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Original scientific paper

ANALYSIS OF PARAMETERS PROTOCOLS IN COMPUTER TOMOGRAPHY OF THE ABDOMEN

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Abstract

Computed tomography (CT) is one of the most significant diagnostic method that provide useful diagnostic data. The quality of images and patient doses as well as the accompanying radiation risk, depend on applied scanning technique during CT examination.

This study was done by analyzing of CT examinations in patients in Department of Radiology - Clinical Hospital Tetovo in the period from November to December 2018. The examinations were carried out by GE Light Speed 64 slice CT Scanner. The scanner was installed in 2011.

The results of the research study conducted in this paper are also presented. What referral diagnoses are required for abdominal CT which clinical indications are sent patients to abdominal CT. How many patients had a CT scan without contrast, and how many with contrast. Analysis of the most common CT protocols in the Clinical Hospital Tetovo. Finally, offers an insight of patients during CT scanning.

Keywords: CT scan, CTDIvol, DLP, CT protocols.

1. Introduction

Soon after the X-rays were discovered, they found their application in medicine. Today, many medical diagnostic methods use methods based on X-ray radiography. One of the diagnostic methods is Computer Tomography (CT).

Computed Tomography (CT) scan is an incredibly useful imaging tool for assessing a variety of abnormalities and diseases in both adults and children. It has replaced many less accurate and more invasive procedures. CT enables rapid access to diagnostic information, often with life-saving implications in multiple body regions including the head, neck, chest, abdomen, pelvis, and the limbs.

In the past two decades, CT scan technology has evolved rapidly. A test that took 20-30 minutes to perform in 1980s, most CT exams now take as little as 1-2 seconds. Along with the technology, use of CT has also increased substantially. From 3-million CT scans in 1980, the utilization of CT raised to 88.7-million CT examinations in 2018 in the United States alone. CT uses X-rays to obtain cross-sectional images of the body which cannot be obtained from the standard radiographs or X-rays.

However, radiation dose from CT is higher than from a radiograph. With increasing use of CT in modern medicine, there have been concerns over rising radiation dose contributions of CT which can increase the risk of radiation-induced cancer. Such risks are higher in children as compared to older adults.

Although CT vendors and researchers have introduced scan techniques, and assessed methods for reducing radiation dose associated with CT, patients, referring physicians, and imaging personnel should be aware of the issues associated with CT radiation dose and help address them. When performing a CT scan, the patient receives the highest dose compared to any other diagnostic imaging.

In the last ten to fifteen years, there is a sharp increase in the number of installed CT scanners in the Republic of Macedonia. While in 2000 there were less than ten CT scanners, in 2013 there are more than 35 CT scanners (with big varieties in their performances) installed on the territory of the Republic of North Macedonia. According to a European survey conducted in 2011 on the population doses from medical procedures, the number of available CT scanners in the Republic of North Macedonia per million populations is higher than that of the United Kingdom or of Slovenia, for example. This led to significant increase of the number and the type of performed CT examinations, as well as of the number of patients with multiple studies and follow-up examinations. [1]

According to the latest official data, in North Macedonia there are total of 29 operational CT scanners with a wide range of technical and software performances. 19 of them are installed in the state hospitals and 10 of them in the private health institutions. Decrase of number of operational CT scanners has been noticed in private institutions.

In North Macedonia in last years, several surveys are conducted about clinical and technical protocols that have been used for different type of CT examinations. The results showed that the protocols are not unified neither at national level nor at the individual hospital level, and which clinical protocols and which exposure parameters will be applied, depends on individual assessment of radiologist or technologist at the site of scanning. These findings suggested that patients receive different doses for the same type of examination, as is presented in Table 2 [2].

Table 1. Different number of phases for the same type of CT examination

Example CT abdomen	Number of phases	Dose indicator (DLP mGy·cm)
Hospital A	3	1549
Hospital B	4	2721
Hospital C	1,3 or 4	715 / 1826 / 2115
Hospital D	3 or 4	1625 / 2440
Hospital G	2 or 3	1127 / 1474

2. Materials and methods

At the Radiology Clinic - Tetovo Clinical Hospital in the period November - December 2018 a research was done about clinical and technical protocols in CT practice.

Radiology Clinic is equipped with GE Light Speed 64 slices CT scanner and all exams were perfumed on the same scanner.

The research was divided into two phases:

Phase One:

-Analysis of indication in referrals by which was required abdominal CT and by which clinical indications patients were referred to abdominal CT.

- Analysis of number of phases .

-Analysis about type and frequency of CT examinations in the Tetovo Clinical Hospital.

Phase Two:

- Analysis of the exposure protocol parameters on which the scans were performed patient radiation dose estimation is an important aspect of performing a scan, and in addition the optimization process is based on knowing the impact of exposure parameters on patient dose and image quality. General measures of radiation dose include exposure, absorbed dose and effective dose, while specific CT dosimetry CT Computed Tomography Dose Index (CTDI),Dose Length Product-DLP and effective dose [4].

The extremely collimated X-ray beam used in CT produces a highly no uniform distribution of absorbed dose in the patient's body. Methods for estimating patient dose in CT are based on basic dosimetry - CTDI, which is a measure of local dose and examination protocol [3].

Exam Description: TORAX+ABDOMEN

Dose Report

Series	Type	Scan Range (mm)	CTDIvol (mGy)	DLP (mGy-cm)	Phantom cm
1	Scout	-	-	-	-
2	Helical	S20.250-I424.750	19.06	936.70	Body 32
4	Helical	S20.250-I424.750	19.19	943.02	Body 32
			Total Exam DLP:	1879.72	

Figure 1. An example of the Dose report from the CT scan shows the values of CTDIvol and DLP parameters (Tetovo Clinical Hospital)

3. Results

From the e-Health Administration "My Appointment" data were obtained about the number of CT scans performed in 2018 at Tetovo Clinical Hospital and for the reason of referral to CT.

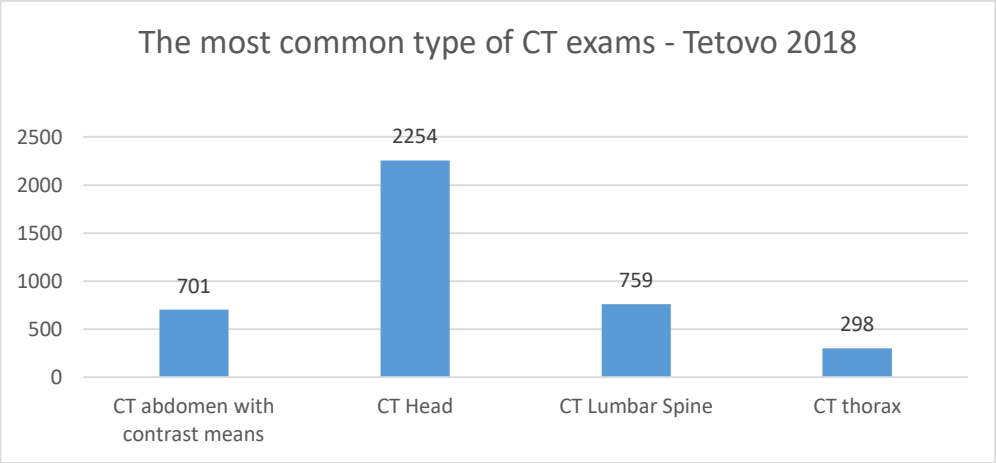

Figure 2. The most common CT examinations at the Tetovo Clinical Hospital

Mostly at the Tetovo Clinical Hospital is scanning the Head with 2254 numbers, then CT of Lumbar Spine with 759 examinations, CT of Abdomen with contrast means 701 examinations, CT Thorax with 298 examinations (Fig.2). We decided to analyze abdominal CT scans because patients receive the highest dose during this type of scanning. Abdominal scanning can be done without contrast or with additional phases that involved contrast media.

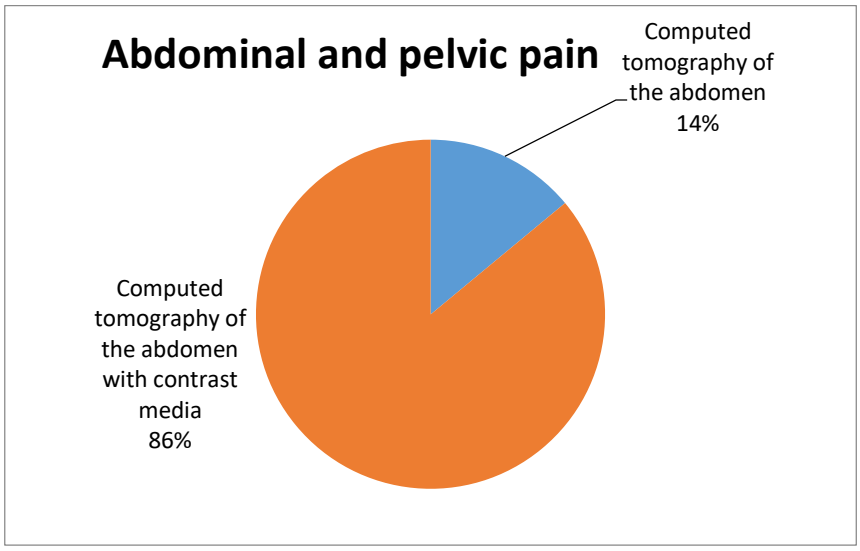

Figure 3. Abdominal CT in Tetovo Clinical Hospital regarding the use of contrast media

In 86% CT abdominal images are done with contrast means and only 18% without contrast (Fig 3); This tells us that 86% of patients will be scanned at least twice during one CT examination.

CT examinations only for the abdomen, 53.35% of patients refer to abdominal CT with a diagnosis of Abdominal and Pelvic pain, Malignant neoplasm of the rectum 8.76%, Malignant neoplasm of the stomach 5.93%, Malignant neoplasm of the colon 4.64%, Gallstones (Cholelithiasis)3.87%, Gastritis and duodenum 3.61%, Malignant neoplasm on the kidney, excluding renal pelvis 3.09%, Hyperplasia of the prostate 3.09%, Malignant neoplasm of the prostate 2.84%, Unrecognized renal colic 2.58%, Malignant neoplasm of testis 2.32%, Calculus in Kidney and Ureter 2.06%, Essential (Primary) Hypertension 2.06%, Malignant neoplasm of the rectosigmoid sphincter 1.80%.

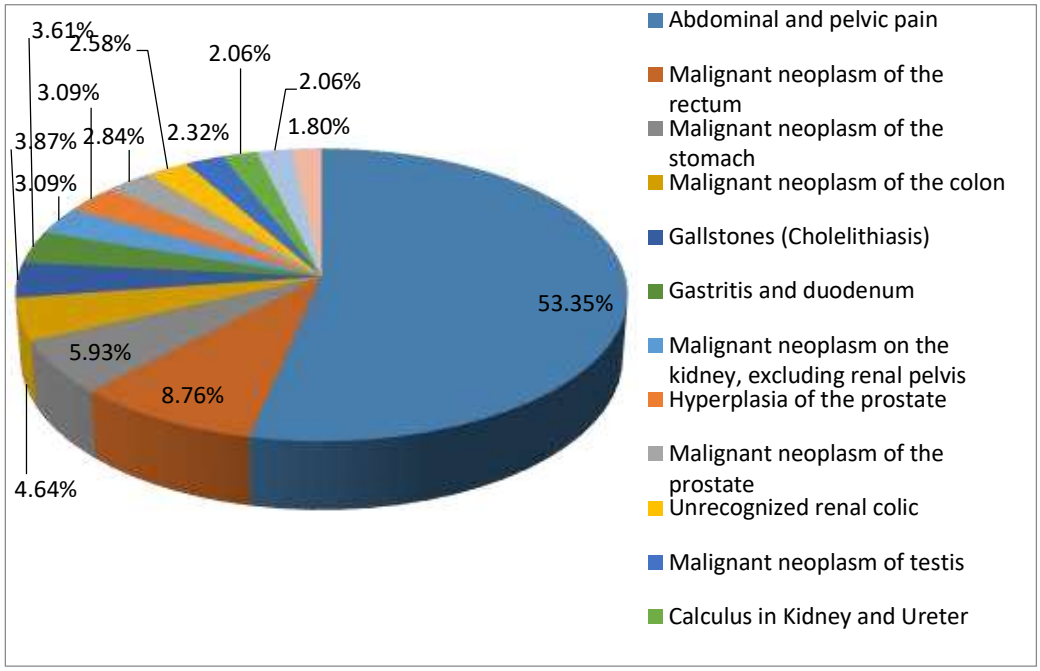

Figure 4. Clinical indications for patients undergoing abdominal CT in Tetovo Clinical Hospital

Analysis of exposure CT protocol parameters.

The study was done by analyzing of 10 CT examinations of abdomen in randomly selected patients at the Radiology Department in the Clinical Hospital in Tetovo. Patient identities or any personal related data were not collected.

Regardless of the referral diagnosis, patients in 86% of cases are scanned in two phases, one without contrast and the other with contrast. Thereby, as we can see from the table 1, identical scan parameters are used. There are no institutional protocols for CT abdominal tailored to different referral diagnosis.

Parameters as Pitch is the ratio of the patient table increment to the total nominal beam width for the CT scan and is 1.375 for all the patients, rotation time is 0.8 for all patients, kilo voltage is 120, and it was kept the same for all patients.

Table 2. Values of dose indicators parameters

Average patient mass [kg]	CTDIvol [mGy]	DLP [mGy·cm]
73.5 ± 11.1	17.85 ± 5.10	1048.33 ± 299.98

Diagnostic Reference Levels (DRL) are good indicator about clinical practice in some radiology department and they are defined as a third quartile value of data distribution. In the next table are presented calculated DRLs for routine abdominal CT examination and comparison with the latest DRLs values from the 4th National UK CT Dose Survey done in 2019 for Abdomen and pelvis type of examination.

	3rd Quartile CTDIvol [mGy]	3rd Quartile DLP [mGy cm]	Difference
Department of Radiology – Tetovo	19.43	1227.85	+43 %
4th National UK CT Dose Survey	13.6	652	+88%

Although, our sample size was very small and this can have influence to our results, it is obvious that dose indicator parameters are higher than in UK. The main reason for this is using of inappropriate exposure parameters, mainly doing scan on very thin slices and unnecessary scanning of body parts that are out of region of interest.

4. Discussion and conclusion

The most important question the patients can ask about their CT are if the CT scan is needed for their specific ailment or condition or if another exam with no or lower ionizing radiation can provide the needed information. Knowing the benefits and risks of CT, and asking about how imaging personnel ensure right radiation dose with CT is also critical. This information is particularly relevant in the children, and in the non-urgent cases. It is important to inform the referring physician at the time of exam ordering if there have been any prior imaging examinations so that inadvertent duplicate examinations can be avoided. When possible, patients must request their physicians to also provide the reason for CT scan to the radiology personnel.

Physicians who order imaging tests have a responsibility to ensure that CT scan is the right test for the given patient, and the desired clinical information can not be obtained in an efficient and accurate manner from other non-ionizing radiation or lower dose tests. Over-utilization or inappropriate of CT scan not only exposes patients to unnecessary radiation dose but also increases healthcare costs and risks associated with detection of incidental findings. Fortunately, there are ample guidelines available on the appropriate use of CT scan for different clinical indications. Online decision support tools help physicians select the best imaging tests for many clinical indications. Referring physicians must specify a reason for ordering a CT scan since this information helps radiology personnel to tailor the exam and radiation dose to best obtain the required diagnostic information.

Ideally, CT scan and radiation dose must be optimized with inputs from all three types of radiology personnel including radiologists, CT technologists, and medical physicists. Radiologists must ensure that CT scan is confined to the region of interest and is acquired with minimum number of scan phases to answer specific clinical questions. Use of clinical indication-based CT protocols helps reduce radiation dose for certain clinical indications such as for lung nodule follow-up and kidney stones. To implement clinical indication-based CT protocols, radiologists must encourage and incentivize the referring physicians to provide reason (s) for ordering CT scan. Likewise, radiologists must ensure that the CT protocols are reviewed on at least annual basis to ensure that they are up-to-date with the latest technology and research in CT radiation dose optimization. Such review should involve the CT radiographers or technologists since they are involved in the actual scanning of patients.

Medical physicists have an important role in monitoring radiation doses from CT scan so that use of excessive radiation doses can be minimized. Fortunately, they can use several automatic dose monitoring software for this purpose. Should they identify sites or protocols with higher than recommended doses, they must communicate their concern with other radiology personnel and help modify CT protocols to reduce higher than needed radiation doses. Due to their technical and physical knowledge, medical physicists play a crucial role in troubleshooting image quality and dose-related issues with CT.

Ideal CT protocols and radiation-safe practices are created when a team of radiology personnel including medical physicists, CT radiographers, and radiologists work together.

CT scan is an incredibly useful test in right clinical circumstances. However, in order to maximize the benefit versus risk equation, and use as low as reasonably achievable radiation doses, patients, ordering physicians, radiology personnel must participate and take active roles.

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