Journal of Disability Research

2023 | Volume 2 | Issue 1 | Pages: 121–124
DOI: 10.57197/JDR-2023-0014

Assessment of the Radiation Exposure and Cancer Risks of Disabled People Undergoing Different Computed Tomography Scans

Abdelmoneim Sulieman[1,*] and Mohammed Almuwannis[2]

[1]Radiology and Medical Imaging Department, College of Applied Medical Sciences, Prince Sattam Bin Abdulaziz University, Al-Kharj 11942, Saudi Arabia
[2]Department of Radiological Sciences, College of Applied Medical Sciences, King Saud University, Riyadh 11433, Saudi Arabia

Correspondence to:
Abdelmoneim Sulieman*, e-mail: abdelmoneim_a@yahoo.com, Tel: +966503297046

Received: May 30 2023; Revised: June 12 2023; Accepted: June 13 2023; Published Online: June 23 2023

ABSTRACT

The usage of radiological investigations is increasing rapidly in Saudi Arabia. It has been estimated that 7.1% of the populace in the Kingdom of Saudi Arabia is disabled. Out of 32.94 million citizens, 1,445,723 (52.2% males and 47.8% females) millions are considered disabled. Disabled individuals are frequently undergoing medical imaging procedures, and there are not enough studies regarding the risk of radiation exposure to disabled patients from these machines. This study aims to quantify the frequency of medical procedures and estimate the collective dose for disabled individuals to predict the overall cancer risk from medical exposure. A total of 108 computed tomography (CT) procedures were carried out for disabled patients. The procedures include the brain, chest, abdomen, pelvis, and cervical spine. A 128-slice CT machine was used in this study Philips Ingenuity (Philips, Netherlands). The CT machine is subjected to regular quality control tests to ensure compliance with national recommendations. In this study, 108 [11 (10.2%) females and 97 (89.8%) males] CT procedures were carried out for disabled patients at the radiology department, King Khalid Hospital and Prince Sultan Center. The average and standard deviation radiation dose per CT procedure [DLP (mGy.cm)] for the brain, chest, abdomen, pelvis, and cervical spine were 1183.4 ± 187, 352.8 ± 88, 654 ± 73, 803 ± 800, and 527 ± 186, respectively. The estimated cancer risk is 1 cancer per 1000 to 10,000 CT procedures. Patient doses are comparable with those of previous studies carried out for normal patients. However, the protection of disabled patients from unnecessary radiation exposure is crucial to reduce the projected radiation risks and minimize the number of repeated CT scans and unproductive radiation exposure.

KEYWORDS

CT imaging, disabled people radiography, effective dose, radiation risks

INTRODUCTION

Disability or limitation in activity is a natural and essential aspect of being human. It is the outcome of the combination of several environmental and individual variables with health disorders including dementia, blindness, and spinal cord injury. Today, 16% of the world's population, or 1.3 billion individuals, are thought to have a major impairment. Due to the rise of illnesses that are not communicable and increased lifespans, this figure is rising (WHO, 2023). People with impairments typically have more limits in daily functioning than nondisabled people, as well as a shorter lifespan (WHO, 2023).

It has been estimated that 7.1% of the populace in the Kingdom of Saudi Arabia is disabled. Out of 32.94 million citizens, 1,445,723 (52.2% males and 47.8% females) million are considered disabled (APD, 2022). People with disabilities have frequently been neglected by global health and international development initiatives, as well as the religious and political life of their communities (Groce, 2018). The usage of radiological investigations is increasing rapidly in Saudi Arabia due to the drastic improvement in health care system and radiological services, with an estimated average 1.5 procedures per patient (Sulieman et al., 2018). In industrialized nations, medical X-ray exposures have long been the main artificial source of ionizing radiation exposure for humans in general. There is a rapid rise in the frequency of computed tomography (CT) examinations, with significant implications for both individual patient doses and the collective dose to the population as a whole. Therefore, it is crucial that authorities responsible for radiation safety and health care in each nation constantly evaluate the scope and distribution of this significant and growing source of population exposure. Previous studies have shown that disabled patients do not receive adequate health care and may have limited access to health care facilities and may lack accessible medical devices (Story et al., 2008). Disabled individuals frequently undergo medical procedures. Imaging patients with disabilities have a unique challenge because some radiological imaging machines present considerable hurdles for some medical patients with disabilities, which may negatively affect their access to health care. Particular imaging protocols are needed to provide accurate diagnostic findings. Smith-Bindman et al. reported that patient doses during CT examinations vary, ranging from 4% to 69% based on the radiology department type, CT machine features, type of procedure, and imaging protocol. Chest and abdominal CT showed a wider variety of patient effective doses (1.7 to 6.4 mSv), while the brain CT procedure showed fewer doses varying from 1.4 mSv to 1.9 mSv per CT procedure (Smith-Bindman et al., 2019). Salah et al. reported patient doses per CT procedure ranged from 290.4 to 6188.9 mGy.cm (Salah et al., 2023). The range of CT doses can increase the radiogenic risk per examination. Abuzaid et al. showed that staff training and proper knowledge of CT protocols and image acquisition parameters can significantly reduce the patient's radiation dose (Abuzaid et al., 2020). To our knowledge, this is the first study in Saudi Arabia regarding radiation exposure and cancer risk for disabled patients. This study aims to quantify the frequency of medical procedures and estimate the collective dose for disabled individuals to predict the overall cancer risk from medical exposure.

MATERIALS AND METHODS

CT procedures and patients' populations

A total of 108 CT procedures were carried out for disabled patients. The procedures include the brain, chest, abdomen, pelvis, and cervical spine. All procedures were carried out according to justified clinical indication using an electronic request form. CT procedures were carried out at King Khalid Hospital and Prince Sultan Center in Al-Kharj, Saudi Arabia. This study was approved by the standing committee for ethics and research, at Prince Sattam bin Abdulaziz University, Al-Kharj, Saudi Arabia. Data were collected and managed accordingly.

CT machines

All CT examinations were carried out at the radiology department at King Khalid Hospital and Prince Sultan Center in Al-Kharj using a 128-slice CT machine (Philips Ingenuity). The CT machine was subjected to regular quality control test to ensure compliance with the national recommendations.

Imaging technique

The data were collected for patients during the routine CT imaging protocol and technique. No modifications were made for dose optimization at this stage of the research.

Radiation dosimetry

In this study, CTDIvol (mGy) and DLP (mGy.cm) were measured using the scanner software; by using these parameters and conversion factors for the brain, sinuses, and facial bone, the effective dose (mSv) was calculated.

Using computer software, the overall effective dose was computed in accordance with the International Commission on Radiological Protection (ICRP) by multiplying the DLP by the CT conversion factors for the brain, head, and neck to get a value in $mSv.mGy^{-1}.cm^{-1}$. (ICRP, 2007), according to Equation 1:

$$E(mSv) = DLP(mGy.cm) \times f \quad (1)$$

The overall cancer risk is calculated by multiplying the effective dose by the cancer-related risk factor (ICRP, 2010).

RESULTS AND DISCUSSION

The percentage of total collective doses received by the population to the number of CT scans continues to rise. Currently, CT accounts for up to 67% of all medical procedure doses given to the public, and the dosage is rising at a pace of 10-15% every year (Stopsack and Cerhan, 2019). In this study, 108 [11 (10.2%) females and 97 (89.8%) males] CT procedures were carried out for disabled patients at the radiology department, King Khalid Hospital and Prince Sultan Center. Patients' age (years), exposure factors, and patient dose per five CT procedures including head, chest, abdomen, pelvis, and cervical spine in terms of dose per slice [CTDIvol (mGy)] and dose per CT procedure [DLP (mGy.cm)] are presented in Table 1. Although patients have a wide range of clinical indications and body characteristics, constant tube potential (kVp), tube current, and CTDIvol(mGy) were used for CT brain, chest, and abdomen procedures, suggesting that the exposure parameters were not adjusted according to the clinical indications and radiation dose and image quality was not optimized. Patients during CT of the pelvis and cervical spine showed limited variation in exposure parameters and patient dose. Because the technologists used fixed exposure parameters and X-ray tube output, the patients' doses showed variation due to the variation in the scan length (Table 1). The patient doses per CT procedure are comparable with those of the previously published studies (Manssor et al., 2015; Sulieman et al., 2015; Suliman et al., 2015; Sulieman et al., 2018; Almujally et al., 2023). Figure 1 provides a comparison of patients' effective doses per five CT procedures. Pelvis and abdomen CT procedures exposed the patients to the highest effective doses due to the irradiation of sensitive organs within the primary beam.

Table 1: Mean and range of patients' age (years), exposure parameters (kVp, mAs), and CT doses [CTDIvol (mGy) and DLP (mGy.cm)] per procedure.

CT procedure	No. of patients	Age (years)	Peak X-ray tube voltage (kVp)	Tube current time product (mAs)	CTDIvol (mGy)	DLP (mGy.cm)
Brain	20 (5 F, 15 M)	44.4 ± 21 (17-83)	140*	270*	54.39*	1183.4 ± 187 (1039-1865)
Chest	16 (M)	51.3 ± 23 (14-87)	120*	120*	8.79*	352.8 ± 88 (260-647)
Abdomen	33 (M)	43.7 ± 15 (17-80)	120*	160*	11.72*	654 ± 73 (547-870)
Pelvis	8 (2 F, 6M)	41.4 ± 19 (17-71)	120*	209 ± 108 (139-458)	17.1 ± 11 (6.1-33.5)	803 ± 800 (358-2816)
Cervical spine	10 (4 F, 6 M)	30 ± 10 (16-48)	120*	207 ± 39 (139-251)	13.7 ± 4.9 (6.1-18.4)	527 ± 186 (223-860)

Abbreviation: CT, computed tomography; *constant value.

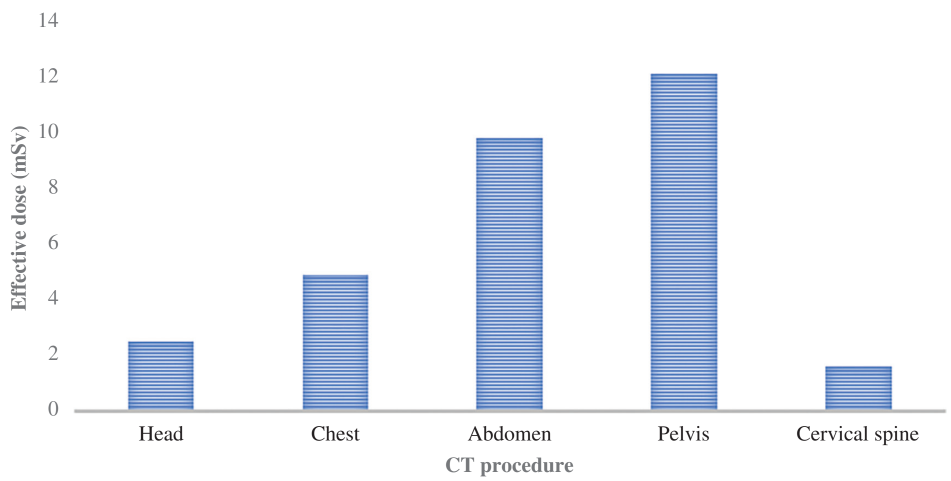

Figure 1: Effective dose (mSv) per CT procedure. Abbreviation: CT, computed tomography.

Patients received the least effective doses during thyroid scans due to the lower DLP per procedure, limited scan length, and the limited number of sensitive organs within the primary beam. It was looked at how much radiation was given to disabled patients having CT scans of the pelvis and abdomen. Variations in dosages were noted in this investigation. In comparison to the abdomen, the pelvis and cervical spine CT have a larger radiation variation (Alkhoaryef et al., 2019; Omer et al., 2021; Salah et al., 2021). The use of an optimized CT protocol is necessary to reduce the high-dose values and harmonize the DLP per CT procedure, when compared to the advantages that precise diagnosis and treatment may offer; the personal radiation risk associated with a CT scan is fairly low (Alameen et al., 2021; Jaafar et al., 2021; Sulieman et al., 2022). However, it is best to minimize unnecessary radiation exposure while undergoing medical operations. The estimated cancer risk is 1 cancer per 1000 to 10,000 CT procedures. Cumulative doses due to frequent CT procedures carried out for follow-up of the patient's condition should be considered. Even low doses of ionizing radiation would increase the probability of developing cancer, according to the "linear-no threshold model," which is most commonly used in radiation protection. The development in CT technology could reduce the patients' doses from CT procedures if the imaging protocols were designed according to the clinical indications. People with disabilities and other special needs should get additional attention due to their decreased mobility and potential inability to follow instructions from the radiography technician, which might lead to more repeated tests.

CONCLUSIONS

The protection of disabled patients from unnecessary radiation exposure is crucial to reduce the projected radiation risks and minimize the number of repeated CT scans and unproductive radiation exposure. Optimization of radiation exposure will also reduce the probability of cancer risk, especially for radiation-sensitive organs within the primary beam. Because disabled patients may undergo frequent CT procedures due to their medical condition, any reduction in radiation dose can affect the cumulative dose per patient. Technologists, radiologists, and referring physicians should be trained in imaging of disabled patients and justification criteria to reduce unnecessary radiation risks. Additionally, the 'optimization of the parameters maximizes the benefits of CT for pediatric patients while reducing the dose and, by extension, the hazards.

FUNDING

This study was funded by King Salman Center for Disability Research through Research Group no KSRG-2023-042.

ACKNOWLEDGEMENTS

The authors extend their appreciation to the King Salman Center for Disability Research for funding this work through Research Group no KSRG-2023-042.

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