QT interval and QT dispersion increase in the elderly during laparoscopic cholecystectomy: a preliminary study

[L'intervalle QT et la dispersion du QT s'accroissent chez les patients âgés pendant la cholécystectomie laparoscopique : une étude préliminaire]

Hirotoishi Egawa MD,* Junichi Minami MD,† Kouichi Fujii MD,* Shinsuke Hamaguchi MD,* Yasuhisa Okuda MD,* Toshimitsu Kitajima MD*

Purpose: To compare the influence of a longer duration of intraperitoneal CO₂ insufflation with head-up tilt on electrocardiogram indices during laparoscopic cholecystectomy between elderly and younger patients.

Methods: Twelve elderly and 12 younger patients were studied. In all patients, intraperitoneal CO₂ insufflation was performed for more than 150 min in the head-up position. RR interval, QT interval, the rate-corrected QT (QTc) interval, QT dispersion (QTD) and the rate-corrected QTD (QTcD) were measured.

Results: The QT interval and the QTc interval increased significantly from 120 to 150 min after CO₂ insufflation in the elderly. The QTD and QTcD increased significantly during CO₂ insufflation in both groups. Those were significantly greater in the elderly than in younger patients from 120 to 150 min after CO₂ insufflation.

Conclusion: Longer duration of CO₂ insufflation with head-up tilt is associated with a prolongation of the QT interval and the QTD in elderly patients. The clinical significance of these findings remains to be determined.

Objectif : Comparer l'influence d'une insufflation intrapéritonéale prolongée de CO₂ en position de Fowler, sur les indices de l'électrocardiogramme pendant la cholécystectomie laparoscopique, entre les patients âgés et de jeunes patients.

Méthode : Douze patients âgés et douze jeunes patients ont participé à l'étude. L'insufflation de CO₂ a été réalisée pendant plus de 150 min en position de Fowler chez tous les patients. L'intervalle RR, l'intervalle QT, l'intervalle QT corrigé pour la fréquence (QTc), la dispersion QT (QTD) et la QTD corrigée pour la fréquence (QTcD) ont été mesurés.

Résultats : L'intervalle QT et l'intervalle QTc ont augmenté significativement de 120 à 150 min après l'insufflation de CO₂ chez les patients âgés. Le QTD et le QTcD ont augmenté de façon significative pendant l'insufflation de CO₂ chez tous les patients. Ces résultats ont été plus élevés chez les patients âgés comparés aux jeunes patients, entre 120 et 150 min après l'insufflation de CO₂.

Conclusion : Une insufflation prolongée de CO₂ en position de Fowler est associée à des intervalles QT et QTD également prolongés chez les patients âgés. La portée clinique de ces résultats demeure indéterminée.

LAPAROSCOPIC cholecystectomy, a minimally invasive surgical technique, has been widely used with intraperitoneal CO₂ insufflation in the head-up position. Increasing abdominal pressure with CO₂ induces a decrease in cardiac performance, and tilting the patient to the head-up position causes further adverse hemodynamics.^{1,2} Therefore, a longer duration of CO₂ insufflation with head-up tilt during laparoscopic cholecystectomy may increase cardiovascular risk, especially in elderly patients.

Recently, much attention has focused on variations of ventricular repolarization because of their relation to cardiac arrhythmia.³⁻⁶ Dispersion of QT interval (QTD) defined as maximal QT interval minus minimal QT interval on 12 leads of the surface electrocardiogram (ECG) reflects regional heterogeneity of ventricular repolarization,³ and has been reported to

From the Department of Anesthesiology,* and Hypertension and Cardioresenal Medicine,† Dokkyo University School of Medicine, Tochigi, Japan.

Address correspondence to: Dr. Hirotoishi Egawa, Department of Anesthesiology, Dokkyo University School of Medicine, Mibu, Tochigi 321-0293, Japan. Phone: 81-28-286-1111; Fax: 81-28-286-0478; E-mail: egawa718@maple.ocn.ne.jp

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be significantly greater in patients with ventricular arrhythmia than in those without.⁴⁻⁶ The effect of intraperitoneal CO₂ insufflation on the QTD during laparoscopy is of considerable interest, and the effect of a longer duration of CO₂ insufflation on the QTD during laparoscopy remains unclear.

The purpose of this preliminary study was to determine the influence of a longer duration of CO₂ insufflation on QT interval and QTD during laparoscopic cholecystectomy between elderly and younger patients.

Methods

After obtaining the approval of the hospital Ethics Committee and informed consent, we studied 12 elderly patients (65–72 yr) and 12 younger patients (34–58 yr), ASA I or II, scheduled to undergo elective laparoscopic cholecystectomy. They were within 15% of ideal body weight. All patients with cardiovascular, respiratory or cerebrovascular disease were excluded from the study. No patients were receiving any medication.

All patients were premedicated with *im* atropine 0.5 mg and hydroxyzine 50 mg 45 min before surgery. After arriving at the operation room, standard 12-lead ECG (FDX-4521L, Fukuda Denshi Co. Ltd., Tokyo, Japan), direct arterial blood pressure, pulse oximetry (Satlite, Datex, Finland) and capnography (Capnomac, Datex, Finland) were monitored. Anesthesia was induced with propofol 2 mg·kg⁻¹, supplemented with fentanyl 0.1 mg *iv*, and tracheal intubation was facilitated with vecuronium 0.1 mg·kg⁻¹. Anesthesia was maintained with 66% nitrous oxide in oxygen supplemented with sevoflurane 1–2%. Ventilation was controlled and P_{ET}CO₂ was maintained between 35 and 40 mmHg before CO₂ insufflation. All patients received a continuous infusion of crystalloid solution of 5 mL·kg⁻¹·hr⁻¹ during the study. Anesthesia was performed by a single anesthesiologist.

A Veress needle was inserted at the umbilical level and connected to the CO₂ insufflator, achieving and maintaining an endoabdominal pressure of 8 to 10 mmHg. The minute ventilation was adjusted to maintain constant P_{ET}CO₂ during the procedure. The patients were moved from the supine to a 20 head-up position before intraabdominal manipulation with the standard four-trocar technique. The operating table was returned to the supine position after intraabdominal manipulation. In all patients, intraperitoneal CO₂ insufflation was performed for more than 150 min.

From each ECG, consecutive beat-to-beat data were digitally recorded at a sample rate of 2 msec and stored on a 3.5-inch floppy disk. QT intervals were determined by the use of newly developed software (QTD-1, Fukuda Denshi Co. Ltd., Tokyo, Japan) that

detects the onset of the Q wave and the end of the T wave. The software uses the differential threshold technique described elsewhere in detail.^{7,8} In brief, this technique determines the onset of the Q wave as the intersection of a threshold level with the differential of the Q wave and the end of the T wave as the intersection of a threshold level with the differential of the T wave, respectively. QT intervals were measured in all 12 leads and corrected for heart rate (HR; QTc) with Bazett's formula.⁹ QTD was calculated as the difference between maximal and minimal QT intervals. The rate corrected QTD (QTcD) was defined as the difference between the maximum and minimum average QTc interval in the 12-lead ECG. The average value of data derived from three successive beats for each lead was used for analysis. A cardiologist blinded to patient age performed all measurements and analyses. Leads in which the end of the T wave could not be clearly discerned were excluded from the study.

Measurements of the RR interval, QT interval, QTc interval, QTD and QTcD were performed before anesthetic induction (baseline), before CO₂ insufflation, every 30 min for 150 min during CO₂ insufflation, five minutes after deflation, and at the end of surgery.

We also measured mean arterial pressure (MAP) before anesthetic induction (baseline), before CO₂ insufflation, 30, 60, 120, 150 min after CO₂ insufflation, five minutes after deflation, and at the end of surgery.

Data are presented as mean ± SD. Intergroup differences were analyzed by 2-way repeated-measures ANOVA. Scheffe's tests were used as determined by the ANOVA results. Comparisons between both groups were made by applying Scheffe's test. The threshold for statistical significance was $P < 0.05$.

Results

Patient details are shown in the Table. Except for age, no significant difference was found between the two groups.

As shown in Figure 1, MAP increased significantly during CO₂ insufflation in elderly and younger patients.

TABLE Demographic data

	Elderly patients	Younger patients
Age (yr)	68 ± 3	48 ± 2
Sex (male/female)	6/6	6/6
Weight (kg)	60 ± 10	60 ± 10
Duration of CO ₂ insufflation (min)	140 ± 5	138 ± 6
Duration of surgery (min)	148 ± 3	145 ± 4
Duration of anesthesia (min)	162 ± 8	160 ± 7

Values are expressed as mean ± SD.

FIGURE 1 Changes in mean arterial pressure (MAP) and RR interval. ●, elderly patients; ■, younger patients. All values are expressed as mean $\pm$ SD. * $P < 0.05$ vs baseline. † $P < 0.01$ vs younger patients.

The RR interval did not change significantly during the study period in both groups. As shown in Figure 2, a significant increase in QT interval occurred only in the elderly from 120 to 150 min after the start of CO₂ insufflation. The QT interval in the elderly was significantly greater at 120 and 150 min after the start of CO₂ insufflation than in younger patients. Similarly, the QTc interval increased significantly from 120 to 150 min after the start of CO₂ insufflation in the elderly. The QTc interval in the elderly was significantly greater at 120 and 150 min after the start of CO₂ insufflation than in younger patients. The QTD and QTcD increased significantly during CO₂ insufflation in both groups (Figure 3). The QTD and QTcD in the elderly were significantly greater at 120 and 150 min after the start of CO₂ insufflation than in younger patients.

Discussion

In the present study, the QT interval, QTc interval, QTD and QTcD at baseline did not differ significantly between elderly and younger patients, in agreement with a recent study. Tran *et al.*¹⁰ have shown that no significant differences are seen among the three different age categories for QTD and QTcD. However, intraperitoneal CO₂ insufflation with head-up tilt caused different responses for QTD and QTcD when comparing elderly and younger patients. In our study, the QT interval and QTc interval did not differ in younger patients. In the elderly, the QT interval and QTc interval increased significantly from 120 to 150

FIGURE 2 Changes in the QT interval and rate-corrected QT (QTc) interval before, during and after CO₂ insufflation. ●, elderly patients; ■, younger patients. All values are expressed as mean $\pm$ SD. * $P < 0.05$ vs baseline. † $P < 0.01$ vs younger patients.

min after the start of intraperitoneal CO₂ insufflation. We also demonstrated that significant increases of the QTD and QTcD during CO₂ insufflation occurred in both groups, and those in the elderly were significantly greater from 120 to 150 min after the start of CO₂ insufflation than in the younger patients.

It is well known that aging is associated with structural and functional alterations in the cardiovascular system. For example, aging is associated with a reduction in circulatory blood volume, an increase in cardiac wall thickness, and a reduction in cardiac compliance.¹¹ In addition, a large number of studies have shown that aging is also accompanied by alterations in neural cardiovascular regulation.¹² Such changes with age may, at least in part, account for the present results.

In addition to age, intraperitoneal CO₂ insufflation, head-up tilt, hypercapnia, inhaled anesthetics, and surgical stress may exert an influence on the QT interval and QTD.^{1,2,13-15} It is well known that intraperitoneal CO₂ insufflation during laparoscopic cholecystectomy induces hemodynamic changes. Previous studies have demonstrated that an increased abdominal pressure with CO₂ diminishes venous return and cardiac output, and increases MAP, HR, pulmonary capillary wedge pressure, systemic and pulmonary vascular resistances, and central venous pressure.^{1,2} From our results and previous studies, intraperitoneal CO₂ insufflation induces alterations of both electrophysiologic and hemodynamic variables.

FIGURE 3 Changes in the QT dispersion (QTD) and corrected QT dispersion (QTcD) before, during and after CO₂ insufflation. ●, elderly patients; ■, younger patients. All values are expressed as mean $\pm$ SD. * $P < 0.05$ vs baseline. † $P < 0.01$ vs younger patients. ‡ $P < 0.01$ vs younger patients.

Head-up tilt induces prolongation of the QTD and QTcD due to increased sympathetic activity or decreased vagal tone.¹³ Watanabe *et al.*¹⁶ reported that the neural control function of blood pressure during head-up tilt in the elderly differed from that in young subjects because of age-related change in baroreflex function. Since a head-up position induces decreases in venous return and cardiac output, a combination of intraperitoneal insufflation and head-up tilt causes further hemodynamic changes.^{1,2}

Hypercapnia produces an increase of QTc interval and QTD.¹⁴ Since laparoscopic cholecystectomy with CO₂ insufflation may induce hypercapnia, PaCO₂ should be maintained within normal limits by adjusting minute ventilation during the procedure.

Inhaled anesthetics such as halothane and sevoflurane induce an increase of the QTD and the QTcD.¹⁵ Since we used sevoflurane in this study, the anesthetic agent may have influenced our results. It is thought that surgical stress also affects the QTD and the QTcD. Since laparoscopic cholecystectomy is a minimally invasive surgical technique, however, surgical invasion may have had little effect on the changes in QT interval and QTD.

Increased QTD has been shown to predispose to ventricular arrhythmias. It is exhibited in patients with myocardial infarction, subarachnoid hemorrhage and diabetes mellitus.^{5,6,17-20} In the present study, however, no arrhythmic events were observed during laparo-

scopic cholecystectomy in both elderly and younger patients. This may be due to the fact that patients with cardiac diseases were not included in this study.

In conclusion, a longer duration of intraperitoneal CO₂ insufflation and head-up tilt during laparoscopic cholecystectomy is associated with increases in the QT interval and the QTD in the elderly. The clinical significance of these findings, specially in elderly patients with cardiovascular diseases, remains to be determined.

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