Original Article

Significant hypercapnia either in CO₂-insufflated or air-insufflated colonoscopy under deep sedation

I-Fang Chao¹, Han-Mo Chiu²,³, Wan-Chi Liu⁴, Chien-Chiang Liu⁴, Hsiu-Po Wang², Ya-Jung Cheng⁴,∗

¹Department of Anesthesiology, Cathay General Hospital, Taipei, Taiwan, R.O.C.
²Department of Internal Medicine, National Taiwan University Hospital, Taipei, Taiwan, R.O.C.
³Department of Health Management Center, National Taiwan University Hospital, Taipei, Taiwan, R.O.C.
⁴Department of Anesthesiology, National Taiwan University Hospital, Taipei, Taiwan, R.O.C.

Abstract

Background: Previous reports showed that CO₂-insufflated colonoscopy is safe and less uncomfortable. However, hypercapnia remains a vital concernment if deep sedation is necessary for difficult colonoscopy with prolonged CO₂ insufflation. This observational study is to measure bodily CO₂ subjected to colonoscopy facilitated by CO₂- and air- or air-insufflation in conscious-sedation, deep-sedation and awake patients.

Objective: To investigate if CO₂-insufflated colonoscopy could increase the risk of hypercapnia in awake, conscious-sedation and deep-sedation patients.

Methods: 104 patients in our health center undergoing sequential esophagogastroscopy and colonoscopy screening were included. At patients’ request, incremental intravenous sedatives were given in order that the air-insufflated esophagogastroscopy could be carried out without the molestation of gag and cough reflexes. The sedation levels were re-evaluated before proceeding colonoscopy and the patients were divided into conscious-sedation (respond purposefully to verbal commands) and deep-sedation groups and randomly allocated for air or CO₂ insufflation. Transcutaneous capnography (TcCO₂) was recorded every minute throughout the colonoscopy procedure.

Results: The baseline TcCO₂ in the air- (50.9 ± 5.7 mmHg) and CO₂-insufflated (53.1 ± 6.5 mmHg) groups under deep sedation was significantly higher than the groups under conscious-sedation and the awake groups (p < 0.01). In both air- and CO₂-insufflation groups there were also a statistically significant (p < 0.01) correlation in TcCO₂ between the start, the peak and the end of colonoscopy. TcCO₂ did not significantly change throughout the colonoscopy in awake and conscious-sedation groups, either with air or CO₂ insufflation. With deep sedation, TcCO₂ significantly increased and peaked around the time when the scope touching the cecum, and then returned to original state with suction and withdrawl of the colonoscope without significant interaction of CO₂ insufflation and deep sedation.

Conclusion: The TcCO₂ during colonoscopy was correlated to the data before inserting colonoscope but significantly different within awake, conscious-sedation and deep-sedation groups. TcCO₂ did not change significantly either with CO₂ insufflation or air insufflations in awake and conscious-sedation groups. However, in deep-sedation groups with significantly higher baseline TcCO₂, further increase of TcCO₂ were significant without interaction with CO₂ insufflation. We concluded that when patients need deep sedation for colonoscopic procedures facilitated by gas insufflation, hypercapnia is still considerably present, not only with CO₂ insufflation but also with air insufflation colonoscopy.

Copyright © 2010, Taiwan Society of Anesthesiologists. Published by Elsevier Taiwan LLC. All rights reserved.

1. Introduction

Colonoscopy is an effective tool for detecting, removing colorectal neoplasms and it also proved itself to be effective in reducing the incidence and mortality of colorectal cancer.¹ It is nowadays gradually accepted as a screening tool and thus the demand for painless colonoscopy by provision of sedation becomes
increasingly substantial. In recent years, the replacement of air insufflation by CO₂ insufflation to facilitate colonoscopy has also been reported to be effective in reducing intra- and post-colonoscopic pain and safety in awake or conscious-sedation patients. Although conscious-sedation is ideal for GI endoscopy, the depth of sedation required to obtain satisfactory results varies in patients individually ranging from mild to intensive close to general anesthesia. Deep sedation is reported to be a necessity for patients with sensitive pharynx in the act of esophageagastroscopy and patients with difficult colonoscopy such as caused by prolongation of the procedure needing insufflations of more gas, in younger, in slender female patients with a history of gynecopelvic surgery but there were few previous reports about colonoscopy carried out under deep sedation. However, when CO₂ insufflation is applied with deep sedation, hypercapnia should be the most concern besides hypoxemia whilst respiratory depression would further interfere with elimination of CO₂. The unwanted effects going along with hypercapnia include not only the preceding hypoxemia by interfering with the O₂ dissociation curve but also activating the sympathetic nervous system and increasing the possibility of arrhythmias.

Sequential screening esophageagastroscopy and colonoscopy whether or not under sedation are frequently at the discretion of the patients of our health care center. We observed that deep sedation, for mitigating the stress of insertion of the esophagagstoprope, remained choosy in about half of the patients who continued to undergo the immediately successive colonoscopy. The risks of hypercapnia may be increased in CO₂-insulated colonoscopy but the common non-invasive end-tidal CO₂ appliance is not accurate enough to serve in non-tracheal intubated patients with respiratory depression. In this study, we applied another non-invasive whole body CO₂ monitor, the transcutaneous capnography (TcCO₂), throughout the entire course of colonoscopy with air or CO₂ insufflation. The goals of this observational study were to investigate the changes of whole body CO₂ during air- or CO₂-insufflation especially concerning with deep sedation and to clarify if there is an interaction of CO₂ insufflation and deep sedation to cause hypercapnia, and compare the effects with those of conscious-sedation or awake colonoscopy.

2. Materials and methods

2.1. Patients

After the approval of the Institute Research Board Committee, 104 patients requesting sequential screening esophageagastroscopy and colonoscopy for health check were included in this study. Among them 12 chose to undergo the procedures awake and 92 requested sedation. After acquiring patients’ informed consent, past history was obtained and general physical condition was assessed pursuant to ASA (American Society of Anesthesiologist) classification. Those patients with smoking habit, age <16 or >80 years old, body mass index >28 and severe cardiac or respiratory disease (ASA physical status >3) were excluded.

2.2. Sedation and monitoring

Prior to the procedure, all patients were placed in the left lateral decubitus position, given oxygen at a rate of 4 L/min via a nasal prong and monitored on ECG, NIBP and pulse oximetry. Intravenous sedation was given by an anesthesiologist before performing esophageagastroscopy with 2.5 mg midazolam and 0.55 mg alfentanil followed by incremental doses of midazolam (0.5 mg/mL) and alfentanil (0.11 mg/mL) till the sedation level was deep enough for inserting the endoscope smoothly without coughing and retching. Esophageagastroscopy was performed under air insufflation first. TcCO₂ (TCM4 TC-CO₂/O₂ Radiometer, Copenhagen, Denmark) sensor was also attached to the derma of the left forearm, where the brachial artery underlay and then heated up to a constant surface temperature of 45 °C as calibrated.

2.3. Sedation levels

After esophageagastroscopy, sedation level was reevaluated before performing colonoscopy by the observing anesthesiologist who was not involved in drug administration. The sedation levels were categorized into consciousness (drugs induced depression of consciousness, respond purposefully to verbal commands) and deep sedation (not responsive to verbal commands but responsive purposefully with repeated or painful stimulation).

2.4. Colonoscopy with CO₂ or air insufflation

The esophageagastroscopy and the successive colonoscopy were performed by a single experienced endoscopist of the health care service. After esophageagastroscopy, patients were randomly assigned to air insufflations group or CO₂ insufflation colonoscopy group based on the date of examination assigned to air or CO₂ insufflation (Air group: 24 Males, 34 Females and CO₂ group: 20 Males, 26 Females). Olympus UCR intra-luminal insufflation unit was applied to deliver CO₂ or air. The patients, the anesthesiologist and the observing anesthesiologist were blinded to which gas was used and the endoscopy assistant was responsible for operating the unit. Colonoscopy was considered successful when the scope could reach the cecum for thorough examination or polypectomy with the patient in placid condition.

2.5. TcCO₂ monitoring during colonoscopy

Recording of TcCO₂ and SpO₂ was begun just before gas insufflation for the colonoscopy and continued every minute thereafter until the end of colonoscopy. Hypoxemia (SpO₂ < 90%) was documented if occurred. The time and TcCO₂ value when the colonoscope reached the cecum, evacuated from the rectum and the peak TcCO₂ were recorded. Total doses of midazolam and alfentanil were also recorded.

After the colonoscopy, patients were sent to the recovery room for close watch until consciousness, physical activity, respiratory function and hemodynamic returned normal.

2.6. Statistical analysis

All statistical analyses were processed with the Sigmastat v.3 by SPSS. Quantitative data were expressed by mean ± SD, (median min—max.). Significant differences at each time point between groups were analyzed with the two way repeated measures ANOVA. A multiple comparison procedure was done to isolate which group(s) differ from the others with interactions in both conscious-sedation and deep sedation groups. The correlation between TcCO₂ at the start, the end and the peak was assessed by Pearson correlation coefficient. A p value less than 0.05 was considered statistically significant.

3. Results

3.1. Patients’ demographic data

104 patients were enrolled in this study, of whom 58 were allocated in the air insufflated colonoscopy group and 46 in CO₂-insufflated colonoscopy group. For the colonoscopy, there were 12
patients in the awake group, 40 in conscious-sedation group and 52 in the deep-sedation group after reevaluation of the anesthesiologist. The patient characteristics, examination time (to cecum, to the end of colonoscopy) and TcCO2 at the beginning of colonoscopy are shown in Table 1. The demographic data were comparable between air and CO2 insufflation groups. The drugs given to two groups were comparable as follows: midazolam 4.1 mg and alfentanly 0.8 ± 0.2 mg in conscious-sedation, air-insufflation group; midazolam 4.1 ± 0.8 mg and alfentanly 0.8 ± 0.2 mg in deep-sedation, air-insufflation group; midazolam 3.6 ± 0.7 mg and alfentanly 0.7 ± 0.1 mg in conscious-sedation, CO2-insufflation group; and midazolam 4.0 ± 0.8 mg and alfentanly 0.8 ± 0.2 mg in deep-sedation, CO2-insufflation group. The examination time was longer in the awake group but there was no significant difference between other groups. There were significantly different baseline TcCO2 between different sedation groups. TcCO2 at the beginning of colonoscopy was highest in the deep-sedation groups than in the conscious-sedation groups and lowest in the awake groups (p < 0.01). Hypoxemia (SpO2 < 90%) was found in 4 patients in the deep-sedation groups (3 in awake group, 1 in CO2 group). No patients had newly developed arrhythmias or forearm burn injury related to the TcCO2 heating probe. After the colonoscopy, all sedated patients left the recovery room within 15 min without complaining of headache or confusion.

Table 2
The number of hypoxemia (SpO2 < 90%) and TcCO2 from the beginning, through the peak and at the end of colonoscopy.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Air insufflation</th>
<th>CO2 insufflation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Awake (n = 4)</td>
<td>Conscious (n = 24)</td>
</tr>
<tr>
<td></td>
<td>Awake (n = 8)</td>
<td>Conscious (n = 16)</td>
</tr>
<tr>
<td>Number of hypoxemia</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>TcCO2</td>
<td>40 ± 6.1</td>
<td>46.9 ± 4.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peak TcCO2</td>
<td>43.5 ± 3.7</td>
<td>50.5 ± 5.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>End of colonoscopy</td>
<td>42.5 ± 4.4</td>
<td>48.5 ± 5.4</td>
</tr>
</tbody>
</table>

Data are presented as mean ± SD or n.

*Significantly different (p < 0.01) with the data of awake group.

4. Discussion

The main results from our study were: 1) Unlike conscious-sedation colonoscopy, a significant further increase of TcCO2 which peaked when the scope reaching around the cecum was found in deep-sedation colonoscopy either with CO2 or air insufflations. 2) CO2 insufflation, as compared with air insufflation, did not increase TcCO2 further with prolongation of the procedure and large-volume gas insufflation even in deep sedated patients.

Our data comparably reconfirmed the state of TcCO2 in conscious-sedation group as previous reports did.10,11 However, this is the first report which compared the risk of hypercapnia of CO2-insufflated colonoscopy with air in deep sedation. Besides deep sedation which bore significantly higher TcCO2 from the beginning, a significant hypercapnia was shown in this study during CO2- or air-insufflated colonoscopy. However, the risks of hypercapnia were considered limited in our patients because the highest TcCO2 in this study remained still within the margin of safety in healthy adults as it was comparable to the state of PaCO2 during sleep.12

Although conscious-sedation was thought to be ideal for colonoscopy, in general, it is not uncommon that deep sedation is necessary for some patients who meet difficult colonoscopic procedures. To achieve adequate sedation for GI endoscopy, the choices of sedatives and analgesics are diverse13 and mostly depend on the patients’ selection.14 However, the comparable dosage of drugs we used showed that TcCO2 was higher in deep sedation due to dose variation between patients rather than the drug dosage applied. Our results further confirmed the importance of monitoring consciousness. Although in this study, we could not conclude that the higher TcCO2 is due to deep-sedation level, the correlation between TcCO2 and sedation levels throughout the colonoscopy...
indicated the higher and variant CO2 threshold of respiratory drive under deep sedation. The elimination of whole body CO2 depends on the respiratory CO2 threshold that returned normal with the recovery of anesthesia. In this study, CO2 threshold that was strictly held within 4 mmHg in awake patients even with prolonged CO2-insufflated colonoscopy.

Standard practice to monitor whole body CO2 requires obtaining the partial pressure of CO2 from arterial blood gas analysis (PaCO2). Non-invasive continuous CO2 monitoring such as end-tidal CO2 (ETCO2) and TcCO2 are both effective. ETCO2 monitor correlated well from PaCO2 in tracheal intubated patients; however, it could dissociate with PaCO2 in spontaneous breathing patients with respiratory depression under deep sedation. Although our results confirmed that the risk of hypercapnia is not increased by CO2-insufflated colonoscopy, TcCO2 monitoring is still valuable to ensure the recovery of ventilatory threshold and should be implemented in patients with impaired ventilatory response to hypercapnia as described in previous report.

There are limitations in our study, of which smaller sample size of the awake groups stands out, due to reluctance that only 12 patients chose wakefulness. We believe that even with larger sample size, the values of TcCO2 and the range of changes in TcCO2  would be similar. Another limitation is that the baseline TcCO2 before sedation and that afterwards in the recovery room are lacking, thus we can not conclude that deep sedation also induces higher TcCO2 before colonoscopy. The third limitation is that the sedation levels chosen depend on the need of performing esophagogastroscopy but not randomized for colonoscopy. Sequential gastroscopy and colonoscopy are not a standard clinical practice but were chosen by over 95% of our patients in health care center.

Our study demonstrated that the whole body CO2 during colonoscopy and conscious-sedation or deep sedation closely correlated independent of application of CO2 or air insufflation. The risk of hypercapnia will be increased with deep sedation although it is limited in normal patients under close monitoring. However, TcCO2 is still valuable to be applied to patients who need deep sedation or are subjected to prolonged gastroenteroscopic procedures especially those with impaired ventilatory response to hypercapnia such as in COPD and sleep apnea syndrome.

Fig. 1. Transcutaneous CO2 at start of colonoscopy, at the peak TcCO2 and at the end of colonoscopy under conscious-sedation and deep sedation with air- and CO2-insufflation. *Significantly different (p < 0.01) with the data between conscious-sedation (solid) and deep sedation (hollow) groups. **Significantly different to the data at the start of colonoscopy (p < 0.01) Data are presented as means ± SE.

References