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Unnecessary computed tomography and magnetic resonance imaging rates in a tertiary care hospital

Mehmet Kilin[1], Evrim Ozmen[2], Oktay Algin[1]

[1]Department of Radiology, Ataturk Training and Research Hospital, Ankara, Turkey
[2]Department of Radiology, Istanbul University Cerrahpasa School of Medicine, Istanbul, Turkey

ABSTRACT

Objectives. The actual rate of unnecessary imaging is unknown in our country. In this study we aimed to detect unnecessary computed tomography (CT) and magnetic resonance imaging (MRI) rates and the radiological quality of these examinations in our hospital. ***Methods.*** CT/MRI request documents of 1,713 patients who had multidetector CT or MRI examination in a 2-month period at a single tertiary care hospital were obtained. We evaluated that whether the disorder that mentioned in request document was present or not in multidetector CT or MR images from the picture and archiving communicating system of our hospital. Scoring was done as follows; score 0 (there is no pathologic finding), score 1 (suspicious findings), and score 2 (presence of mentioned pathology). The radiological quality of the examinations was scored as follows; grade 0 (poor quality), grade 1 (moderate quality), and grade 2 (good quality). ***Results.*** There was not any pathologic finding in 35% of the patients included in the study (score 0, unnecessary imaging). There was/were finding(s) regarding to the disorder that mentioned in the request document in 43% of the patients (score 2). Suspicious findings were existed in the remaining patients (score 1). In the assessment of radiologic quality of the examinations that included in the study; 94% of the radiologic examinations had good quality and the remaining had moderate (0.2%) and poor (5.5%) quality. ***Conclusions.*** Unnecessary CT or MRI rate was detected as 35% in our hospital. Unnecessary imaging causes increased nephrogenic systemic fibrosis, contrast-induced nephropathy and/or radiation risks, and total cost. It may also cause reduced patient compliance and prolongation of therapy period.

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Keywords: Ionizing radiation, medical education, radiological examinations, health policy, imaging utilization, repeat imaging, CT, MRI, health care

Introduction

Unnecessary radiologic examinations leads to increase in the health expenditure and those examinations may also lead to development of nephrogenic systemic fibrosis (NSF), contrast-induced nephropathy (CIN), malignancy, reduced patient compliance and prolongation of treatment time [1]. According to Gimbel *et al.* [1], approximately 50% of advanced medical imaging in USA is unnecessary.

Address for correspondence:
Oktay Algin, MD., Ataturk Training and Research Hospital, Department of Radiology, Ankara, Turkey
E-mail: droktayalgin@gmail.com
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There are many factors including patient age and sex, underlying disease, health care delivery model, access to high-cost imaging modalities, hospital characteristics, radiologist recommendations, national medical education status, and styles of practice can contribute to unnecessary imaging. Reducing the unnecessary CT or MR imaging can save healthcare resources, significantly.

In our country, the actual rate of unnecessary imaging is unknown. The primary aim of this study is to detect the rate of unnecessary CT and/or MR imaging at a single tertiary care hospital radiology department. Our second aim is to make a group for the reasons of CT and MR examinations and radiological quality of those examinations. Our last aim is to detect the correlation between unnecessary CT and MR imaging and intravenous (i.v.) contrast media administration in our hospital.

Methods

Local ethical committee approval or informed patient consent was obtained for this retrospective study. All of the patients (n=2,064) who had CT or MRI examination within two-month period of time were found from the picture and archiving communicating system (PACS) of our hospital. Also, MR or CT imaging request document of those patients were obtained. The patients who did not have request document or whose request form did not include enough clinical information and the patients who had time interval more than 2 weeks between the date of fulfilling the request form and CT/MR acquisition, were not included in the study. Also, CT and/or MR exams for oncologic follow-up were excluded from the study. If a patient had multiple radiologic examinations, only the most recent CT or MRI examination was enrolled in the study. As a result, CT or MR examinations of 1,713 patients that composed of 820 (47.9%) men and 893 (52.1%) women were included in the study. The mean age of men was 49.36±17.67 years, the mean age of women was 49.41±16.29 years and the mean age of all patients included in the study was 49.38±16.96 years. All of the patients who meet our study criteria were selected randomly and analyzed.

All of CT and MRI examinations were performed in the same unit. CT examinations were performed with 16-slice CT machine (Somatom Perspective, Siemens, Erlangen, Germany), and MRI examinations were obtained with 1.5-tesla MR unit (Achieva; Philips Healthcare, Best, The Netherlands). CT and MRI protocols of our hospital were described previously in our publications [2-6].

We scored that whether the disorder that mentioned in the request document was present or not in MDCT or MR images as follows:

Score 0 (there is no pathologic finding): When all of the images of the patients were evaluated, there was not any pathologic finding regarding to the possible diagnosis mentioned in the request document or any other pathologic finding.

Score 1 (suspected findings): There were suspicious findings regarding to the possible diagnosis mentioned in the request document or there were some other findings which were not related with the pre-diagnosis or patient complaint in the radiologic images of the patients.

Score 2 (apparent pathology): There were findings related with the pre-diagnosis that mentioned in the request form at CT or MR examination of the patient.

The radiological quality of the 1,713 examinations mentioned above was scored as follows;

Grade 0 (poor quality): The quality of examination was not sufficient for radiological assessment.

Grade 1 (moderate quality): Interpreting of the examination was possible however the image quality was suboptimal.

Grade 2 (good quality): Radiological reporting confidence was perfect. There was not any problem with image quality.

In addition, it was noted that whether the contrast media was administered intravenously for each of the examination or not (score 0: no contrast-material administration, score 1: contrast-media +). The results of these measurements were recorded in study table subsequently.

All of the scorings were performed by one radiologist who had an experience of 5 years (M.K.) to detect the findings mentioned above. The assessment duration of CT or MR exams was not limited, and all of the images were evaluated in same PACS system by using the same computer and same screen. All cases reviewed independently.

Statistical Analysis

For statistical analysis, all of the groups and subgroups were calculated in percentage form. The parametric data was given by mean ± standard deviation. The categorical variables were presented as frequency with related percentage.

Table 1. Examination types of the study group

Examination types	Patients (n)
Brain MRI	192
Spinal MRI	171
Extremity MRI	155
Abdominal MRI	24
Sacroiliac MRI	21
Pituitary MRI	2
Brain+cervical MRI	1
Abdominal MDCT	328
Brain MDCT	275
Thorax MDCT	263
Paranasal Sinuses MDCT	73
Temporal bone HRCT	41
Neck/Cervical MDCT	54
Thoracoabdominal MDCTA	35
Cardiac MDCTA	23
Extremity MDCT	19
Brain MDCTA	18
Thorax MDCTA	6
Thoracoabdominal MDCT	6
Neck+thorax MDCT	1
Pelvis MDCT	1
Sacroiliac MDCT	1
Maxillofacial MDCT	1

HRCT=high resolution computed tomography, MDCT=multidetector computed tomography, MDCTA=multidetector computed tomography angiography, MRI=magnetic resonance imaging, n=number of the patients

Results

The numbers and types of the CT or MR examinations which were assessed in this study were given in Table 1. There was not any pathologic finding in 35% of the patients that included in the study (score 0). There was at least one finding regarding to the disorder that mentioned in the request document in 43% of the patients (score 2). There were suspicious findings in the remaining patients (score 1) (Table 2) .

Table 2. Results of the study examination reports

Reporting Scores	Number (%)
Score 0 (there is no pathology)	595 (34.7%)
Score 1 (suspected findings)	389 (22.7%)
Score 2 (apparent pathology)	729 (42.6%)
Total	1,713 (100%)

In the evaluation of radiologic quality of CT/MR images that included in the study; 94.3% of the examinations had good quality, and the remaining part of the examinations had moderate (5.5%) or poor (0.2%) quality (Table 3).

Table 3. Radiological quality grades of the study population

Quality Grades	Number (%)
Grade 0 (poor)	4 (0.2%)
Grade 1 (moderate)	94 (5.5%)
Grade 2 (good)	1,615 (94.3%)
Total	1,713 (100%)

CT and MR examinations were performed without administration of contrast media in 904 (53%) patients while i.v. contrast-media was administered in 809 (47%) patients. There was not any pathologic finding in 162 of the patients who had i.v. contrast-media administration. There was at least one finding regarding to the disorder mentioned in the request document in 413 of the patients who had i.v. contrast-

media administration. Finally there were suspicious findings (score 1) in the remaining 234 patients (Table 4).

Table 4. Radiological quality grades of the study population

Scores	I.V. Contrast administration		Total
	No	Yes	
Score 0	433	162	595
Score 1	155	234	389
Score 2	316	413	729
Total	904	809	1,713

Contrast media was administered intravenously 27% (n=162) of the examinations which had no pathologic finding (score 0) while contrast media administration was not performed in 73% (n=433) of the examinations. Contrast media administration was not performed in 43% (n=316) of the examinations which had at least one finding regarding to the disorder that mentioned in the request form (score 2) while i.v. contrast media was administered in the remaining 57% (n=413) of the examinations (Table 4).

Discussion

All over the world, the numbers of radiologic examinations and national health expenditure have been increased due to the progression in CT and MR technology, excessive health insurance coverage and increase in geriatric population [7-10]. In our country, 11 million CT and 9 million MR examinations were performed at 2013 while 12.4 million CT and 10.3 million MR examinations were performed at 2014 [8, 10]. Three hundred and eighty million radiologic procedures (including 67 million CT scans) were performed in the USA only at 2006 [9]. According to our Ministry of Health 2014 reports, there are 1100 CT devices and 800 MR devices in our country [10-12].

When we look at the distribution of the examinations that included in the study, we detected that the most requested CT imaging types were abdomen, brain and thorax MDCT examinations respectively. The most requested MR examinations were brain, spinal and extremity MR examinations respectively as well (Table 1). According to our observations and the literature; the reasons for requesting these examinations were primarily neurologic disorders, trauma, and malignancy [13]. Thus, the task of preventing unnecessary or repeated CT/MR examinations falls on especially neurologist, neurosurgeons, oncologist, emergency unit doctors, and orthopedists.

In this study, we aimed to detect unnecessary imaging rates and evaluate the radiological quality of CT and MR examinations in our country. There was not any pathologic finding (score 0) in CT or MR examinations of 595 (35%) patients included in the study. Therefore, we can suggest that 35% of the CT or MR examinations that performed in our hospital was unnecessary (Table 2). This ratio is similar with others in literature [1].

Many factors contribute to unnecessary imaging, including patient age and sex, underlying disease, health care delivery model, access to high-cost imaging modalities, hospital characteristics, styles of practice, lack of adequate interest of doctors, social/individual preferences, national medical education status, knowledge gap regarding the safety/cost of cross sectional imaging, and radiologist recommendations [1, 14]. The repetitive use of CT and MR techniques is the main unnecessary imaging reason. Chen *et al.* [13] detected that 20% of all CT or MR examinations which were performed in a period of 90 days were repetitive imaging. Also; in this study, repetitive imaging rates were altered due to the diagnosis of the patients and hospital characteristics [13].

Preventing unnecessary cross-section examinations is crucial for decreasing health expenditure, improving health care quality, preventing the delay in treatment of the patients, avoiding of ionizing radiation (for CT exams), prevention of contrast-material related diseases (such as NSF or CIN) [14]. Obtaining the history of the patients appropriately and completely, performing optimal physical examination, and continuing education about radiation exposure risk and evidence-based principles of cross-sectional imaging to the doctors can be useful in preventing side effects which may be develop due to unnecessary or increased CT/MR imaging [9]. Gimbel *et al.* [1] decreased the number of unnecessary imaging to 50% after the education regarding to safety and cost information.

CT examinations are the main cause of medical related radiation exposure [11]. The radiation exposure applied to the patients for each CT examination has increased approximately 6 times due to the

development in technology [9]. Increasing in awareness of future cancer risk from radiation exposure was illustrated in previous studies and previous CT exposures cause approximately 15,000 deaths annually [9, 11, 15]. There are 2 main methods which may reduce cancer development due to CT examinations. First is performing specific CT protocols with the lowest dose as possible and second method is reducing the number of unnecessary CT examinations [16]. Reducing the number of unnecessary CT examinations should be noticed since this can also reduce health expenditure, delay in establishing the diagnosis for the patients and the risk of contrast nephropathy development. For the optimization of CT scanning protocols, we should implement the recommendations of international societies including International Commission on Radiological Protection, the European Commission or national radiological societies precisely in a close cooperation with the medical physicists [11, 17]. Arslanoglu *et al.* [18] focused on the knowledge of doctors and intern-doctors about the radiation exposure applied to the patients for common radiological imaging procedures in their study. This study showed us that most of the doctors underestimated the real radiation exposure. Therefore, Arslanoglu *et al.* [18] proposed that continuous education about radiation protection is necessary for all doctors.

Application of radiation protection of the patient principles which were recommended by the international atomic energy agency (preventing other parts of body out of region of interest with a lead apron, using protective goggles, and performing efficient tests regularly and frequently for X-ray permeability of CT room and lead aprons) is crucial for preventing cancer development due to CT examinations for the patients (especially for pediatric and pregnant patients) as well as health workers [19, 20].

The radiological quality of CT and MR examinations was generally good in our study (Table 3). However the expected or predicted radiological quality of CT and MR examinations can be lower in smaller hospitals (primary or secondary centers) since our center was a tertiary care reference hospital. Unnecessary examinations increase with the decrease of radiological quality and this situation may bring all of the risks that mentioned above. We should keep in mind and follow the recommendations of radiology societies for achieving the optimal radiological quality of CT or MR examinations [13, 20]. Fulfilling of the request documents by the clinicians in detail or evaluation of the patient together with the clinicians may increase the radiologic quality and contribute patient management.

In our study, unnecessary i.v. contrast media was administered in 27% (162 cases) of 595 patients who had unnecessary CT or MR examination (score 0) (Table 4). Contrast-agents are distributed over intravascular and extracellular fluids, and eliminated by glomerular filtration in patients with normal kidney function [21]. However, i.v. CT contrast media (iodine-based agents) administration can lead to CIN and i.v. MR contrast media (gadolinium compounds) administration can lead to NSF and accumulation of gadolinium at brain in the patients who have lower estimated glomerular filtration level (eGFR) (<60 mL/min) [21, 22]. Those risks are increased in patients with GFR<30 mL/min [21-23]. Although immediate hemodialysis after contrast-agent injection reduce the risk of CIN or NSF development, the etiopathogenesis of CIN or NSF is quite complicated and prediction of which patient would have CIN or NSF development is very difficult due to patient-related risk factors [22, 23]. Although there are some suggestions about avoiding NSF and CIN development in literature; the most efficient, fast and cheapest method is avoiding the unnecessary or repetitive examinations [22, 23].

The Limitations of the Study

The main limitation of this study was lack of diagnosis and imaging types based unnecessary and repeat imaging numbers, and lack of data about complications (e.g. NSF, CIN or gadolinium accumulation in the brain) due to i.v. contrast-media administrations. Also, our major concern is that a 'normal' examination is presumed as unnecessary examination. Sometimes, a normal examination has a significant contribution to patient management. Many practitioners would not consider a normal examination as unnecessary examination. "Rule out" is a very common reason for performing radiologic examinations. If patient management would not be changed then we could argue that those examinations were unnecessary. New studies are necessary to assess the contribution of the imaging findings on management of these patients. According to some reviewers, this research should be a double-blind and multicenter study for more effective results. We are planning a new and comprehensive study for clarifying these issues.

Conclusions

The rate of unnecessary CT or MR imaging was 35% which was quite high in our country according to our study. Obtaining the history of the patients appropriately and completely, performing physical examination, continuing education issues including radiation exposure and health risk, imaging costs and implementation of evidence-based medicine imaging principles to the doctors can be useful in preventing side effects which may be develop due to unnecessary or increased CT or MR imaging. Continuous education about radiation protection (especially for dose and duration reduction of ionizing radiation) is necessary for all doctors.

Conflict of interest

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