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Unjustified CT examinations in young patients

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Abstract The doses of radiation from computed tomography (CT) are relatively high, yet CT is being increasingly utilized. Furthermore, the radiation-induced lifetime risk of cancer mortality is higher at younger age. The purpose of this study was to find out whether previous CT examinations done on patients aged under 35 years were justified, and if not, whether there would have been other, more justifiable imaging modalities available. Fifty CT examinations of the head and 30 CT examinations each of the lumbar spine, cervical spine, abdomen, nasal sinuses and trauma were evaluated consecutively since the beginning of the year 2005 by using electronic patient files, the referral guidelines for imaging recommended by the European Commission and certain principles of classification. Seventy-seven per cent of the CT examinations of the lumbar spine, 36% of the head, 37% of the abdomen, 20% of the nasal sinuses and 3% of the cervical spine were unjustified. Most of these unjustified examinations could have been replaced by magnetic resonance imaging. In order to reduce utilization of ionizing radiation, both the referring practitioner and the radiologist responsible for the examination should carefully consider the justification for CT examinations and the possibility of using other imaging modalities.

Keywords Computed tomography · Justification · Radiation · Radiation protection · Dose

Introduction

The three fundamental principles of radiation protection in radiology are justification, optimization of protection, and application of dose limits [1]. Shortly after publication of the European Commission's directive 97/43/EURATOM in June 1997, justification was considered to be the challenge of the decade with large implications for prescribers, practitioners and their training [2]. Ten years later, it has been speculated that the process of justification is sometimes weak or even nonexistent [3]; however, to our knowledge this has not been systematically explored.

The radiation doses from computed tomography (CT) examinations are among the highest in diagnostic radiology, yet CT is being increasingly utilized. According to the referral criteria for imaging recommended by the European Commission, imaging methods without ionizing radiation, such as ultrasound (US) and magnetic resonance imaging (MRI), or methods with low-dose radiation should be considered whenever justified [4]. Particular attention should be paid to young patients, since the radiation-induced lifetime risk of cancer mortality is higher at younger age until approximately the age of 35 years (Fig. 1) [5].

The aim of the present study was to determine whether previous CT examinations done at our university hospital on patients under the age of 35 years were justified. To accomplish this, the patient files of 200 former examinations were retrospectively reviewed.

Materials and methods

Altogether 148,988 examinations were performed in the Department of Diagnostic Radiology of Oulu University Hospital, Oulu, Finland, in 2005. Eleven per cent (16,975) of the examinations were done using computed tomography, and 2,367 (14%) of the CT examinations were done on patients under the age of 35 years. The main groups of examinations were CT of the head, thorax or lungs, lumbar (and sacral) spine, abdomen or upper abdomen, trauma, cervical spine, nasal sinuses and body (thorax and abdomen) (Table 1).

The examinations analysed in this study were CT of the head (50 patients), lumbar (and sacral) spine (30), abdomen or upper abdomen (30), trauma (30), cervical spine (30) and nasal sinuses (30). The final study thus included 200 examinations. Images falling in these categories were extracted from the electronic patient files of our hospital consecutively from the beginning of the year 2005. CT of the thorax or lungs and body were excluded from the study because there is no good alternative for these examinations.

Patient files, clinicians' referrals, and indications and findings of the examinations were analysed by an experienced radiology specialist. Using that information and the referral criteria for imaging recommended by the European Commission [4], it was decided whether the examinations had been justified, and if not, whether there would have been some other, more justifiable imaging modalities available.

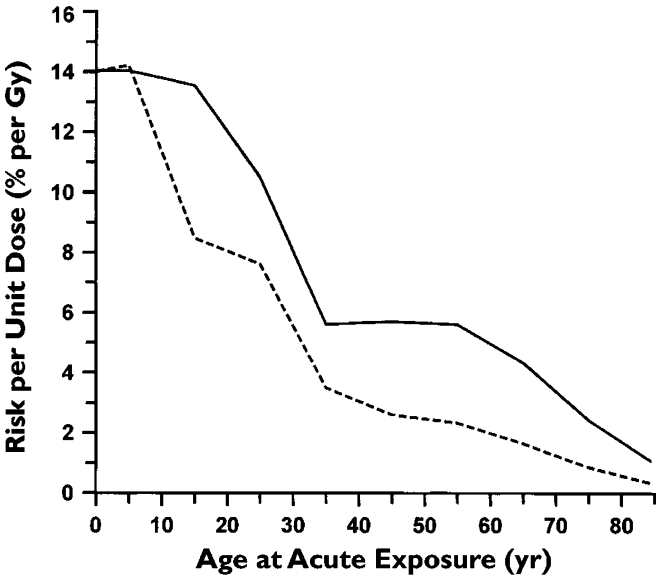

Fig. 1 Lifetime attributable cancer mortality risks per unit dose as a function of age at a single acute exposure as estimated by National Academy of Sciences BEIR V (Biological Effects of Ionizing Radiations) committee (*solid line*) and in ICRP (International Commission on Radiological Protection) report 60 (*dashed line*). Note rapid increase in lifetime risk with decreasing age at exposure [5]. (Reprinted with permission from the *American Journal of Roentgenology*)

Table 1 CT examinations performed on patients under 35 years of age in 2005 at Oulu University Hospital (total 2,367 CT examinations)

Head	1,063
Thorax or lungs	241
Lumbar and sacral spine	130
Abdomen or upper abdomen	123
Trauma	117
Cervical spine	110
Nasal sinuses	100
Body	80
Other	403

In the evaluation, the following main categories were used:

1. Lumbar spine: MRI is justified in the case of disk syndrome (of lumbosacral area) in young patients, while CT is indicated in trauma and control of fixation of the lumbar spine.
2. Head: MRI is justified in elective cases, while CT is indicated in trauma or in some other acute cases (see below).
3. Abdomen or upper abdomen: the cases had to be considered case by case because they were so variable.
4. Nasal sinuses: each patient expected to have functional endoscopic sinus surgery (FESS) should have CT of the sinuses.
5. Cervical spine: CT is justified in the case of trauma.
6. CT of trauma is indicated in high-energy traumas.

Cases not falling into these categories were analysed individually. After that, other specialists in radiology went through the information collected and expressed their opinion; if necessary, consensus was used.

Results

About 30% of all the 200 examinations evaluated were unjustified. Twenty-three of the 30 CT examinations of the

Table 2 Justification for the CT examinations analysed

	Justified *n* (%)	Unjustified *n* (%)	Total *n*
Lumbar and sacral spine	7 (23)	23 (77)	30
Head	32 (64)	18 (36)	50
Abdomen or upper abdomen	19 (63)	11 (37)	30
Nasal sinuses	24 (80)	6 (20)	30
Cervical spine	29 (97)	1 (3)	30
Trauma	30 (100)	0	30

Percentage out of total number of cases is given in parentheses

lumbar spine (77%) were considered not justified (Table 2). Twenty cases could have been replaced by MRI, and three patients would have needed no radiological examination. Symptoms of disk syndrome, suspicion of spinal stenosis and control of spinal lymphoma in young patients may indicate MRI. Trauma and control of fixation indicate CT.

Eighteen of the 50 CT examinations of the head (36%) were not justified. All of them could have been replaced by MRI. Elective cases should have MRI performed. CT is indicated in trauma or some other acute cases, such as suspicion of intracranial bleeding or acute stroke.

CT was not justified in 11 of the 30 CT examinations of the abdomen or upper abdomen (37%). Five of the cases could have been replaced by MRI, four by US and one by fluoroscopy. One patient did not need any radiological examination. Two patients had unspecific hepatic lesions at US, which should have indicated MRI instead of CT. Other patients in this group were so variable that no classification could be done; the analysis had to be done case by case.

Six of the 30 CT examinations of the nasal sinuses (20%) were not justified. Five of them could have been replaced by MRI, and one did not need any other examination but CT of the head. CT was considered to be justified especially if operation of the sinuses was being planned, since there is a need for accurate delineation of the bony structures for FESS. However, five of the unjustified cases also had rhinitis or sinusitis, but there was no information about plans for operation in the referral.

Only one of the 30 CT examinations of the cervical spine was not justified. The patient did not need any CT examination of the cervical spine in addition to one of the lumbar spine. Other cases were traumas and a control of fixation, which indicated CT. All the 30 CT examinations of trauma were justified because the traumas were high-energy ones.

Discussion

The European Commission's directive 97/43/EURATOM published in 1997 recommends decreasing excessive exposure of patients to ionizing radiation because it always increases the statistical risk of cancer mortality [4]. The risk is higher at younger age because the expected lifetime is longer than at older age (Fig. 1) [5]. Division of the cells is also fast and the organs are particularly sensitive to radiation at younger age [6]. One important way of decreasing radiation is to avoid unnecessary examinations that utilize ionizing radiation.

The estimated global total number of diagnostic medical x-ray examinations increased in the 1990s, and the annual collective effective dose has increased relatively even more. The national frequencies of examinations have increased in some countries and decreased in others. CT is being increasingly utilized, and advances such as helical and dynamic CT scanning are likely to result in further increase in the global average dose per examination [7].

There were about 3.9 million medical x-ray examinations performed in Finland in 2005. About 7% were CT scans, and there were 30% more CT examinations in Finland in 2005 compared with 2000 [8]. It is estimated that about 50% of the global collective dose is caused by CT with its relatively high doses of radiation [4]. It is assumed that although the risk to a single individual is small, the exposed global population is large and increasing, which may result in significant long-term public health problems [9]. It is therefore important to have good indications for CT or to utilize US, MRI or examinations with lower radiation doses whenever possible [4]. Special attention should be paid to paediatric CT because radiation doses from CT may be similar or even higher than the levels observed for adults, and growing children are particularly sensitive to radiation [7]. In addition to the importance of advances in the use of paediatric protocols and in CT technology, it is highly important to provide education for practitioners in order to eliminate inappropriate referrals because radiation risks are frequently underestimated [10]. It is also estimated that advances in imaging technology, particularly those involving nonionizing radiation, will have a significant influence on the practice of radiology and the medical exposure of populations. MRI is becoming the imaging modality of choice for many areas of anatomical examination. However, there is still a shortage of MRI capacity in many countries [7].

The utilization of radiology is accepted as part of medicine, especially after careful justification. Despite the rules and recommendations defined in the legislation on medical radiation, it is obvious that some of the radiological examinations are inappropriate [9, 11]. With the help of our retrospective analysis we wanted to find out whether the number of CT examinations done on young patients could have been decreased with better justification. For the analysis, we chose CT examinations which could be replaced by other investigations, even ones not involving any radiation.

Most of the unjustified examinations, 77%, appeared to fall into the group of lumbar CT. The dose of radiation from lumbar CT is about 170 times the level of thorax PA x-ray. Most of these unjustified cases could have been replaced by MRI. In particular, a young patient with symptoms of disk syndrome should undergo MRI instead of CT.

Thirty-seven per cent of the cases in the group of abdominal CT were unjustified. The dose of radiation from abdominal CT examination is about 500 times that of a single thorax PA x-ray [4]. Five of the cases could have been replaced by MRI, four by US and one by fluoroscopy. The indications for the examinations of these patients were so varied that they had to be analysed case by case. The modality should be carefully chosen in each case involving a young patient with abdominal complaints. In the case of lumbar or abdominal CT examination, the radiation is also directed to the area of radiation-sensitive organs.

Thirty-six per cent of the cranial CT studies were deemed unjustified. All these 18 examinations should have

been replaced by MRI because they were elective cases. The dose of radiation from CT of the head is also about 115 times that of a thorax PA x-ray [4]. There were fewer unjustified cases in the group of CT examinations of the nasal sinuses or the cervical spine, and all cases in the trauma group were justified.

Our study is an audit of the practice at one department of radiology. However, suspicions of inappropriate use of radiological examinations and less selective use of diagnostic CT have been reported [9]. Some paediatric radiologists have estimated that about a third of CT examinations are unnecessary [12]. In the present study, we have also reported the main indications of the request forms to give readers an opportunity to compare their own practice with the one we used to have. The commonly accepted referral criteria for imaging recommended by the European Commission were considered as the gold standard in our study. Our conclusions regarding the possibilities of other investigations to replace CT examinations are also theoretical because the study is retrospective and other investigations, such as MRI or US, had not been performed. The conclusions are, however, based on patient files, clinicians' referrals, indications of the examinations and the abovementioned criteria for imaging, i.e. the information that was available at the moment of writing the request form. The process of justification was also analysed by experienced radiologists.

There have only been a few studies about the justification for examinations causing radiation. Clarke et al. reported in 2001 about the possibilities of using MRI to replace CT examinations. This team had more patients and subgroups than we did, and more than 70% of the CT examinations could have been replaced by MRI; of the examinations of the head and the lumbar spine, more than 90% could have been replaced by MRI [13]. In another report concerning CT examinations of the abdomen, pelvis and lumbar spine, the last of these was often recommended to be replaced by MRI [14]. One study reports about 60% justification of CT examinations according to the request forms; in particular, US could have been useful as a preceding or alternative investigation [15].

International recommendations for radiological examinations have been published [4, 16, 17]. The referral criteria for imaging recommended by the European Commission have also been accepted in Finland [4]. Regular use of referral guidelines can lead to a reduction in the number of request forms and ultimately to a reduction in patient exposure to ionizing radiation [4, 18]. As a consequence of our study, we made some new recommendations for the referring practitioners and the radiologists of our hospital: (1) MRI is the primary examination of the head. CT examination is indicated only in acute cases. (2) MRI is usually the primary examination of the lumbar spine in young patients. (3) Clinicians are recommended to consult a radiologist before sending a request form for abdominal CT in the case of a young patient.

We expect that in the near future, some of the types of examinations analysed will be replaced by MRI in our hospital. One of the problems has been shortage of MRI capacity. We have addressed this by purchasing a new MR system. We have also provided education for the referring practitioners in the areas of radiation risks, doses of radiation of different examinations, and the process of justification. We plan to follow up both indications for CT examinations and the ratio of examinations with and without ionizing radiation in the future. In 2005 the ratio was 77%:23%, in 2006 76%:24%, but in 2007 it was 74%:26%. Although we do not as yet have any detailed follow-up results of the justification, it seems that the number of unjustified CT examinations is decreasing. In the future we expect to have a better system in place aimed at reducing the utilization and risks of radiation.

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