COMPUTED TOMOGRAPHY COLONOGRAPHY – THE PROCEDURE IN OUR DAYS. LITERATURE REVIEW

KOMPIUTERINĖS TOMOGRAFIJOS KOLONOGRAFIJA ŠIANDIEN. LITERATŪROS APŽVALGA

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ABSTRACT
Key words: virtual colonoscopy, CT colonography, colon cancer, colon polyps.

Colorectal cancer is a common malignancy that results in significant morbidity and mortality. It is a curable disease if detected early and may be prevented if precursor adenomas are detected and removed. One of noninvasive examination methods of the colon is computed tomography colonography. Computed tomography colonography has been shown to be sufficiently accurate in detecting colorectal neoplasia. Recent data about examination was collected from MEDLINE and Pubmed databases. This article reviews current indications, contraindications and methodology of computed tomography colonography. We describe computed tomography colonography Reporting and Data System and discuss the accuracy of computed tomography colonography based on recent reports and literature data. We conclude that computed tomography colonography is safe and effective colon examination method, especially when carried out properly. Probability of complications of this procedure is very low with minimal discomfort for the patient. The noninvasive nature of computed tomography colonography may be attractive to patients, and the use of this modality may improve screening compliance and diagnostic rates.

SANTRAUKA
Reikšminiai žodžiai: virtuali kolonoskopija, KT kolonografija, storosios žarnos vėžys, storosios žarnos polipai.

INTRODUCTION

Colorectal cancer is the second leading cause of cancer mortality in Europe. Each year approximately 435,000 people are newly diagnosed with colorectal carcinoma (CRC) [1]. It is a curable disease if detected early and may be prevented if precursor adenomas are detected and removed. Computed tomography colonography (CTC), also called virtual colonoscopy, has made great progress over the years, and is becoming more and more popular. With the advent of faster computed tomography scanners and powerful computer software, examinations are performed more quickly with less patient radiation exposure providing the radiologist data that allow accurate polyp detection using two- and three-dimensional imaging [2].

In the article we review the literature data about CTC methodology, indications and contraindications, complications and CTC accuracy for detection colon cancer and polyps.

OBJECTIVE

CT colonography, also known as virtual colonoscopy, is a technique that uses data generated from CT imaging of the fully cleaned and gas-distended colon to generate two-dimensional (2D) and three-dimensional (3D) images of the colon. It was first reported by Vining et al. in 1994 as a rapid, noninvasive imaging method to investigate the colon and rectum [2].

CTC is an alternative diagnostic test to colonoscopy diagnosing colorectal cancer and polyps [3]. Up to now, on-going debate continues on CTC suitability of the screening. Despite the evidence that it can be as sensitive as optical colonoscopy for large polyps and cancer detection it is not yet recommended as a routine screening tool by all organizations. To date, no studies have been published assessing reduction in CRC incidence or mortality. The majority of studies have focused on comparing the characteristics of this method with colonoscopy [4]. A number of meta-analyses to determine the accuracy of this study were carried out. CTC is a potential screening test, with an estimated sensitivity of 88% for advanced neoplasia ≥ 10 mm [5]. In recent systematic review and meta-analysis CTC was mostly an effective diagnostic technique for lesions > 6 mm with an average sensitivity of 68.35% for lesions of all sizes. Sensitivity for detection of lesions >6mm was calculated at 76.24%, increasing to 77.55% for lesions > 10 mm. It follows that the results of CTC improves with large size lesions and shows that CTC compares favorably with optical colonoscopy for detection of larger polyps (> 6 mm) [6].

Barium enema examination accurately identifies late-stage cancer, but it is a poor test for important cancer-precursor lesions [7] and is rarely used for colorectal-cancer screening today.

PATIENT PREPARATION

The purpose of the bowel preparation for CTC is to minimize or eliminate the negative effect of stool on the interpretation of the examination. Three major approaches have been undertaken: cathartic-only, tagging-only, and complete cathartic/tagging strategies. Whereas the first two approaches have demonstrated adequate polyp sensitivities in high-prevalence cohorts, only the complete cathartic/tagging strategy has demonstrated effective polyp detection rates in the intended cohorts of low-prevalence or screening populations [8]. Fecal and fluid tagging is a promising technique being evaluated to replace standard bowel cleansing. It may be performed with or without electronic bowel cleansing. The patient ingests small amounts of barium or iodinated oral contrast medium with meals prior to CTC. The high attenuation contrast medium incorporates within the residual stool facilitating differentiation from polyps. When electronic bowel cleansing techniques are used (“digital cleansing”), the high attenuation tagged stool is segmented from the data leaving only the colonic mucosa and filling defects which are attributed to polyps and cancerous masses [2].
EXAMINATION TECHNIQUE
Adequate colon distension should be obtained to visualize the complete colonic lumen and optimal scan parameters should be used to prevent unnecessary radiation burden. For optimal distension, automatic carbon dioxide or manual room air insufflation should be performed, preferably via a thin, flexible catheter [2, 9] (Figure 1). If we use automatic insufflator for colon distention, usually about 3 liters of carbon dioxide is used. Manually we insufflate room air until the patient indicates discomfort.

Hyoscine butylbromide or glucagone (when available) – are the spasmolytic agents because of the positive effect on insufflation and pain/burden [10]. Scans in two positions – prone and supine – are required for adequate distension and high polyp sensitivity and decubitus position may be used as an alternative for patients unable to lie in prone position. The great intrinsic contrast between air or tagging and polyps allows the use of low radiation dose. The low-dose protocol without intravenous contrast agent should be used when extracolonic findings are deemed unimportant. The normal abdominal CT scan protocols with intravenous enhancement should be used in supine position for the evaluation of extracolonic findings in patients suspected for colorectal cancer [9]. If we perform CTC study with intravenous contrast agent, the native scan is performed in prone patient position and a scan with contrast agent in supine position. Only portovenous contrast phase is usually recommended. The amount of contrast agent is chosen depending on the body weight of the patient.

DATA VISUALIZATION AND INTERPRETATION (C-RADS)
After scanning acquired CT data are transferred onto a dedicated postprocessing work station equipped with navigator software, permitting the radiologist to obtain multiplanar reformations as well as to construct an endoluminal model of the air-distended colon, allowing fly-through capabilities in the distended colon in both the antegrade and retrograde directions. Workstations allow simultaneous viewing of the 3D and 2D images and also provide a 3D map of the colon indicating the position along the colon of the area being viewed [2] (Figure 2).

All colonic findings are described according to C-RADS (CT Colonography Reporting and Data System) [11] (Table 1).

CTC INDICATIONS, DIAGNOSTIC ADVANTAGE AND DISCUSSION
Laghi A. (2012) in recent article summarise indications for CTC [12]. Incomplete colonoscopy is the most important and accepted indication. It completely replace barium enema and is recommended by AGA (American Gastroenterological Association) since 2006 [13]. CTC we can choose for elderly patients unfit for colonoscopy (CC) for the purpose of avoiding excessive risk at CC; in such case this procedure achievable with reduced preparation since target lesions are cancers and not polyps.

CT colonography is suitable in case of asymptomatic diverticular disease for extension and severity assessment of diverticulosis. Colon mapping are similar to barium enema (BE), in addition CTC is more accurate than BE, preferred by patients, with a shorter room time, fewer complications, lower radiation exposure [14].

Table 1. CT Colonography Reporting and Data System: CT colonography findings and follow-up recommendation (our adapted from [11])

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>C0</td>
<td>Inadequate study/Awaiting Prior Comparison</td>
<td>Inadequate preparation or insufflation</td>
</tr>
<tr>
<td>C1</td>
<td>Normal Colon or Benign Lesion; Continue Routine Screening</td>
<td>No polyp≥6 mm; lipoma or diverticula</td>
</tr>
<tr>
<td>C2</td>
<td>Intermediate Polyp or Indeterminate Finding; Surveillance or Colonoscopy Recommended</td>
<td>Intermediate polyp 6-9mm, &lt;3 in number</td>
</tr>
<tr>
<td>C3</td>
<td>Polyp, Possibly Advanced Adenoma; Follow-up Colonoscopy Recommended</td>
<td>Polyp ≥10mm; ≥3 polyps, each 6-9mm</td>
</tr>
<tr>
<td>C4</td>
<td>Colonic Mass, Likely Malignant; Surgical Consultation Recommended</td>
<td>Lesion compromises bowel lumen, demonstrates extracolonic invasion</td>
</tr>
</tbody>
</table>
Colonoscopy has a considerable error rate for localization of colorectal cancer, especially when previous colorectal procedures have been performed. Without accurate localization and definitions of margins, the surgeon may resect the wrong segment or incompletely remove the tumor, and this is especially important with the advent of laparoscopic surgery and the loss of the ability to palpate the colon [15]. So with the help of CTC we can accurately detect localization of the tumor and synchronous lesions and/or polypectomy site before a laparoscopic surgery.

CTC is a potential technique for colorectal carcinoma screening. Studies on the impact of CTC screening on CRC incidence or mortality have not yet been conducted. Seven systematic reviews and metaanalyses on CTC performance characteristics in comparison to colonoscopy [16–22] reported that sensitivity was low for small polyps and increased with polyp size (Table 2 and Table 3).

In accordance with “European guidelines for quality assurance in colorectal cancer screening and diagnosis” (2010) – “New technologies under evaluation are not recommended for CRC screening by the EU”.

Virtual colonoscopy is recommended in the United States for first-line screening in high- and medium-risk patients. Only the patients with one or more polyps measuring more than 9 mm detected by that procedure are referred for optical colonoscopy. In this strategy, polyps measuring less than 6 mm are deliberately disregarded, while for polyps measuring 6-9 mm, the patient has the choice between monitoring with future colonography procedures or undergoing colonoscopy to remove the polyp [23]. At the moment CC should be recommended as the first choice, whereas CTC to be offered in those who refuse or are unwilling to undergo CC [12].

When used for surveillance after surgery for CRC cancer, CTC with intravenous contrast enhancement combines the ability of detecting polyps and cancer with an accuracy that is similar to CC, and, at the same time, it offers the evaluation of extra-colic findings (regional and distant lymphadenopathies and liver metastases) [12].

During the CTC we can determine or suspect any changes, however, it is not possible to take a biopsy as we would do during CC. CTC is very sensitive to small changes, but is not as specific in assessing the nature of changes as CC is.

**CTC CONTRAINDICATIONS**

Contraindications are: intestinal obstruction syndrome, acute abdomen syndrome, recent abdominal surgery and pregnancy. Difficulties insufflating the colon or positioning the patient may be encountered with obese patients [23]. Absolute contraindications are diverticulitis and acute phase of irritable bowel diseases (IBDs). In the case of sus-

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**Table 2. Meta-analyses and systematic reviews targeted on CTC founded polyps according their size in mixed population of patients**

<table>
<thead>
<tr>
<th>CTC founded polyps according their size per-patient sensitivity</th>
<th>Number of patients</th>
<th>&lt;6 mm</th>
<th>6-9 mm</th>
<th>&gt;9 mm</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pickard et al. (2011) [21]</td>
<td>11 151 (49 studies)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>96.1%</td>
</tr>
<tr>
<td>Chaparro et al. (2009) [43]</td>
<td>10 546 (47 studies)</td>
<td>-</td>
<td>60%</td>
<td>83%</td>
<td>69%</td>
</tr>
<tr>
<td>Rosman et al. (2007) [19]</td>
<td>30 studies</td>
<td>56%</td>
<td>63%</td>
<td>82%</td>
<td>-</td>
</tr>
<tr>
<td>Mulhall et al. (2005) [18]</td>
<td>6393 (33 studies)</td>
<td>48%</td>
<td>70%</td>
<td>85%</td>
<td>70%</td>
</tr>
<tr>
<td>Halligan et al. (2005) [17]</td>
<td>2610 (24 studies)</td>
<td>-</td>
<td>86%</td>
<td>93%</td>
<td>-</td>
</tr>
<tr>
<td>Sosna et al. (2003) [16]</td>
<td>1324 (14 studies)</td>
<td>65%</td>
<td>84%</td>
<td>88%</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>CTC founded polyps according their size per-patient specificity</th>
<th>Number of patients</th>
<th>&lt;6 mm</th>
<th>6-9 mm</th>
<th>&gt;9 mm</th>
<th>Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pickard et al. (2011) [21]</td>
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<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Chaparro et al. (2009) [43]</td>
<td>10 546 (47 studies)</td>
<td>-</td>
<td>90%</td>
<td>92%</td>
<td>83%</td>
</tr>
<tr>
<td>Rosman et al. (2007) [19]</td>
<td>30 studies</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Mulhall et al. (2005) [18]</td>
<td>6393 (33 studies)</td>
<td>92%</td>
<td>93%</td>
<td>97%</td>
<td>86%</td>
</tr>
<tr>
<td>Halligan et al. (2005) [17]</td>
<td>2610 (24 studies)</td>
<td>-</td>
<td>86%</td>
<td>97%</td>
<td>-</td>
</tr>
<tr>
<td>Sosna et al. (2003) [16]</td>
<td>1324 (14 studies)</td>
<td>-</td>
<td>-</td>
<td>95%</td>
<td>-</td>
</tr>
</tbody>
</table>

**Table 3. Meta-analysis targeted on nonscreening population with positive fecal occult blood test (Walleser et al. 2007) [20]**

<table>
<thead>
<tr>
<th>Per patient analysis</th>
<th>Number of patients</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polyps ≥10 mm</td>
<td>5 studies</td>
<td>63%</td>
<td>95%</td>
</tr>
<tr>
<td>Cancers</td>
<td>89%</td>
<td>97%</td>
<td></td>
</tr>
</tbody>
</table>
pected diverticulitis and in patients with IBDs presenting with acute symptoms, CTC should be avoided because of the risk of complications. In these conditions, contrast-enhanced multidetector computed tomography is the preferable examination to provide all the necessary information to the clinician [12].

INCIDENTAL FINDINGS IN CT COLONOGRAPHY

In addition to intracolonic findings, CTC examines the entire abdomen and pelvis similarly to a CT scan [24]. Incidental extracolonic findings are classified according CTC reporting and data system [11], it helps to classify significant versus insignificant extracolonic lesions (Table 4).

Veerappan GR. et al. (2010) retrospective study of 2,277 patients undergoing CTC, extracolonic findings were identified in 1,037 (46%) patients, with 787 (34.5%) insignificant and 240 (11.0%) significant findings [25]. Extracolonic incidental findings are more frequent with increasing age and although they are common, only a minority are of high significance [26]. Pickhardt PJ. et al. (2011) study results suggest very interesting findings that small sliding hiatal hernias are commonly induced by colonic distention at CTC and should probably not be reported to avoid inappropriate diagnosis, workup, or treatment [27]. O’Connor examined that renal masses in unenhanced CTC are very common finding, but imaging criteria can be used for reliable identification of most of these lesions as benign without further workup. Mean attenuation alone appears reliable for determining which renal masses need further evaluation [28].

PATIENT PREFERENCE, ACCEPTANCE AND TOLERANCE OF CTC

Von Wagner et al. (2012) the randomized controlled study found that symptomatic patients consider CT colonography as more acceptable than colonoscopy [29]. Patients have also significantly less physical discomfort after CT colonography than after colonoscopy (median colonoscopy score of 39 vs median CT colonography score of 35, P = .001) and experience significantly fewer adverse events. Thomeer M. and colleagues (2002) found that factors other than the discomfort related to the examination play an important role in the patient’s preference for virtual CT colonography, namely the faster procedure, the lower physical challenge, and the absence of sedation [29].

In the studies, when the patients indicated CT colonography as more painful examination, bowel relaxants were not used, and sedatives and analgesics were administered during colonoscopy in all patients [30-33]. In the studies when the patients indicated that CT colonography was a less painful examination, bowel relaxants were routinely administered, and sedatives and analgesics were administered during colonoscopy in a lower proportion of the study population [29, 30, 34, 35].

In a recent study [10], which compare colonic distension and perceived burden of CT colonography between participants receiving hyoscine butylbromide (buscopan) and glucagon hydrochloride as bowel relaxant most frequently reported side effects were a dry mouth in the buscopan group (15%) and nausea in the glucagon group (13%). Compared to glucagon, premedication with buscopan results in significantly more adequately distended colons and a less burdensome procedure. When buscopan can be used, it is the preferred bowel relaxant. The patients experience during both examinations mainly depends on the technique of the procedure.

COMPLICATIONS

Adequate colonic distention is critical for effective performance of CT colonography. Optimal colonic distention (which is distinct from maximal distention) is achieved when diagnostic quality is properly balanced against patient comfort and safety [36]. Perforation of the colon is an exceedingly uncommon complication of CT colonography. An advantage of CT colonography is that unlike colonoscopy it does not require the insertion and maneuvering of an endoscope to the cecum [37]. The first time CTC related perforation was described and published in 2004 by Kamar M. [38]. Therefore, perforation rates for diagnostic colonoscopy are significantly higher than for CT colonography. Colonic perforation is a known risk of conventional colonoscopy screening and ranges between 0.06–0.19 % of cases.

Table 4. CT Colonography Reporting and Data System: Radiologic Method of Categorizing Extracolonic Findings According to Clinical Significance (our adapted from [11])

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
<th>Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>E0</td>
<td>Limited examination: compromised by artifact; evaluation of extracolonic soft tissues is severely limited</td>
<td>Not applicable</td>
</tr>
<tr>
<td>E1</td>
<td>Normal exam or anatomic variant</td>
<td>Retroaortic left renal vein</td>
</tr>
<tr>
<td>E2</td>
<td>Clinically unimportant findings; no work-up indicated</td>
<td>Simple liver or kidney cysts</td>
</tr>
<tr>
<td>E3</td>
<td>Likely unimportant findings, incompletely characterized; work-up may be indicated</td>
<td>Complex kidney cyst</td>
</tr>
<tr>
<td>E4</td>
<td>Potentially important findings; communicate to referring physician as per accepted practice guidelines</td>
<td>Aortic aneurysm, lymphadenopathy</td>
</tr>
</tbody>
</table>
Conclusions
The noninvasive nature of CTC may be attractive to patients, and the use of this modality can improve screening compliance and diagnostic rates. Many people are reluctant to undergo colonoscopy because of its inconvenience or discomfort, or because of embarrassment [41]. Adequate preparation and colon distension should be obtained to visualize the complete colonic lumen for best results.

One of the main disadvantages of CTC is ionizing radiation, but we can apply the low dose protocols when carrying out the scan. If possible, it is recommended to use CTC instead of BE because the CTC is much more sensitive and produces less radiation.

In everyday practice, in Lithuania, we would recommend to start applying this method when CC is incomplete and the whole colon is not inspected. CTC can be prescribed for elderly patients when CC is contraindicated for any side effects. We would recommend the CTC as an alternative for colon cancer screening, especially when the patient refuses the CC.

References


