Wójcik Anna, Kurzepa Joanna, Samek Ilona, Jańczyk Magdalena, Krawiec Paulina, Białek Justyna, Kozioł Magdalena. The importance of CAD and DECT in CT colonography. Journal of Education, Health and Sport. 2021;11(9):187-195. eISSN 2391-8306. DOI http://dx.doi.org/10.12775/JEHS.2021.11.09.024
https://apcz.umk.pl/czasopisma/index.php/JEHS/article/view/JEHS.2021.11.09.024
https://zenodo.org/record/5502484

The journal has had 5 points in Ministry of Science and Higher Education parametric evaluation. § 8. 2) and § 12. 1. 2) 22.02.2019.

Received: 01.09.2021. Revised: 12.09.2021. Accepted: 13.09.2021.

The importance of CAD and DECT in CT colonography

Anna Wójcik M.Sc.[b], Joanna Kurzepa PhD[a], Ilona Samek[c], Magdalena Jańczyk[c], Paulina Krawiec[c], Justyna Białek[c], Magdalena Kozioł[c]

[a]Ist Department of Medical Radiology, Medical University of Lublin, ul. Jaczewskiego 8 20-954 Lublin

[b]Scientific Students Association at the Ist Department of Medical Radiology, Medical University of Lublin, ul. Jaczewskiego 8 20-954 Lublin

[c]Student Scientific Association at Department of Epidemiology and Clinical Research Methodology, Medical University of Lublin, ul. Radziwiłłowska 11, Lublin 20-080, Poland

Corresponding author: Anna Wójcik, anna.m.wojcikpl@gmail.com

ORCID ID:

Anna Wójcik, https://orcid.org/0000-0002-2697-8600, anna.m.wojcikpl@gmail.com

Joanna Kurzepa, https://orcid.org/0000-0002-3659-8556, kurzepa.joanna@gmail.com

Ilona Samek, https://orcid.org/0000-0002-5538-5396, samekilona@gmail.com

Magdalena Jańczyk, https://orcid.org/0000-0002-4948-9463, magdajanczyk7@gmail.com

Paulina Krawiec, https://orcid.org/0000-0002-9527-5837, paulina.krawiec96@gmail.com

Justyna Białek, https://orcid.org/0000-0002-8447-3395, justynabialek111@gmail.com

Magdalena Kozioł, https://orcid.org/0000-0002-8671-5968, magdalena.koziol@icloud.com

ABSTRACT

Introduction

According to the American College of Radiology and the American Cancer Society, CTC has been recognized as a valuable screening method for detecting CRC in people at medium risk as an alternative to endoscopic colonoscopy. The condition for the proper interpretation of this procedure is the patient's preparation for the examination. The evaluation of the test includes: topogram, transverse images (as reference images), multifaceted reconstructions and three-dimensional images (3D navigator).

Materials and methods
The literature on the use of CTC in the diagnosis of CRC was analyzed. A review of the scientific literature indexed in the PUBMED database from the last 10 years was carried out.

Results
The introduction of dual energy computed tomography (DECT) clearly improved the diagnostic accuracy of CTC. The main advantage of DECT is the possibility of obtaining iodine maps and VNC (virtual non-contrast) – a ''virtual'' native image (without the use of contrast). DECT allows you to monitor the results and extent of iodine capture on VNC and iodine map images, respectively, without using pre-recorded tomographic images. Pilot tests showed that DECT is an effective tool in CT colonography diagnostics and electronic colon loop cleaning after barium labeling. The use of the Computer Aided Diagnosis (CAD) algorithm in high energy tomography helps in the diagnosis and detection of intestinal tumors.

Conclusions
The development of modern technologies used in CT colonography proves that it is a safe and acceptable technique for patients. Lack of invasiveness, low radiation dose and high diagnostic efficiency of CTC may encourage more people to undergo colorectal cancer screening in the future.

Key words: CT colonography, colorectal cancer, DECT, CAD

Introduction

Computed tomography colonography (CTC) was first introduced in 1994. Currently, it is used, inter alia, as a non-invasive screening test for colorectal cancer. According to the American College of Radiology, MSTF and the American Cancer Society – CT colonography has been recognized as a valuable screening method for detecting colorectal cancer in intermediate-risk patients [1].

From the age of 50, CT colonography is recommended as a screening method to detect preclinical colorectal cancer. The test is also used as a diagnostic method for a clinically known tumor in the intestine. Depending on the purpose of the examination (screening or in-depth diagnostics), it can be performed in native scanning or after intravenous administration of a contrast agent. The condition of good diagnostic quality of the examination is proper preparation of the large intestine (thorough cleaning of residual feces) [1].

Advantages of CT colonography:

• due to the lack of sedation, shorter examination time, non-invasiveness - CT colonography is better tolerated by patients compared to endoscopy

• low risk of perforation

• enables the cancer stage to be assessed based on the TMN classification

• compared to classic colonoscopy, it provides accurate information about the location and size of the lesion (before surgery), especially when the infiltration spreads to adjacent tissues and organs

• allows you to evaluate the loops of the colon behind the stricture that are inaccessible to the endoscope in a colonoscopy

• detection of pathologies occurring in other organs of the abdominal cavity and small pelvis (e.g. metastatic changes)

• enables the assessment of the intestine in patients with contraindication to colonoscopy (allergy to anesthetics, anticoagulants, refusal to perform a conoscopic examination)

• is characterized by a lower radiation dose (by approx. 20% compared to the rectal infusion with the double-contrast method) [2].

Disadvantages of CT colonography:

• exposure of the patient to the radiation dose

• it is not possible to collect material for histopathological examination and assessment of the color of the intestinal mucosa

• often unable to distinguish between functional and structural strictures.

• contraindicated in patients allergic to a contrast agent [2].

Depending on the clinical indications and the patient's health condition, the examination is performed with the use of such scanning parameters that allow obtaining the appropriate diagnostic value of the images while maintaining the ALARA principle. The most important technical parameters influencing the quality of the test include: scanner order, rotation time, pitch, current (mA) and voltage (kV) [3].

Scanning parameters - detector performance

According to the 2007 ESGAR guidelines, CT colonography should be performed on MDCT scanners (at least 16 rows), which is a prerequisite for obtaining high-quality images. The greater number of detectors allows for an accurate assessment of the abdominal cavity and pelvis with a shorter acquisition time (less than 10 seconds per position). This allows to avoid motor artifacts originating from intestinal peristalsis and to maintain high spatial resolution [4].

In the case of the MDCT 16-row scanner, the scanning time is approx. 11-12 s. In the case of a 64-row camera, the scanning time may be reduced to approx. 6-7 s [4].

Collimation

In the CT examination of CT colonography, it is recommended to use narrow collimations, not exceeding 3 mm, which allows the visualization of a polyp about 5 mm in size. Reducing the thickness of the reconstruction layer allows for increased sensitivity in detecting minor pathologies of the large intestine [5].

The use of a thin layer thickness (on the order of 1 mm) to obtain a dataset with isotropic resolution, allows to perform secondary multiplanar reconstructions with high spatial resolution and good quality three-dimensional reconstruction. In the case of using a very narrow collimation, it is recommended to increase the intensity on the lamp in order to reduce image noise and ensure good image quality [5].

Lamp voltage (kV)

When selecting parameters in the CT colonography protocol, the voltage at the lamp is a very important parameter. The voltage applied to the lamp affects the X-ray power. The higher the voltage on the lamp, the greater the penetration force of the radiation beam and the dose reaching the patient's body. The voltage range used in CT colonography ranges from 80 kV to 140 kV [6].

In the case of obese patients, a voltage of approx. 140 kV is used. Lower lamp voltage (approx. 80 kV) is used to improve the visibility of polyps after administration of an iodine or barium-based contrast agent. According to ESGAR, a voltage of about 120 kV is routinely recommended for imaging colon loops in both the prone and supine positions [7].

Lamp current (mA)

Virtual CT colonoscopy in adult patients is performed with a lamp current below 100 mA. Higher intensity values result in a lower noise level. This affects the better quality of the obtained image, the use of the high-resolution reconstruction algorithm, but also causes greater exposure of the patient to radiation. In order to reduce the radiation dose, it is advisable to reduce the intensity on the lamp at the expense of good image quality (signal to noise ratio) [7].

Automatic Exposure Control (AEC) continuously adjusts the lamp current based on the patient's body volume. It allows for the reduction of radiation exposure, especially in slim patients, even by 20 to 35% [8].

Reconstruction algorithm

The choice of an image reconstruction algorithm from the raw data affects the noise level. High spatial resolution increases the noise in the image, while a slight reduction in resolution reduces the dose of ionizing radiation received by the patient. A pilot study demonstrated the ability to maintain CTC image quality using a reduced radiation dose following iterative reconstruction. It was found that the radiation dose during CT virtual colonoscopy can be reduced by 50% without affecting the image quality after iterative reconstruction [8].

Image noise reduction program

Cameras equipped with adaptive statistical iterative reconstruction, ASIR reduces the amount of noise in an image. ASIR allows to reduce the radiation dose by up to 65% while maintaining good image quality (Fig. 1). Similarly to the ASIR system used in GE (General Electic) devices, a similar system is used by Toshiba (adaptive iterative dose reduction, AIDR) and Siemens Healthcare (sinogram affirmed iterative reconstruction, SAFIRE) [9].

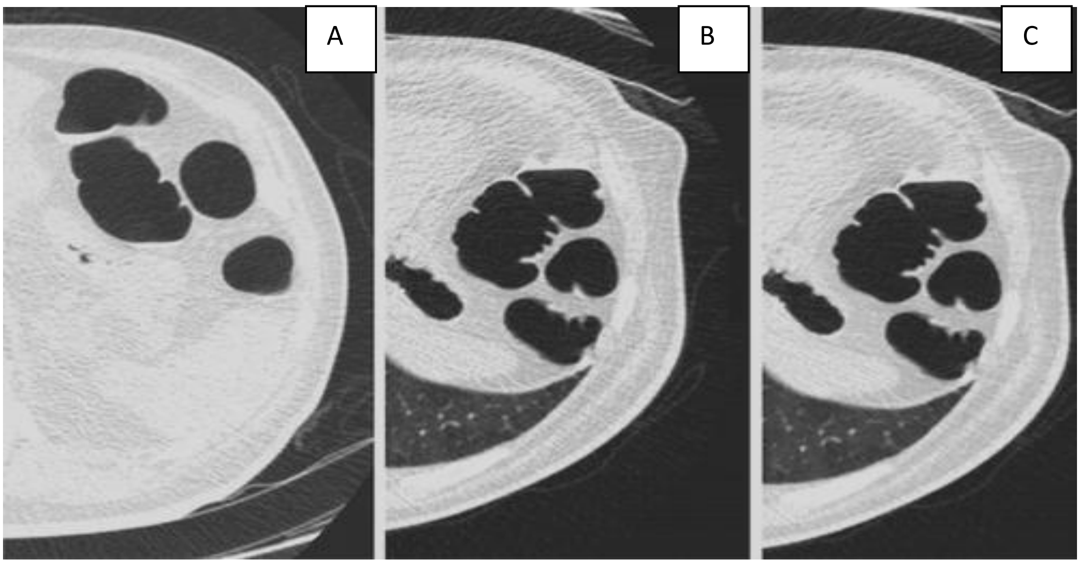


Fig.1 Image in the axial plane at the level of the splenic flexure of the colon. (A) CT colonography performed in the supine position using a standard current of 50 mAs; no ASIR. (B) CT colonography image in the prone position using 25 mAs and 40% ASIR. (C) ASIR reduces the noise index providing a good image [9].

C-RADS scale

The C-RADS scale (CT Colonography Reporting & Data System) published in 2005 is a scale used to assess the pathology of the colon (C) and extraintestinal changes (E) in CT virtual colonoscopy. It is a standardized reporting system used in CTC screening that promotes the quality and consistency of diagnostic results. It allows for the appropriate classification of the intestinal pathology detected in CTC and the selection of appropriate further diagnostic and therapeutic procedures [10].

Secondary image reconstruction is used in the evaluation of CT examinations in virtual colonoscopy. Due to the possibility of obtaining isotropic data in the MDCT, the assessment of colon pathology can be carried out in any chosen plane, without loss of information or disturbance of the quality of two- and three-dimensional images.

The assessment of virtual colonoscopy CT is based on the analysis of two-dimensional images in the axial plane. The evaluation should include scans from the supine and prone positions. The window parameters should be properly selected to maximize the detection of changes in the lumen of the colon. This assessment allows for the detection of major pathologies and a possible decision to extend the examination to the scope of the chest in terms of metastases, with intravenous administration of a contrast agent (Fig. 2 and 3). Multi-plane Reformations (MPR) in any cross-sectional planes are very helpful [11].

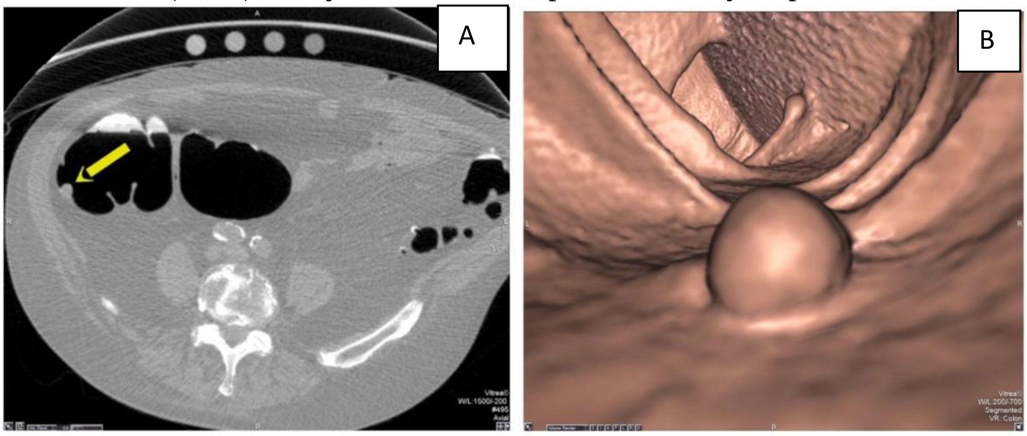


Fig. 2 The axial two-dimensional image (A shows) shows the parietal polyp in the large intestine. (B) VR reconstruction detect changes (non-pedunculated polyp) [11].

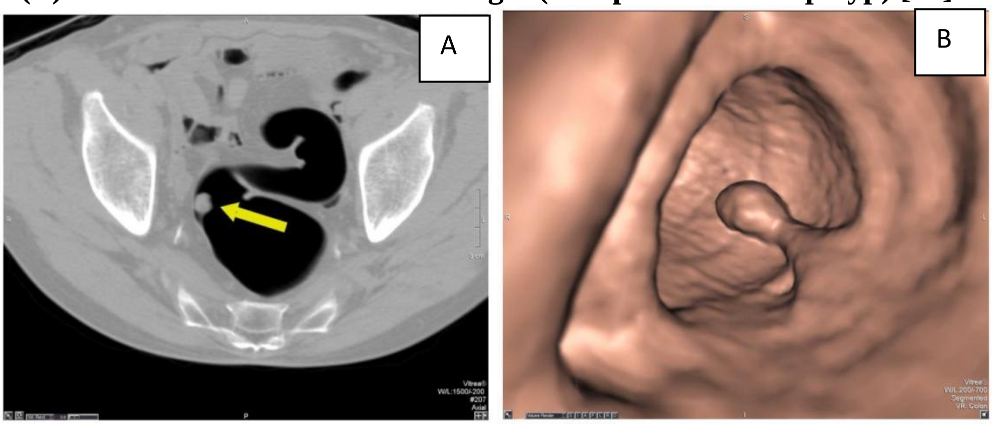


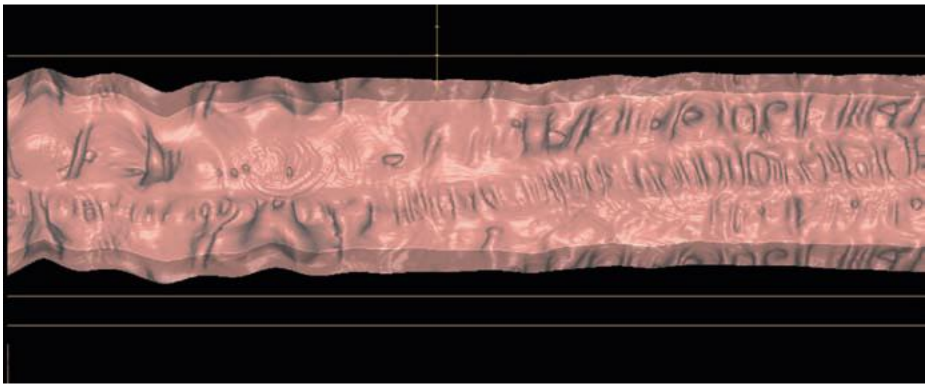
Fig. 3 Pedunculated polyp. (A) Axial view and (B) VR reconstruction show pedunculated polyp in the sigmoid colon [11].

If abnormalities are detected, secondary 2D and 3D reconstructions can differentiate the polyp from intestinal folds or fecal masses [11]. 3D images of the interior of the colon lumen can be obtained thanks to specialized computer software for data processing. 3D images are interpreted using 3D algorithms, such as virtual endoscopy or the navigation option [12].

The navigator program allows you to assess the inside of the large intestine through a virtual camera. This analysis is performed supine and prone in both directions [12].

Increasing the visibility of the intestinal lumen can be achieved using a so-called "panoramic view" (PV). The three-dimensional endoscopic view allows you to continuously render 5 surfaces in one imaging plane [13].

The technique of virtual stretching of the intestinal wall allows for virtual straightening of the intestine and precise assessment of the mucosa surface. This modern 3D method allows to increase the sensitivity of the virtual CT colonoscopy in detecting minor pathologies of the large intestine and reduces the time of radiological evaluation of the CT examination. It allows for the differentiation of intestinal polyps and visualizations (Fig. 4) [14].



Dig. 4 Colon - virtal disssection reconstructions [14].

CAD - computer aided diagnosis

CAD is a method of computer image analysis commonly used in radiological practice [15].
In CT colonography, it is used to:

- Assessment of the stretching of the intestinal loops
- Differentiation of pathological changes from motor artifacts
- Detection of pathologies of the large intestine (including polyps)

CAD closely interacts with advanced visualization hardware and software, analyzing original images obtained from CTC systems from all manufacturers. CTC CAD technology uses advanced algorithms to identify potential polyps to improve the quality of the diagnostic assessment of the study. This type of image analysis uses image processing, pattern recognition and artificial intelligence [15].

Recent studies show a sensitivity for CAD of about 89.3% in the detection of adenomas up to about 10 mm in size. Computer-assisted detection aims to reduce diagnostic errors by finding and marking changes in polyp morphology, which should then be verified and assessed by a physician. However, CAD should always be the second line of study evaluation and be a supportive method. False positive results in CAD are common and may be associated with mucosa irregularity, intestinal peristalsis, technical artifacts or the presence of other pathological changes (diverticula, lipomas, etc.) (Fig. 5) [15].

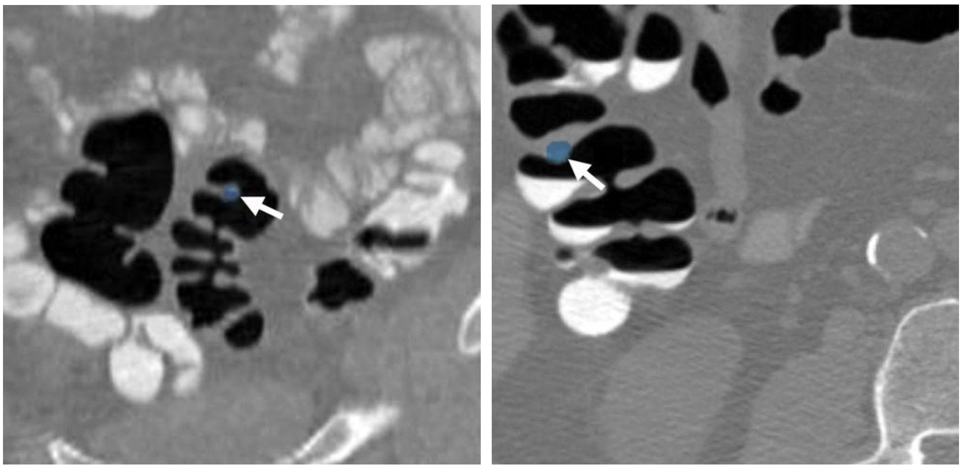


Fig. 5 Images in the coronary plane. (arrow) In the colonography examination, the CT shows a thickened fold of the haustration. Thickened drawing fold as a potential polypoid lesion according to CAD. The polypoid lesion was not visualized. 1st Department of Medical Radiology, SPSK no. 4 in Lublin

Dual source computed tomography (DSCT) in the diagnosis of colorectal cancer

Since the introduction of dual source computed tomography (DSCT), there has been progress in the development of the method of virtual colonoscopy CT. Thanks to the use of two X-ray tubes, it was possible to use at the same time two sources of X-ray energy, registered on the detector panel. The most common lamp voltage is 80 kV and 120 kV or 80 kV and 140 kV. The use of various intensity and voltage parameters allows for the differentiation of tissues depending on various radiation absorption coefficients, expressed in Hounsfield units (UH) [16].

The main advantage of DECT is the possibility of obtaining iodine and VNC (virtual non-contrast) maps - a "virtual" native image (without the use of contrast). DECT enables the measurement of basal density and the degree of iodine uptake on VNC and iodine map images, respectively, without obtaining native tomographic images. This allows the radiation dose to be reduced in the CTC study. Pilot studies have demonstrated the high effectiveness of DECT in diagnostic CT colonography and electronic colon loop cleansing after barite labeling [16].

The use of a computer assisted algorithm (CAD) in high energy tomography helps in the diagnosis and detection of colon tumors (Fig. 6).

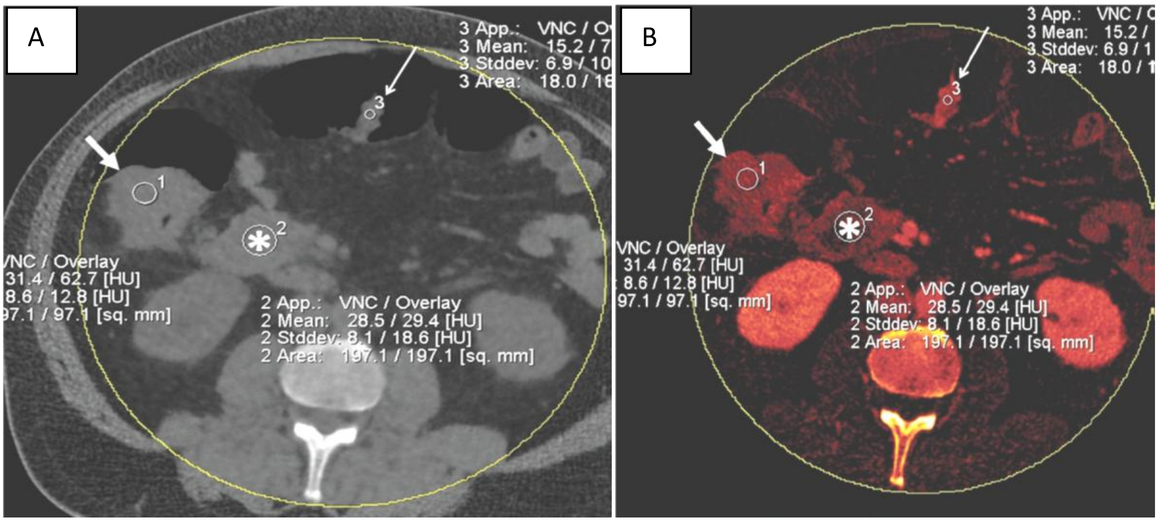


Fig. 6 DECT images of a patient with colon adenocarcinoma. (A) Axial image of the VNC. (B) Colonic adenocarcinoma iodine map (thick white arrow), showing a uniform pattern on the iodine map. The iodine density on the iodine map due to iodine uptake is 62.7 HU (enhanced), while the basic density in the VNC image is approximately 31.4 HU. Mesenteric lymphadenopathy (asterisk) and transverse colon polyp with a tumor-like image (thin arrow) [16].

Summary

CT virtual colonoscopy has been recognized by the American College of Radiology, MSTF, and the American Cancer Society as a valuable screening method for the detection of intermediate-risk colon cancer. Modern MDCT scanners allow for obtaining good-quality images, and the increase in the number of detectors results in an accurate assessment of the abdominal cavity and pelvis with reduced acquisition time, while maintaining high spatial resolution.

CT colonography is a good diagnostic test in patients at high risk of developing colorectal cancer. It is characterized by high sensitivity in detecting polypoid lesions (respectively of the order: 85.3% for polyps 6-9 mm in size and 90.8% for polyps 10 mm). The test is also highly specific, amounting to approx. 87.8%.

Iterative reconstruction (IR) techniques allow for a significant reduction of the radiation dose thanks to the reduction of noise in the processing of the CT image. This improves image quality and SNR especially in obese patients.

The C-RADS scale is a standardized reporting system used in CTC screening that promotes the quality and consistency of diagnostic results. It allows for the appropriate classification of the intestinal pathology detected in CTC and the selection of appropriate further diagnostic and therapeutic procedures.

Virtual CT colonoscopy is a constantly evolving method. DECT quality quality pilot studies in diagnostic CT colonography and electronic cost cleaning after barite marking. Get information linked to the system, alarm, you will get to download the scan time, what reading information about the patient's condition.

Bibliography

[1] Levin B1, L. D. Screening and surveillance for the early detection of colorectal cancer and adenomatous polyps, 2008: a joint guideline from the American Cancer Society, the US Multi-Society Task Force on Colorectal Cancer, and the American College of Radiology. CA Cancer J Clin. 2008; 58 (3): 130-60. Available in: doi: 10.3322/CA. 2007.0018.

[2] Lebda-Wyborny T., Barczyk A., Pilch-Kowalczyk J., Wirtualna kolonoskopia CT – nowa metoda oceny patologii jelita grubego. Chirurgia Polska. 2008; 10 (2): 88-100.

[3] Prokop Mathias. Spiralna i wielorzędowa tomografia komputerowa człowieka. Warszawa: MediPage, 2009.

[4] Neri Emanuele, Halligan S, Hellström M, Lefere P, Mang T, Regge D, Stoker J, Taylor S, Laghi A. The second ESGAR consensus statement on CT colonography. Eur Radiol. 2013;23(3):720-9. Available in: doi: 10.1007/s00330-012-2632-x.

[5] Laghi Andrea. (2014, December 7). Computed tomography colonography in 2014: An update on technique and indications. World J Gastroenterol. 2014; 20 (45): 16858–1686. Available in: doi: 10.3748/wjg.v20.i45.16858.

[6] Segnan N, Armaroli P, Bonelli L, et al. Once-only sigmoidoscopy in colorectal cancer screening follow-up findings of the Italian Randomized Controlled trial-SCORE. JNCI 2011; 103 (17): 1310-22. Available in: doi: 10.1093/jnci/djr284.

[7] Boellaard Thierry. Colon distension and scan protocol for CT colonography: an overview. European Journal of Radiology. 2013; 82(8): 1144-58. Available in:
10.1016/j.ejrad.2011.10.030.

[8] Kalender WA. Application- and patient size-dependent optimization of x-ray spectra for CT. Med Phys. 2009; 36(3): 993-1007.

[9] Lambert L, Danes J, Jahoda J, Masek M, Lisy J, Ourednicek P., et al. Submilisievert ultralow-dose CT colonography using iterative reconstruction technique: a feasibility study. PeerJ. 2016; 4: e1883. Available in: doi: 10.7717/peerj.1883.

[10] Flicek Kristina T. Amy K. Hara Alvin C. Silva Qing Wu Mary B. Peter1 C. Daniel Johnson. Reducing the Radiation Dose for CT Colonography Using Adaptive Stastical Iterative Reconstruction: A Pilot Study. American Journal of Roentgenology. 2010;195: 126-131.

[11] Zalis ME, Barish MA, Choi JR, et al. CT colonography reporting and data system: a consensus proposal. Radiology. 2005;236(1):3-9. [online]. Available 10.1148/radiol.2361041926.

[12] Pilch-Kowalczyk Joanna. Badanie kontrastowe dolnego odcinka przewodu pokarmowego. Medycyna praktyczna. Available in: https://www.mp.pl/pacjent/gastrologia/diagnostyka/134501,badanie-kontrastowe-dolnegoodcinkaprzewodupokarmowego.

[13] Tytgat GN. Hyoscine butylbromide - a review on its parenteral use in acute abdominal spasm and as an aid in abdominal diagnostic and therapeutic procedures. Curr Med Res Opin. 2008; 24(11): 3159-73.

[14] Seuss H, Janka R, Hammon M, Cavallaro A, Uder M, Dankerl P. Virtual Computed Tomography Colonography: Evaluation of 2D and Virtual 3D Image Quality of Sub-mSv Examinations Enabled by Third-generation Dual Source Scanner Featuring Tin Filtering. Acad Radiol. 2018;25(8):1046-1051. Available in: doi: 10.1016/j.acra. 2017.12.014.

[15] Petrick N., Haider M., Summers RM., et al. CT colonography with computer-aided detection as a second reader: observer performance study. Radiology. 2008; 248(2): 704.

[16] Yoshida H., Näppi J. CAD in CT colonography without and with oral contrast agents: progress and challenges. Comput Med Imaging Graph 2007;31(4-5):267-84.

[17] Wójcik A., Samek I., Jańczyk M., Kurzepa J. The use of innovative technological solutions in the assessment of colorectal cancer in CT colonography. National Scientific e-Conference „e-Factory of Science" 3rd ed. [B. m.] May 9, 2020 [online]. Abstr, s. 49. Promovendi Foundation Publishing. ISBN: 978-83-955366-8-7.