Effect of CO$_2$ Insufflation on Corrected QT Interval Prolongation during Laparoscopic Surgeries: A Prospective Observational Study

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Abstract

Introduction: Laparoscopic surgeries in various surgical specialties are most routinely performed with general anesthesia. The physiological effects of intra-abdominal CO$_2$ insufflation combined with the variations in patient positioning can have a major impact on cardiorespiratory function. Prolongation of corrected QT interval (QTc) has been known to predispose torsades de pointes, a potentially fatal ventricular arrhythmia may occur during CO$_2$ insufflation. Our aim is to evaluate the effect of insufflation of CO$_2$ on QT interval and QTc during prolonged laparoscopic surgeries.

Methodology: Fifty patients of American Society of Anesthesiologists physical status 1 and 2, of either sex, between the ages of 25 and 65 years posted for laparoscopic surgeries included in the study. After general anesthesia, we measured mean arterial pressure, heart rate, SpO$_2$ and ETCO$_2$ before anesthesia induction, before CO$_2$ insufflation, 30, 60, 120, and 150 min after CO$_2$ insufflation, 5 min after CO$_2$ deflation, and at the end of surgery. We observed statistically significant increase of QTc interval around 120 min after CO$_2$ insufflation.

Conclusion: The cause of this QTc interval prolongation is multifactorial and clinical significance of producing life-threatening cardiac arrhythmias has to be determined.

Key words: Cardiac arrhythmias, CO$_2$ insufflation, Laparoscopic surgeries, Corrected QT interval

INTRODUCTION

Laparoscopic surgery is a principle technique for minimally invasive surgery of the abdomen, and it has been employed in procedures ranging across multiple surgical disciplines.$^{[1]}$ Laparoscopic surgeries in various surgical specialties are most routinely performed with general anesthesia. It is, furthermore, facilitated by proper decompression of the gastrointestinal tract and by the establishment of adequate muscle relaxation, pneumoperitoneum, and various patient positions. The physiological effects of intra-abdominal CO$_2$ insufflation combined with the variations in patient positioning can have a major impact on cardiorespiratory function. A complete understanding of these hemodynamic changes is essential for optimal anesthetic care. One indicator of these changes is corrected QT interval (QTc), an index of myocardial function. Prolongation of QTc has been known to predispose torsades de pointes, a potentially fatal ventricular arrhythmia may occur during CO$_2$ insufflation.$^{[2]}$ The purpose of this study is to evaluate the effect of insufflation of CO$_2$ on QT interval and QTc during prolonged laparoscopic surgeries.

METHODOLOGY

This prospective observational study conducted in our tertiary care hospital. After obtaining the Institutional Ethical Committee approval and informed consent, 50 patients of American Society of Anesthesiologists physical status 1 and 2, of either sex, between the ages of 25 and 65 years posted for laparoscopic surgeries included in the study. Patients with cardiovascular, respiratory, or cerebrovascular diseases were excluded from the study.
All patients received injection glycopyrrolate 0.2 mg intramuscular as premedication. At operation theater, all anesthesia equipment and anesthesia drugs were checked and kept ready as per institutional protocol. On arrival of the patient at operation theater standard, 12-lead electrocardiogram (ECG), non-invasive blood pressure, and pulse oximetry were attached to all patients. After preoxygenation, anesthesia induced with injection propofol 2 mg/kg and injection fentanyl 150 µg. Tracheal intubation done with appropriate size endotracheal tube and injection vecuronium 0.1 mg/kg. Once airway secured ETCO₂ monitoring device attached to endotracheal tube. Anesthesia was maintained with nitrous oxide and oxygen 2:1 supplemented with 1–2% of sevoflurane and titrated dose of injection vecuronium. The anesthesia ventilator setting adjusted to tidal volume of 9 ml/kg of patient weight and respiratory rate of 10–12/min. The PETCO₂ was maintained between 35 and 45 mmHg by adjusting the respiratory rate during intraperitoneal CO₂ insufflation. All patients received continuous infusion of crystalloid solution 5 ml/kg intraoperatively.

Intraoperatively, pneumoperitoneum was created by insufflation CO₂ through Veress needle and CO₂ insufflator. Intra-abdominal pressure was maintained between 10 and 12 mmHg throughout the procedure. The patient was positioned according to the type of laparoscopic surgery.

We measured mean arterial pressure, heart rate, SpO₂ and ETCO₂ before anesthesia induction, before CO₂ insufflation, 30, 60, 120, and 150 min after CO₂ insufflation, 5 min after CO₂ deflation, and at the end of surgery. Intraoperatively, measurement of the RR interval, QT interval, and QTc interval according to the Bazett's formula was performed before anesthesia induction, before CO₂ insufflation, 30, 60, 120, and 150 min after CO₂ insufflation, 5 min after CO₂ deflation, and at the end of surgery. Statistical analysis for continuous variables such as mean arterial pressure, heart rate, and SpO₂, QT interval, and QTc interval is presented as mean ± standard deviation (SD). P value was determined and P < 0.05 was taken as statistically significant.

RESULTS

A total of 50 cases were enrolled in this study. The demographic details of the patients such as age, gender, duration of surgery, and duration of anesthesia were recorded [Table 1]. The pre-operative and intraoperative mean arterial pressure, heart rate, SpO₂, ETCO₂, QT interval, QTc interval before CO₂ insufflation, 30, 60, 120, and 150 min after CO₂ insufflation, and 5 min after CO₂ deflation were recorded. We observed that the mean arterial pressure was increased from 86.36 ± 5.76 mmHg before insufflation of CO₂ to 88.04 ± 5.92 mmHg at 120 min after insufflation [Figure 1]. The rise in mean arterial pressure was not statistically significant (P > 0.15). We noticed that the heart rate was increased from 84.18 ± 5.36 per minute before insufflation of CO₂ to 82.34 ± 5.72 per minute at 120 min after insufflation [Figure 1] and it was statistically insignificant (P > 0.15) [Figure 1].

We observed statistically significant increase (P < 0.0001) of QTc interval from 361.7 ± 11.76 ms before insufflation of CO₂ to 461.10 ± 17.2 ms at 120 min after insufflation [Table 2] [Figure 2]. We also observed statistically significant increase (P < 0.008) in ETCO₂ from 34.78 ± 3.14 mmHg before insufflation of CO₂ to 42.10 ± 3.54 mmHg at 120 min after insufflation [Figure 3].

DISCUSSION

The QT interval recorded on the surface ECG reflects the time required for ventricular depolarization and repolarization. The normal range of heart rate QTc varies with age and sex. Typically, QTc interval <440 ms is considered to be normal. Abnormal cardiac repolarization which can be identified by prolongation of QT interval and QTc interval on ECG is a well-known cause for developing life-threatening tachyarrhythmias like torsade des pointes, characterized by “twisting” of QRS axis around the isoelectric line.

The QTc interval prolongation may be due to either inherited like long QT syndrome or acquired causes. Large numbers of medications have potential to prolong QTc interval. Some of the drug classes that are implicated in QTc prolongation are antiarrhythmic agents, antihistaminic

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Mean±SD</th>
</tr>
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<tbody>
<tr>
<td>Age (years)</td>
<td>40.94±16.0</td>
</tr>
<tr>
<td>Duration of surgery (minutes)</td>
<td>140.98±12.97</td>
</tr>
<tr>
<td>Duration of anesthesia (minutes)</td>
<td>154.12±11.59</td>
</tr>
<tr>
<td>Gender (M/F)</td>
<td>27/23</td>
</tr>
<tr>
<td>SD: Standard deviation</td>
<td></td>
</tr>
</tbody>
</table>

Figure 1: Changes in heart rate, mean arterial pressure, and SpO₂
agents, antimicrobials, promotility drugs, and antineoplastic agents. Non-pharmacologic factors which cause QTc prolongation include electrolyte disturbances such as hypokalemia, hypomagnesemia, and hypocalcemia.

In the present study, QTc interval of all the patients before start of laparoscopy was within normal limits. After about 120 min from the start of insufflation of CO₂, we noted QTc prolongation in all patients with mean ± SD of 461.10 ± 17.2 ms. The cause of this prolongation cannot identify but hypothesized to the following reasons such as intraoperative electrolyte disturbance, hypercapnia due to CO₂ insufflation during laparoscopy, and anesthetic drugs such as sevoflurane and surgical stress.

Hypercapnia which may be a result of insufflation of CO₂ during laparoscopic surgeries has been incriminated to produce QTc interval prolongation, which was confirmed by Ciftci et al.\[^3\] in their study. In our study, ETCO₂ monitored during laparoscopic surgeries and there was no hypercapnia noted during the procedure.

Surgical stress may cause QTc interval prolongation but as mentioned in Egawa et al.\[^4\] The laparoscopic procedures are minimally invasive procedures and surgical invasion may have had minimal effect on changes in QT interval and QTc interval.

The effects of commonly used general anesthetic drugs and inhalational agents on QTc interval have been studied in healthy adults and children. A recent study found that the mean QTc interval prolongation of 46 ms in patients anesthetized with inhalational agents.\[^5\] The effect of sevoflurane on QTc interval is controversial. Some studies have shown a prolongation of QTc interval, but others failed to show the QTc interval prolongation.\[^5\]

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Before CO₂ insufflation Mean±SD</th>
<th>120 min after CO₂ insufflation Mean±SD</th>
<th>P value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heart rate (per minute)</td>
<td>84.18±5.36</td>
<td>82.34±5.72</td>
<td>&gt;0.10</td>
</tr>
<tr>
<td>Mean arterial pressure (mmHg)</td>
<td>86.36±5.76</td>
<td>88.04±5.92</td>
<td>&gt;0.15</td>
</tr>
<tr>
<td>ETCO₂ (mmHg)</td>
<td>34.78±3.14</td>
<td>42.10±3.54</td>
<td>&lt;0.008</td>
</tr>
<tr>
<td>Corrected QT interval (ms)</td>
<td>361.7±11.76</td>
<td>461.10±17</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

*P<0.05 is significant SD: Standard deviation

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**Figure 2: Corrected QT interval in ms**

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**Figure 3: ETCO₂ in mmHg**

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**Table 2: Mean and SD of all measured variables**
QTc interval prolongation has been shown to predispose to ventricular arrhythmias. It is exhibited in patients with myocardial infarction, subarachnoid hemorrhage, and diabetes mellitus.[6] In the present study, however, no arrhythmic events were observed during laparoscopic 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.

CONCLUSION

CO₂ insufflation in laparoscopic surgeries is associated with prolongation of QTc interval. The cause of this QTc interval prolongation is multifactorial and clinical significance of producing life-threatening cardiac arrhythmias has to be determined.

REFERENCES


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