocity in the femoral vein, which was 0.227 ± 0.028 m/s in the supine position before abdominal insufflation, decreased significantly after the start of 5-mmHg insufflation in the supine position. The decrease was greater when insufflation pressure was 10 mmHg. The velocity showed a further significant decrease to 0.088 ± 0.004 m/s when the patient was placed in the reverse Trendelenburg position after 10-mmHg insufflation. The velocity during 10-mmHg insufflation in the reverse Trendelenburg position was significantly lower than that during 10-mmHg insufflation in the supine position. The blood velocity in the femoral vein also differed significantly between 5-mmHg insufflation and 10-mmHg insufflation in the supine position. In all cases the velocity returned to the baseline soon after insufflation was released (Fig. 2).

The cross-sectional area of the femoral vein, which was 20.45 ± 1.679 mm^2 in the supine position before insufflation, increased slightly at the start of 5-mmHg insufflation in the supine position and increased significantly by 10-mmHg insufflation in the supine position. The cross-sectional area showed a further significant increase to 48.24 ± 4.288 mm^2 during 10-mmHg insufflation in the reverse Trendelenburg position. However, cross-sectional area did not differ significantly between 5-mmHg and 10-mmHg insufflation in the su-

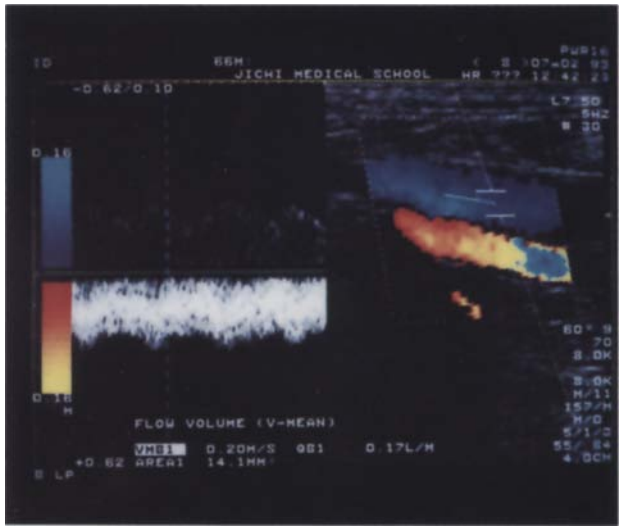

Fig. 1. Ultrasonography of the common femoral vein. Figure on the left side shows blood velocity in the femoral vein using color-doppler ultrasound; the right side shows longitudinal section of the femoral vein using B-mode ultrasonography.

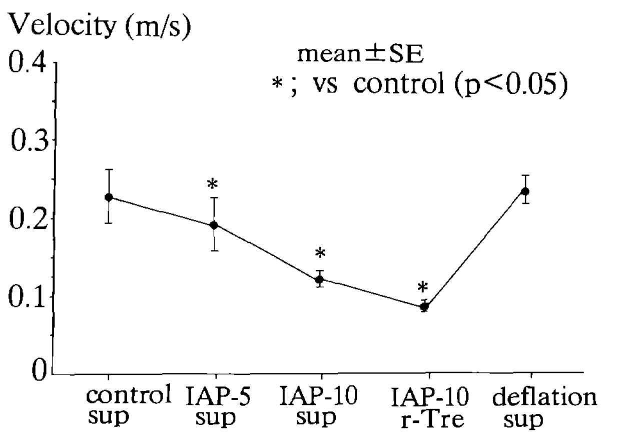

Fig. 2. Mean blood velocities of the femoral veins. *IAP-5:* 5 mmHg of intraabdominal pressure; *IAP-10:* 10 mmHg of intraabdominal pressure; *sup:* supine position; *r-Tre:* reverse Trendelenburg position.

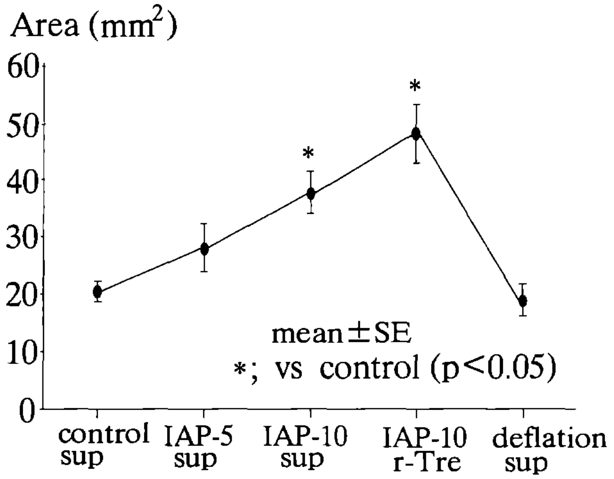

Fig. 3. Cross-sectional areas of the femoral veins. *IAP-5:* 5 mmHg of intraabdominal pressure; *IAP-10:* 10 mmHg of intraabdominal pressure; *sup:* supine position; *r-Tre:* reverse Trendelenburg position.

pine position or between 10-mmHg insufflation in the supine position and 10-mmHg insufflation in the reverse Trendelenburg position. In all cases, cross-sectional area returned to the baseline soon after the release of insufflation (Fig. 3).

Discussion

The color Doppler method employed in this study to measure femoral blood flow and to observe changes in vein size has recently been attracting attention as a means of diagnosing thrombosis in the leg veins. This noninvasive method visualizes changes in leg veins on a real-time basis and is reported to allow accurate anatomical orientation easily [10, 12].

Beebe et al. used this method to measure peak blood velocity in the femoral vein at the end of expiratory phase of the ventilatory cycle and the cross-sectional area of the femoral vein before, during, and after release of 14-mmHg abdominal insufflation in eight patients who underwent laparoscopic cholecystectomy. They found indications of a significant reduction in blood velocity after the start of abdominal insufflation, without any accompanying change in the venous diameter. Their study did not involve any postural change during insufflation [1]. Jorgensen et al. also used the color Doppler method, and suggested that abdominal insufflation can cause femoral vein stasis, since blood velocity in the femoral vein was reduced and the outflow phase during inspiration was shortened during insufflation. Jorgensen et al. reported that pulmonary embolism developed in three of the 438 patients who underwent laparoscopic cholecystectomy. This incidence is much higher than that of pulmonary embolism (0.2 persons per 1,000 population) secondary to diagnostic laparoscopy for gynecological purposes. Based on these results, Jorgensen et al. speculate that the reverse Trendelenburg position also promotes stasis of the femoral vein [6].

In the present study, abdominal insufflation reduced the blood velocity in the femoral vein while increasing the cross-sectional area of the femoral vein. The decrease in the blood velocity of the femoral vein differed significantly between 5-mmHg insufflation and 10-mmHg insufflation. This finding suggests that venous stasis, caused by abdominal insufflation, can be reduced to some extent by using lower pressures. Furthermore, the blood velocity of the femoral vein was significantly altered by changing from the supine position to the reverse Trendelenburg position during insufflation. This suggests that postural changes during abdominal insufflation also greatly affect venous stasis. It seems therefore preferable to minimize postural changes during laparoscopic cholecystectomy.

Methods used to prevent leg-vein thrombosis include drug therapy (low doses of heparin [16], or low-molecular-weight dextran [4]) and physical methods (elastic bandages [13], or an intermittent sequential compression device [11]). Of these methods, heparin has been shown to markedly reduce venous thrombosis. However, a recent study by Kakkar et al. found that pulmonary embolism occurred in 0.7% of all patients after celiotomy despite the use of heparin [8]. The incidence of pulmonary embolism after laparoscopic surgery may be higher. Low-molecular-weight dextran is as effective as heparin in preventing venous thrombosis but it is reported to cause anaphylaxis [4]. Physical compression using elastic bandages has been reported to be ineffective [13]. The intermittent sequential compression device for lower extremities is composed of six chambers. This device induces wavy milking in the entire leg by repetitions of air inflow and outflow into/from these chambers. The incidence of DVT in patients who used this bandage is reported to be lower than that in patients who used a single-chamber bandage. Thus, the sequential compression device has been reported to be as effective as low-dose heparin [11]. In the present study, the blood velocity in the femoral vein and the cross-sectional area of the femoral vein returned to the baseline levels soon after deflation. That is, venous stasis disappeared soon after the deflation. Venous stasis has long been recognized as one of the factors that may increase the risk of deep-vein thrombosis and pulmonary embolism [1, 15]. So, our findings suggest that the formation of thrombi in veins during laparoscopic surgery can be prevented to some extent by periodic release of insufflation during the course of surgery.

To date, no reliable method of preventing DVT has been established. As the number of patients who undergo laparoscopic cholecystectomy increases, accidental pulmonary embolism during this kind of surgery will become increasingly significant. It is therefore desirable to establish more effective methods of preventing this complication, including combinations of existing methods.

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