Computed Tomography Colonography: Patient Tolerance to CO₂ Insufflation

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Abstract

Computed Tomography (CT) colonography, also known as “virtual colonoscopy” is a relatively new technique for colorectal evaluation. It allows imaging of the colonic mucosa and wall similar to those obtained during conventional colonoscopy. The aim of the present study was to investigate patient tolerance to carbon dioxide (CO₂) insufflation during CT colonography and whether the CO₂ insufflation was adequate to distend the bowel sufficiently for radiological diagnosis. This study also aimed to demonstrate a relationship between patient age and patient tolerance to CO₂ insufflation. This research investigated 22 patients (50 per cent male, mean age 64 years) with a variety of clinical indications. CO₂ was insufflated through a rectal catheter to the maximum extent of patient tolerance. Volumetric data of the abdomen and pelvis was acquired in a single breathhold using a GE Lightspeed Plus multislice CT scanner with the patient in the supine and prone positions. The CO₂ insufflation time for the supine and prone series was recorded and the patients rated their tolerance to the CO₂ insufflation based on a modified Likert scale. The results were analysed using scatter graphs and Pearson’s Correlation Coefficient, mapping the CO₂ insufflation time for the prone and supine series and comparing it to patient age. The findings indicate that there was a statistical significance between patient age and patient tolerance (r=-0.47), however, no statistical significance was found between the other variables. This may be due to several reasons including variable bowel length and a small sample. Additional studies are required with a larger sample in order to further investigate this topic.

INTRODUCTION

Colorectal cancer is one of the most common non skin malignant diseases affecting both men and women in Australia. The risk of developing colorectal cancer increases with age and in those with genetic risk factors. It is believed that most cancers arise from pre-existing adenomatous polyps. Detection and removal of these polyps can prevent the disease from occurring and has been associated with a reduction in the prevalence of colorectal cancer and colorectal mortality. It can take from 10 to 15 years for an adenomatous polyp to become an invasive cancer. Thus, there is a considerable time for detection and clinical intervention if the proper screening methods are used. Colonoscopy can, in most cases, visualise the entire colon and is the “gold standard” of examination methods. However, the procedure does not permit passage through obstructions or twisted portions of bowel. Furthermore, colonoscopy is associated with the risk of bowel perforation, mortality and is invasive. These disadvantages can result in decreased patient compliance.

Computed Tomography (CT) colonography (“virtual colonoscopy”) is a relatively new technique that attempts to solve some of the problems associated with conventional colonoscopy. It allows the study of inside wall and outside of the colon, designed to make delineation of colonic lesions such as polyps easier. Patients require full colonic evacuation, insufflation and data acquisition with the patient in the supine and prone positions. Previous research has focused on the areas of determining appropriate bowel cleansing methods prior to the examination, the appropriate technique of CT colonography (comparison of multislice and single slice) and in determining the sensitivity and specificity of detecting colorectal polyps using CT colonography as compared to conventional colonoscopy and other techniques.

However, patient acceptance is one of the most important factors in the analysis and determination of the success of the CT colonography examination. To date there is limited research published concerning patient acceptance and tolerance of CO₂ insufflation for adequate distension during CT colonography. The major cause of poor patient acceptance is due to the bowel preparation, perception of embarrassment and abdominal discomfort from the CO₂ insufflation. Conversely, patient acceptance of CT colonography was found to be more comfortable when compared with other full colonic examinations such as barium enema or colonoscopy. In a study by Dr Maria Svensson from the Sahlgrenska University Hospital in Sweden, patient satisfaction, discomfort and embarrassment was assessed by questionnaires to patients who underwent CT colonography immediately followed by conventional colonoscopy. Overall, 69 per cent of patients considered colonoscopy to be more difficult. CT colonography was not considered to be painful by 57 per cent of patients compared with 26 per cent for colonoscopy. More patients rated their pain higher during colonoscopy than CT colonography. The major complaint from patients was the discomfort from insufflation of the colon during CT colonography. An optimal CT colonography study requires a clean well distended colon to prevent mucosal surfaces from collapsing. Because accurate diagnosis relies on adequate insufflation, poor colonic distension can lower the examinations sensitivity to unacceptable levels. Insufflation is important because polyps cannot generally be detected in collapsed colon segments. Therefore, as distension worsens, so does the accuracy of the examination. The degree of distension is dictated by patient tolerance which is increased by the use of spasmylic agents such as Hyoscine Butylbromide. However, the benefit of the spasmylic agents is controversial. Hung et al. investigated the quantification of distension in CT colonography using three computer algorithms and another study by Svensson examined bowel wall visualisation during CT Colonography. It was reported that incomplete air filling was most common in the sigmoid colon but scanning and review in the supine and prone positions...
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compensated for the incomplete distension and provided complete or almost complete visualisation of the bowel wall. This investigation was similarly studied by Yee et al., who concluded that colonic distension was significantly improved by using supine and prone scanning. Several other studies have been done evaluating patient acceptance of CT colonography, the results indicating an acceptable examination for patients with low levels of pain and discomfort and a high likelihood of having the examination repeated in the future.

Given the key influence of patient tolerance and distension on CT colonography, it was hypothesised that it would be beneficial to develop an experiment assessing the amount of CO₂ insufflation related to bowel distension. Therefore, the aim of this study was to investigate patient tolerance to CO₂ insufflation during CT colonography and whether the CO₂ insufflation was adequate to distend the bowel sufficiently for radiological diagnosis. Furthermore, this study also aimed to demonstrate a relationship between patient age and patient tolerance to CO₂ insufflation.

METHODS AND MATERIALS

Subject Description

This study was conducted over a seven week period in a medium size private hospital and was approved by the radiology department and the University of Sydney. Twenty-two patients were included in the study which consisted of 11 men (50 per cent) and 11 women (50 per cent), mean age was 64 years, range 34-87 years. The main clinical indications were diverticular disease, abdominal pain, previous polyps removed, unsuitable for colonoscopy, rectal bleeding, constipation and screening. There were no specific criteria for subject selection because a variety of age groups and socio-economic backgrounds were required. Nine patients referred immediately following failed colonoscopies did not require as much CO₂ insufflation due to a partially distended bowel from the conventional colonoscopy and consequently were excluded from the study. A typical examination time was approximately 15 minutes in total.

Patient Preparation

In preparation for CT colonography, the colon needs to be prepared with various regimes to remove faeces that interfere with interpretation. Two days prior to the examination, patients commenced a low fibre diet and one day prior, patients were allowed only a clear liquid diet. In addition, patients were required to dissolve two sachets of Colonlytely (sodium sulphate solution) in a total of four litres of water, drinking at a rate of 1 litre/hour beginning in the afternoon prior to the examination. Patients were required to fast six hours prior to the procedure.

On the day of the examination, patients were asked to evacuate their rectum immediately prior to the examination. To reduce bowel peristalsis and optimise bowel distension an intravenous injection of 20mg of Buscopan (Hyoscine Butylbromide) was given. A small rubber catheter (16 Fr - 6mm Foley's catheter) was inserted into the rectum of the patient and gentle CO₂ insufflation was administered (rate of 1ml/second). CO₂ has a steep diffusion gradient across the colonic wall and is
resorbed rapidly and it is thought to decrease patient discomfort and post examination flatulence. Patients were encouraged to hold on to the CO\textsubscript{2} but asked to let the technologist know when they were beginning to feel uncomfortable. Generally this signalled that the colon was well distended, however, a set time for insufflation was not used since the length of a person’s colon is variable. Additionally, an incompetent ileocecal valve will require more insufflation as CO\textsubscript{2} escapes into the small bowel.\textsuperscript{15}

### Image Acquisition

After insufflation, the catheter was clamped off and a single supine scout image was obtained to verify adequate bowel distension (Figure 1). If adequate bowel distension was present, the CT examination was performed but if insufficient distension was achieved (Figure 2), additional CO\textsubscript{2} was administered. Patients were scanned first in the supine position in a cephalo-caudad direction encompassing the entire colon and rectum and then placed in the prone position. Additional CO\textsubscript{2} was given in the prone position. Following a second scout localising image, the process was repeated over the same z-axis range. Supine and prone imaging doubles the radiation dose but was essential to allow optimal bowel distension, redistribution of residual fluid and differentiation of faecal material from polyps since visualisation of mobility of a filling defect implies residual faecal material.\textsuperscript{16}

A multislice CT scanner (GE Lightspeed Plus) was used with a 4 X 2.5 mm slice detector configuration, 120kV, 0.5 sec gantry rotation and 200 mA. A pitch of 1.5 was used so that the entire abdomen and pelvis was covered within a 15-20 second breathhold. CT slice thickness was 2.5mm with a 1.25mm reconstruction interval on a standard algorithm and a 512 x 512 reconstruction matrix. Acquired images were sent through an ethernet network to a dedicated workstation equipped with software that allowed generation of coronal, sagittal and 3D endoluminal images with volume rendering. The images were evaluated by a radiologist.

### Data Collection

During the examination different variables were recorded on the data results sheet (Appendix 1) including the patient age, CO\textsubscript{2} insufflation rate and time for supine and prone series, clinical indications, whether insufflation was adequate and any additional comments. The time was determined using a stop watch and the rate recorded from the CO\textsubscript{2} cylinder. After the examination the patient’s tolerance to the CO\textsubscript{2} insufflation was assessed. Patients were required to answer a question designed to assess the degree of discomfort they experienced with the whole procedure and specifically with the administration of CO\textsubscript{2}. However, because tolerance is a subjective response which is classified as “intangible personal experiences”\textsuperscript{20} an arbitrary grade of increasing intensity was identified and each grade was assigned a numerical score. Assessing patient tolerance to CO\textsubscript{2} insufflation was based on a five level threshold modified Likert scale\textsuperscript{20} using the response alternatives defined in Table 1.

### Statistical analysis

The results of the examination were tabulated (Appendix 1 – Table 2) and analysed using scatter graphs and Pearson’s correlation coefficient, mapping the CO\textsubscript{2} insufflation time for the prone and supine series and comparing it to patient age. In addition, patient tolerance was compared to patient age. The mean values were calculated for the quantitative variables when appropriate.

### RESULTS

Twenty-two patients had a CT colonography examination. Nineteen examinations based on the radiologist’s report were rated as excellent distension enabling visualisation of the mucosal wall and three examinations were reported as only adequate due to inadequate distension in the sigmoid colon on the supine series. Seven supine series had to be repeated due to inadequate insufflation on the scout views consequently resulting in the addition of extra CO\textsubscript{2}. 31 per cent of patients considered the CO\textsubscript{2} insufflation to be painful or unbearable. The majority (69 per cent) of patients found the CO\textsubscript{2} insufflation to be mod-

### Table 1: Tolerance Ranking Scale

<table>
<thead>
<tr>
<th>Rating</th>
<th>Description</th>
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<tr>
<td>5</td>
<td>Tolerance (tolerable and doesn’t interfere with functioning of examination)</td>
</tr>
<tr>
<td>4</td>
<td>Mild discomfort (starting to become troublesome, perceived consciously)</td>
</tr>
<tr>
<td>3</td>
<td>Moderate discomfort (become restless and irritable, causing mild stress)</td>
</tr>
<tr>
<td>2</td>
<td>Painful discomfort (patient complaining)</td>
</tr>
<tr>
<td>1</td>
<td>Unbearable discomfort or intolerable (patient moaning, writhing, not able to continue)</td>
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Figure 3  CO₂ Insufflation Time Supine Series Vs Patient Age

Figure 4  CO₂ Insufflation Time Prone Series Vs Patient Age

erately or mildly uncomfortable. The major variables compared were CO₂ insufflation time and adequate bowel distension for radiological diagnosis, CO₂ insufflation time supine series and patient age (Figure 3, 4), CO₂ insufflation time and patient tolerance (Figure 5) and lastly patient tolerance and patient age (Figure 6). The mean overall tolerance rating was 2.8 and the mean insufflation time for the supine series was 1.77 minutes and prone was 0.48 minutes. A Pearson’s correlation coefficient (r) was determined for several variables. There was no association found with patient age and CO₂ insufflation time (r=0.04) and CO₂ insufflation time and patient tolerance (r=0.03). However, there was a positive correlation of patient age and patient tolerance (r=0.47), as the patient age increases, patient tolerance decreases.

DISCUSSION
CT colonography is a minimally invasive diagnostic method with huge potential for screening of colorectal cancer, post polypectomy and for abdominal disorders. In this study, patient tolerance of CO₂ insufflation during CT colonography was examined and whether the insufflation was adequate for radiological diagnosis. Previously published studies evaluated patient acceptance to CT colonography compared with conventional colonoscopy. Of the 22 patients involved in this study, 19 examinations based on the radiologists report were rated as having excellent distension enabling visualisation of the mucosal wall and three examinations were reported as only adequate. The three examinations that resulted in reduced distension resulted from ileocaecal valve incompetence and therefore CO₂ escaped into the small bowel. This caused suboptimal distension within the sigmoid colon. In addition, several patients were diagnosed with diverticular disease which can also affect the degree of distension within the bowel. However, scanning in both the supine and prone positions allowed visualisation of the
bowel wall within the sigmoid colon. This is consistent with Svensson’s (2002) findings\textsuperscript{15} that prone and supine review can compensate for incomplete distension as collapsed colonic segments can mimic a tumour. In addition to positional change, multiplanar reformats helped confirm normal collapsed haustral folds whilst the endoluminal view demonstrated a smooth mucosal surface in the collapsed segment where some residual gas was present.\textsuperscript{9} Within this study, 31 per cent of patients considered the CO\textsubscript{2} insufflation painful or unbearable and 69 per cent of patients found the CO\textsubscript{2} insufflation to be moderately or mildly uncomfortable. This is similar to the study by Langhi et al.\textsuperscript{13} which found that discomfort was graded as low by 68 per cent of patients, moderate by 30 per cent and high by two per cent. Patients that tolerated a time less than 1.25 minutes on the supine run were found to have inadequate distension and required additional CO\textsubscript{2}. Similarly patients with a CO\textsubscript{2} insufflation time on the prone series less than 0.25 seconds also produced suboptimal distension and required additional CO\textsubscript{2}. Therefore, these times could be used as an indicator to determine an appropriate amount of CO\textsubscript{2} insufflation in order to achieve optimal bowel distension for radiological diagnosis. However, because the length of a person’s colon is variable and patients have different thresholds of pain tolerance determining a specific time for CO\textsubscript{2} insufflation is inappropriate. Rather it can be used as a guide to indicate when a suitable amount of CO\textsubscript{2} has been insufflated for adequate distension of the bowel.

The results of this study indicated that there was a positive correlation of patient age and patient tolerance ($r$=-0.47). As the patient age increases, patient tolerance decreases. This may be due to the presence of anal sphincter incontinence in older individuals which causes the CO\textsubscript{2} to escape. This requires the addition of more CO\textsubscript{2} resulting in longer examination times and greater discomfort for the patient. Therefore, this can result in
older patients having a decreased tolerance to the procedure. Additionally, because the local community is of Italian origin, a majority of the older patients included in the study were Italian speaking. Consequently, because of the language barrier they may have misunderstood the explanation of the procedure. Thus, they found the CO₂ insufflation painful and rated their tolerance lower.

Conversely, when comparing patient age and CO₂ insufflation time there was no statistical significance found (r=0.04). As mentioned previously, this can be attributed to the variable length of a person’s colon and accordingly, patient age cannot be related to the time of CO₂ insufflation. This may also explain why there was no statistical significance found when CO₂ insufflation time and patient tolerance were compared (r=0.03). Because tolerance is a subjective factor and patients vary in their pain threshold, a time that is adequate for optimal distension in one patient, may not be tolerated by another.

In addition, the Pearson’s value r may not be statistically significant because of several limitations inherent within the study. These include the limited sample size and the short collection time. The sample size was dependent on the number of CT colonography patients referred by doctors to the department within the time frame. Consequently, the small sample size employed made it difficult to translate these observations to the population level and therefore the results were not generalised. As a result, this study could be described as a pilot study which can lead to further investigation using a larger sample over a longer period of time. The number of subjects may be unrepresentative of the various subject ages and socio-economic background, again due to the short period of time for the experimental work, the age group of patients that are examined within the department and the surrounding local community.

CONCLUSION

CT colonography is an interesting area of investigation which is still in the process of evolution as an imaging and screening tool. It is quick, minimally invasive, is well tolerated and has the potential to become an effective radiological tool in diagnosing colonic lesions. Patient acceptance and tolerance of CO₂ insufflation is a topic with limited previous research. Increased patient age was found to have a positive correlation with decreasing patient tolerance. However, there was no statistical significance between CO₂ insufflation time and patient age and CO₂ insufflation time and patient tolerance. Additional studies are required with a larger sample in order to further investigate this topic.

REFERENCES


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