ADDIS ABABA UNIVERSITY

COLLEGE OF HEALTH SCIENCE

Computed Tomography Radiation Exposure Among urinary tract Stone Patients At Tikuranbessa Specialized Hospital: A retrospective study

A thesis submitted to the Radiology department college of health science, Addis Ababa University; in partial fulfillment for the requirement for a specialty certificate of Radiology

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Computed Tomography Radiation Exposure Among urinary tract stone patients At Tikuranbessa specialized Hospital: A retrospective study

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Table of Contents

List of abbreviations

ACR------------------Americal College of Radiology

ALARA-------------------as low as reasonably attainable

CT ------------------Computed Tomography

CTDIvol-------------Volume Computed Tomography Dose Index

DLP------------------Dose Length Product

Esv --------------------Effective Dose in siveret

ETB-------------------- Ethiopian Birr

ICRP-----------------International Commission on Radiological Protection

IQR------------------Interquartile Range

k---------------------Tissue weighting factor

kVp------------------Tube voltage peak in kilovolt

mAs------------------Tube current-time product in milliampere second

mGy-----------------Milligray

mm-------------------Millimeter

mSv------------------Millisilvert

NDRL---------------National Dose Reference Level

SPSS-----------------Statistical Package for Social Science

wT ---------------------- tissue weighting factor for tissue T

TASH----------------Tikur Anbessa Specialized Hospital

US-------------------United States

List of figures

List of tables

Abstract

Background: Urinary tract stone is increasing dramatically in recent years so is the diagnostic capability especially after the employment of abdominopelvic CT. The wide use of abdominopelvic CT in the diagnosis, treatment planning, and follow-up of these patients raised the issue of radiation exposure. For this reason, CT protocols that decrease the radiation dose without decreasing the sensitivity and specificity of depicting stone have been implemented. The common of these protocols is low dose CT despite its wide advocation there is wide variation in CT protocols in different institutions. The CT protocol used in our country is not known and there is no national guideline or recommendation for these types of patients, therefore, a wide variety of protocols in different institutions is expected of which some may expose patients to unnecessary radiation.

Objectives: To study the amount of radiation dose patients at tikuranbessa specialized hospital patients with urinary tract stone disease receive in being evaluated by abdomen/pelvic CT

Methods: a retrospective cross-sectional was done February 1to august 31, 2021, at TASH in patients who had their scan for urolithiasis or symptoms related to urolithiasis 1/07/2020-31/10/2020 G.C are included until the sample size is attained. Data were collected by the principal investigator with a structured questioner that evaluates the number of CT they had The CT characteristics like DLP CTDvol, date, and place the CT was taken. These data were analyzed by statistical software SPSS version 22

Results: None of our patients have exposure more than 50msv per year or 100msv over 5 years. 3.6% of our patients have radiation exposure of more than 4msv, which is the standard for low-dose CT. The median radiation exposure is 1.27mSv per scan. Exposure factors like tube current, tube current product, dose length product, scan range all have similar values with almost null interquartile range.Tube current product was found to have a statistically significant positive

correlation with effective dose.All the scans that overpassed the low dose threshold(4msv) were done outside TASH.

Conclusion: Our study showed that TASH's low dose CT protocol for patients with urolithiasis is well optimized and patients are not being overexposed but even with the limited data we have non-TASH institutions are likely using non-optimized CT scans and patients may be a victim of radiation overexposure for either diagnosis or follow of urolithiasis.

Introduction

Background

Tikuranbessa specialized hospital (TASH) is the largest referral hospital in the country with around 700 beds. It is also the main teaching hospital in the country in multiple clinical disciplines even being the only teaching center for some disciplines.

Urolithiasis is the major cause of urologic admission in TASH. Around 22.3% of urology patients that are admitted to TASH are due to urolithiasis according to research done in 2013. The study also makes renal stone the commonest affected anatomical region accounting for 48.8% of the studied urinary tract stone patients (1).

In the 21st century, non-contrast abdominopelvic CT is becoming the imaging modality of choice in the detection of urinary calculi(2). IT has proven to be a good imaging modality in the detection, characterization, and treatment planning of urolithiasis patients with remarkable sensitivity, specificity, and accuracy (2).

The wide use of this non-contrast abdominopelvic CT for detection and follow-up of patients with urolithiasis brought a concern of radiation exposure which may increase the risk of patients developing secondary malignancies, especially in the young population. Therefore, exposing patients to multiple scans of standard abdominopelvic CT for urolithiasis was inconsistent with the ALARA (as low as reasonably achievable) principle. currently, the American college of radiology recommends the use of low-dose CT for flank pain. A meta-analysis study done in 2008 to evaluate the performance of low dose CT defined by an estimated effective dose of <3mSV showed that it can diagnose urolithiasis with a sensitivity of 96.6% and specificity of 95%(3).

Despite the advocation of low dose CT for imaging of urolithiasis different institutions have different radiation dose utilization determined by scanner type or manufacturer, the protocol they utilize, tube rotation speed, helical pitch, collimation, etc(4)

An effective dose is a tissue weighted sum of the equivalent doses in all specific tissues and organs of the body and represents the health risk to the whole body which Could be cancer induction and genetic defects(5). it takes Into account the type of tissue Irritated and the types of radiation. It provides the summated total calculated dose. It is given by the formula

$$E = \sum_{T} w_T H_T = \sum_{T} w_T \sum_{R} w_R D_{T,R}$$

Where wT is the tissue weighting factor for tissue T and∑ wT = 1. The sum is performed over all organs and tissues of the human body considered to be sensitive to the induction of stochastic effects. These wT values are chosen to represent the contributions of individual organs and tissues to overall radiation detriment from stochastic effects. The unit of effective dose is J kg-1 with the special name sievert (Sv)(5).

The recommended effective dose according to the international commission on radiological protection(ICRP) for occupational exposure is <100msv in 5 years with an average of <20msv per year and further states that any exposure shouldn't be greater than 50msv in a year(5). Although the ICRP fails to state the dose limit for medical exposure, It can be inferred from atomic bomb survivors that 20-30msv of effective dose is associated with a significantly increased risk of solid tumors(6).

CT radiation dose is recorded in a metric dose like CTdose index volume (CTDIvol) or dose length product(DLP). These measurements don't directly measure the radiation dose that the patient absorbs rather to quantify the radiation that the patient is exposed to (7). The radiation dose the patient absorbs is dependent on the size of the patient and largely by the radiation emitted by the machine. These measurements don't consider the size of the patient but any measurement in medicine or research is not perfect despite their limitation they are useful radiation dose measurement indexes.

The above-mentioned indexes play a significant role in understanding and improving the safety of imaging because they provide readily available and controllable measures(7).

CT dose index volume CTDIvol (measured in mGy) is a measure of radiation dose output of a CT scanner which allows for the comparison of radiation output of different CT scanners(8). It is obtained as CTDIvol CTDIvol =CTDIw/pitch factor(9)

Where CTDIw is weighted average dose of a single slice. pitch factor is table distance traveled in one 360° gantry rotation divided by the total thickness of all simultaneously acquired slices)(10).

The other commonly used index is dose length product(DLP) which considers the length of the scan. It is obtained as DLP (mGy*cm) = CTDIvol x scan length.

The effective dose is calculated from DLP by multiplying the DLP by a standard conversion factor (k = 0.015 mSv/mGy-cm for a CT of abdomen/pelvis(11).

Statement of the problem

In our hospital patients that are sent for abdominopelvic CT for diagnosis and follow-up of urolithiasis are increasing but the radiation dose they receive is not known since there are no studies done to evaluate this issue.

Significance of the study

This study is aimed at estimating the EDdose for a patient who had gone abdomen/pelvic ct to diagnose renal colic or to follow already diagnosed patients. This will show where we are in the radiation exposure in these specific type of patients. If the practice we are taking is exposing patients to high radiation it will be a turning point to improve our scanning parameters or if the practice we are following is giving optimized radiation exposure it will help us to continue our current practice and share our protocol with other institutions. This study will also help other institutions to improve their scanning parameters and dose parameters in accordance with the result that this study provides. It will also be a reference for future researches.

Literature review

Many works of literature show that the prevalence of urolithiasis is increasing dramatically. Research done in Germany comparing the incidence and prevalence of urolithiasis 1979 vs 2000 showed that there is a marked increase in the prevalence and incidence of the disease within the 21 years, making an increase in diagnostic capability, nutritional change, and environmental change as ascribed factors for the increase(12). Another research done in the United States shows, because of global warming there will be an expansion of the previously stated ‘kidney stone belt’ which are states with the highest prevalence of kidney stone(13).It also anticipates that there will be an increase of 1.6–2.2 million lifetime cases of nephrolithiasis by 2050, which corresponds to a 30% increase(13). A 13-year retrospective case analysis done in our country at St paul’s referral hospital also showed that there was an increase in the occurrence of urolithiasis in the hospital(14). The ascribed factors for the increase are the increase in diagnostic capability and the availability of surgery in the hospital(14).

As the prevalence of urolithiasis is increasing worldwide and in our country, one of the agreed-upon cause for the increase is the advancement of diagnosing capability[12-14]. one of the advancements of urolithiasis diagnosis is the implementation of abdomen/pelvic CT which is becoming the main imaging modality in the diagnosis of urolithiasis(15). Non-contrast abdomen/pelvic CT has a sensitivity of more than 95% and specificity of more than 96% in detecting urolithiasis (15). The improvement in the technology of CT has increased its role in the imaging of urolithiasis from just diagnosing to treatment planning and monitoring of treatment success(15).in recent pieces of literature, CT is being increasingly used in the emergency department in patients presenting with acute flank pain(16).compared to intravenous urography which was the dominant imaging modality in emergency patients presenting with acute flank pain, CT is superior detecting ureteral stones and determining the cause of ureteral obstruction and was also superior compared to abdominal radiography(16). There is no written literature that I have found on the degree of usage of abdomen/pelvic CT in the evaluation of urolithiasis. This study may fill this gap. As for personal experience, the role of abdomen/pelvic ct is increasing in the diagnosis and follow up of a patient with urolithiasis in TASH.

The amplified usage of CT in the diagnosis, treatment planning, and post-treatment follow up has raised a concern of increased radiation exposure. A single body CT scan in a 45-year-old patient will increase an estimated lifetime attributable cancer mortality risk of by around 0.08%(6).If this patient plans to go annual body ct up to the age of 75 he will have 30 examinations which will increase his estimated lifetime attributable cancer mortality risk close to 2%[6].In a study done in the united states showed that imaging procedures are an important source of ionizing radiation in the general population(18). The other concern is in the radiation exposure is its dramatic increment. The average radiation dose a person in the united states receive has doubled in the last 30 years and currently, medical imaging is taking around 50% of the total radiation dose of the US population(19).A study done in our hospital as a postgraduate fulfillment thesis showed that DLP and effective dose used for routine abdomen/pelvic CT are considerably higher than that of the international dose reference level20]. The ascribed factors for this increase were the hight tube voltage and longer scan length time used(20).

To tackle the concerns of abdomen/pelvic CT radiation exposure for the use in patients with suspected or confirmed urolithiasis, there are some algorithms have been implemented that give the same result with lower radiation exposure. one of these is low dose CT.a study done to compare the sensitivity and specificity of low dose CT vs standard CT where they defined low dose CT to be <2.4msv where the standard ct having radiation dose upto 14msv showed that low dose CT has similar sensitivity and specificity in depicting renal and ureteral stone which is greater than 3mm in patients BMI <30(21). Another study done to evaluate the yield of ultra low dose ct which is comparable to KUB with an effective dose of 0.5 and 0.7msv in men and women respectively showed that the sensitivity and specificity was 97% and 95% not only that it provided alternative diagnosis better than ultrasound and KUB(22).

Even though multiple literatures advocate the use of low dose CT for diagnosis and follow-up of patients with urolithiasis there is considerable variability in the amount of radiation dose in different institutions(4).A study done in five universities of California medical centers showed significant variability in radiation exposure for the same examination(4). There were also institutions that use contrast-enhanced or multiphasic scan which are clearly against the new ACR choosing wisely recommendation(23)(24). There are no works of literature that evaluate the practice in our country and there is no national guideline or recommendation for appropriate CT algorithm for patients with urolithiasis. Therefore these study tries to evaluate the current practice in our hospital and other institutions if patients have CT outside our hospital, the amount of radiation exposure they receive in being evaluated for urinary tract stone filling the literature gap we are facing in the matter.

Objectives of the study

General objective

To study the amount of radiation dose patients at tikuranbessa specialized hospital with urinary tract stone disease receive in being evaluated by abdomen/pelvic CT

Specific objective

Quantify the radiation dose patients with urolithiasis receive during abdomen/pelvic CT

State how often these patients exceed the dose limit of occupational exposure and try to determine the factors for the exceeded dose

Express what type CT protocol they are being evaluated with and compare with the internationally recommended protocols

Methods and material

Study area and period

The study will be conducted in Tikur Anbessa Specialized Hospital, College of Health Science, Addis Ababa University, Addis Ababa, Ethiopia(TASH). TASH is under the administration of Addis Ababa University and is located in the nation's capital, Addis Ababa. It is the largest referral and the main teaching hospital in the country. It is also the main referral center for patients with urolithiasis since the hospital has the largest number of urologists and nephrologists.The hospital has around 700 beds and gives diagnostic and treatment services for about 370,000-400,000 patients per year. 22.3% of its urology patient admission is urolithiasis patients. The Radiology department is one of the many departments in the institution which gives imaging services and academic activities. It has two CT scans (64 and 128 slices) where the 64 slice CT is currently functional

The study was conducted from 1/07/2020-31/10/2020 G.C

Study design

A retrospective cross-sectional study was conducted from the period of 1/07/2020-31/10/2020 G.C

Source population

All urolithiasis patients or patients suspected of urolithiasis in TASH

Study population

All patients who had their scan for urolithiasis or symptoms related to urolithiasis 1/07/2020-31/10/2020 G.C

Study unit

Each selected urolithisasis patient or suspected of urolithiasis patient who has at least one abdominopelvic CT

Inclusion criteria

•All patients greater than 18 years of age and are on follow up or are new patients for urinary stone disease in TASH and had abdominopelvic CT for diagnosis or follow up

Also, patients who had abdomen/pelvic ct for evaluation of flank pain hematuria and recurrent UTI are included since these are the symptoms patients urolithiasis present with

Exclusion criteria

- Patients who cannot provide the abdominopelvic CT
- If the CT they provide has missing radiation dose metric data

If the patient refuses to participate in the study

Sample size determination

The study is a retrospective cross-sectional study. The minimum required sample size is calculated by the following formula:-

$$n = \frac{\left(Z^{\alpha}/_{2}\right)^{2} p(1-p)}{d^{2}}$$

Here n is the minimum required sample size, Zα/2 is the value under the standard normal table for a given confidence interval (1.96 for 95% CI), p is the best estimate of prevalence In this study since we don’t have a similar previous study done in our country we used P to be 50% which is the most conservative and d is the margin of error (0.1).

$$n = \frac{(1.96)^{2}\ 0.5(1-0.5)}{0.1^{2}}$$

$$n \approx 100$$

Sampling procedure

A convenience nonprobability sampling method was used. All patients who had their scan for urolithiasis or symptoms related to urolithiasis 1/07/2020-31/10/2020 G.C are included until the sample size is attained.

Study variables

Independent variables

Age

Sex

Type of abdomen/pelvic CT performed

Indication for the CT

Institution the CT is take Tube current-time product (mAs)

Tube voltage peak in kilovolts (kVp)

Contrast Usage

Pitch

Collimation

Rotation time

Number of CT scans performed per patient

Dependent variables

Volume Computed Tomography Dose Index (CTDIvol)

Dose Length Product (DLP)

Effective Dose (EDsv)

Computed Tomography Dose Index (CTDI)

Operational definition

CT dose index volume CTDIvol (measured in mGy) is a measure of radiation dose output of a CT scanner which allows for the comparison of radiation output of different CT scanners

CTDIw is weighted average dose of a single slice

Dose length product (DLP): a measure of CT tube radiation output/exposure for the length of scan

An effective dose is tissue weighted sum of the equivalent doses in all specific tissues and organs of the body and represents the health risk to the whole body which Could be cancer induction and genetic defects

The effective dose is calculated from DLP by multiplying the DLP by a standard conversion factor (k = 0.015 mSv/mGy-cm for a CT of abdomen/pelvis.

Data collection method

The selected patients were given a phone call, where their phone number is retrieved from 'ICARE' an electronic health record system practiced in TASH, asked for consent and if they have previous CT scan done in the last five years for urolithiasis or symptoms of urolithiasis. If their previous scan is done in TASH it will be retrived from TASH's PACS(picture archiving and communication system) and was told to bring their digital optical disc data storage given from the institution they had their scan in their convenience time if the scan is done outside TASH.

Data were collected by the principal investigator. The data were collected using a structured data collecting instrument The data collecting format has included quantities for assessing CT doses like CTDIvol, DLP, and scan parameters like kVp and mAs. The data collecting format also had socio-demographic characteristics like age and sex.

All data regarding data collecting format were retrieved from TASH PACS if it was done in TASH and from the dose metric data found digital optical disc data storage given to the patient if it is done outside TASH.

The checklist was prepared by using google forms and was filed online.

Data processing and analysis

In this study, the data was filed by google forms where the data can be immediately checked. This was essential to examine the data and prevent possible data processing errors (consistency errors, implausible values, duplicating errors, transpositions, copying errors). The data is then fed to the statistical software SPSS version 22. After being further evaluated by the software for possible errors the data was processed by the same software.

All available CT scans performed within the last 5 years were retrospectively reviewed to determine the patients' maximum EDose for a single 12-month period and the total five years and compared to the recommended EDose limit for occupational exposure by the International Commission on Radiological Protection (ICRP) is <100 mSv in 5 years with the further provision that no annual exposure is>50 mSv.

A Pearson's correlation coefficient was used to determine the scan characteristics that have a statistically significant correlation with the effective dose at a p-value <0.05

Ethical consideration

Data collection was started after getting permission from the ethical review committee of the Department of Radiology, TASH, Addis Ababa University.

Results

A total of 100 patients with 109 CT scans have met the inclusion criteria and their CTs have been evaluated. Out of this 38% are female and the rest are male(Figure 6). The patients evaluated are with a minimum age of 18 and maximum age of 70 years and an average of 35.4 years. Showing most of the patients are middle-aged patients(Figure 4).

Out of the evaluated patients, only 9 patients(9%) have had more than one CT performed during the last 5 years.

The commonest indication for the CT scans is ureteric stone while flank pain being the second common indication for the scans(Figure 1). follow up for already diagnosed urolithiasis patients was the commonest indication for the second CT.

All the evaluated patients have non-contrast CT done for them, none of them had post-contrast CT or multiphasic CT. All the scans have a beamwidth of 40mm. All the scanners used helical scanning mode. All scans used a pitch of 0.98.

Out of the 109 CT scans, only 4(3.6%) patients had a calculated effective dose of >4msv which is greater than what is considered a low dose CT. on sub analysis all of these CT scans were done in non-TASH locations(Figure 2)Figure 2.similarly Out of the 109 CT scans, only 4(3.6%) patients had CT dose index >2mGy which is greater than what is considered a low dose CT and this too are from non TASH institutions (Figure 3).

The effective dose of all scans has similar values except for four outliners as depicted in Figure 8 with a median of 1.266mSv(IQR,1.36-1.21) All of these outliners are scans done outside TASH. Similarly, the tube current product of the scans has similar value except for the four outliners as shown in Figure 7.

None of the evaluated patients has an effective dose greater than 20 millisieverts in a year or greater than 50 millisieverts in 5 years which is the recommended occupational exposure (Figure 2).All the CT scans used a tube voltage of 120 kvp.

The tube current product(mAS) were all 18.3 with exception of four scans which were done outside TASH which are in the range of 162-325mAs (figure 3). The average dose length product(DLP) of all the scans is 95.4(IQR,90.69-80.72mGy.cm). scans done in TASH are in a similar range regarding DLP but those done outside TASH showed significantly increased value (Table 2).

The mean CTDIvol in the CT scans done in TASH is in the range of 1.56-1.57(mGy). Out of the scan done outside TASH, three scans show CTDI vol of 10.28mGy and one scan show 20.18mGy(Table 2).

The average scan range used in the scans is 41.3cm(IQR,46-39.4)(Table 2).

None of the scans used a contrast agent and all of the scans were single-phase scans.

The median and interquartile range of the evaluated CT scan's exposure parameter values are summarized in

Table 2.It shows that the values are very constant or homogenous with no significant variation

Bivariate correlation using Pearson's correlation coefficient showed that mAs has significant postive correlation in determining the effective dose(P-value <0.01). However, The number of scans per patient and the scan range didn't have any correlation in determining an effective dose. KVp was constant in all evaluated CT scans so the relation was not evaluated. (

Table 1).

Table 1 correlation between mAS, KVP, scan range, no of CT scan taken in determining the effective dose

CT scan parameters		***Effective dose***
	Pearson Correlation	*Sig. (2-tailed)*
mAs	*.998***	*<0.01*
KVp	*a*	*a*
Scan range	*0.023*	*0.818*
No of CT taken	*0.152*	*0.130*

a = the data is constant no correlation can be done

***** significant correlation***

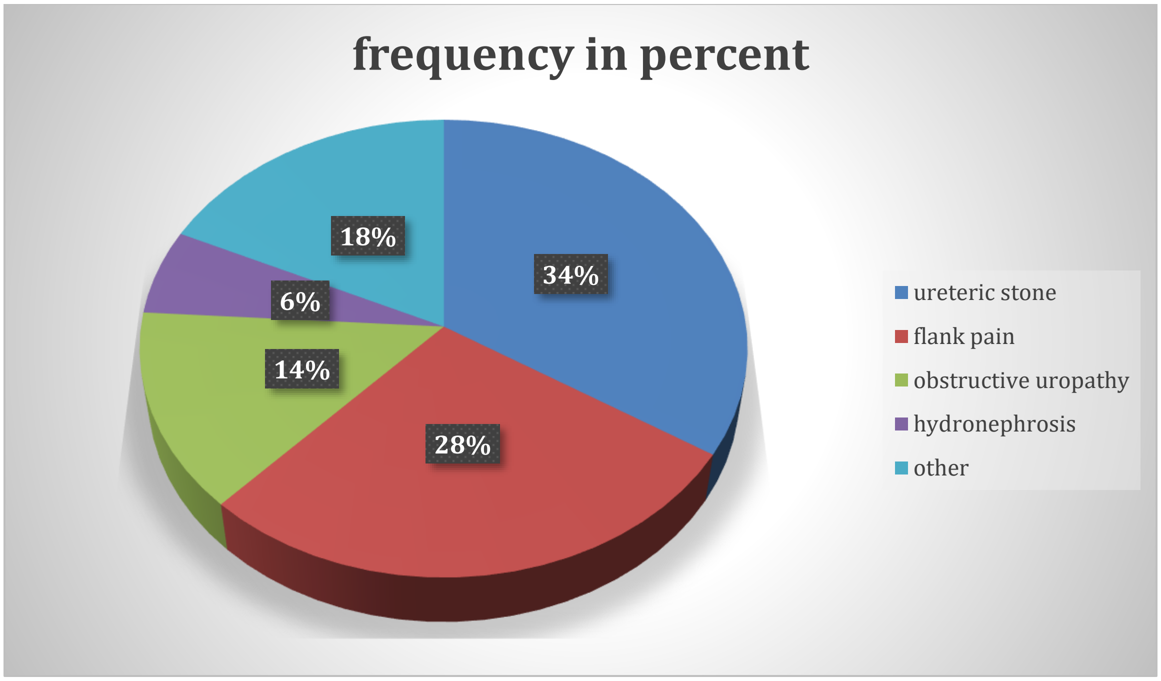

Figure 1 pie chart showing common indications for the CT scans done

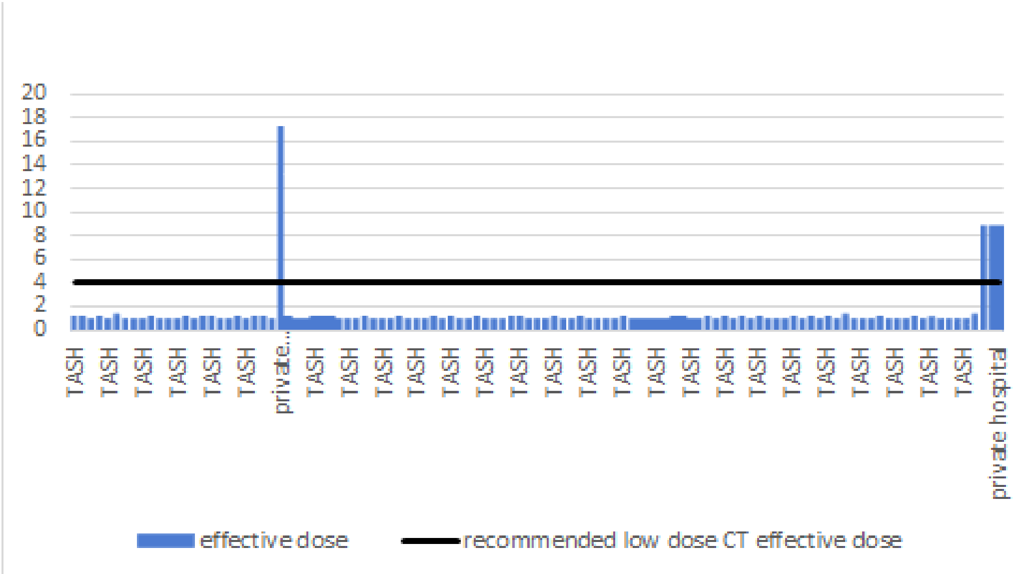

Figure 2 Bar graph showing each evaluated CT scan effective dose compared to the recommended low dose CT scan dose (4msv)

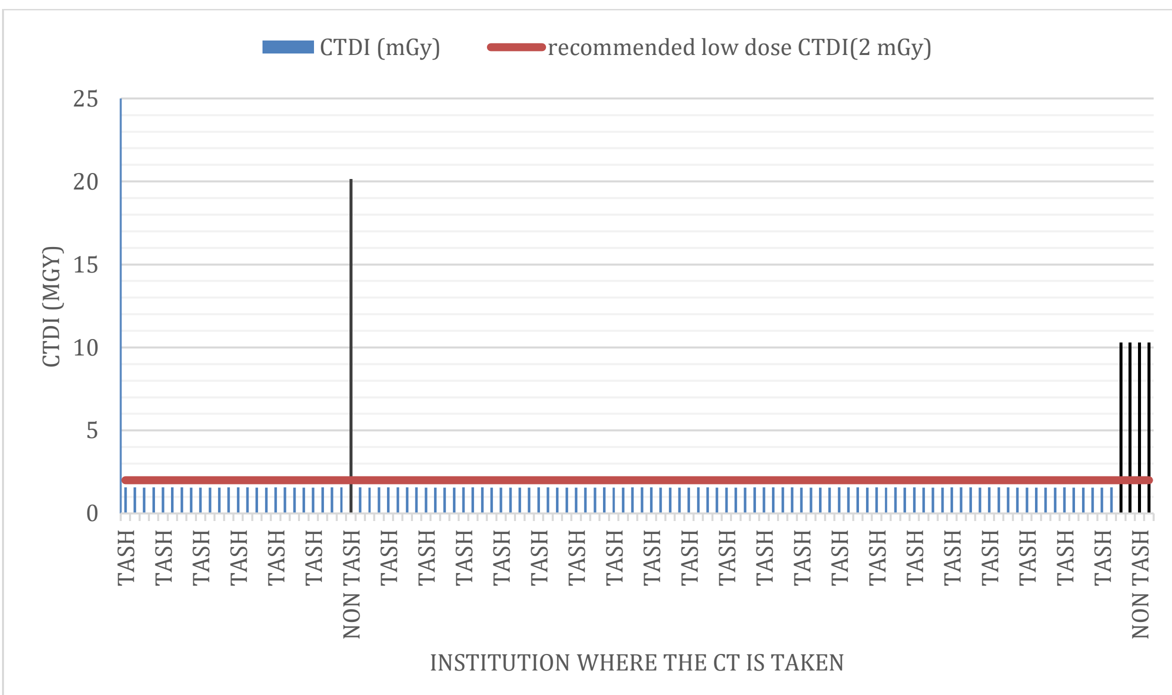

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Figure 3 Bar graph showing CT dose index (CTDI) (measured in mGy) values of all the CT scans done in TASH and non TASH institutions compared to the recommended low dose CTDI(2mGy)

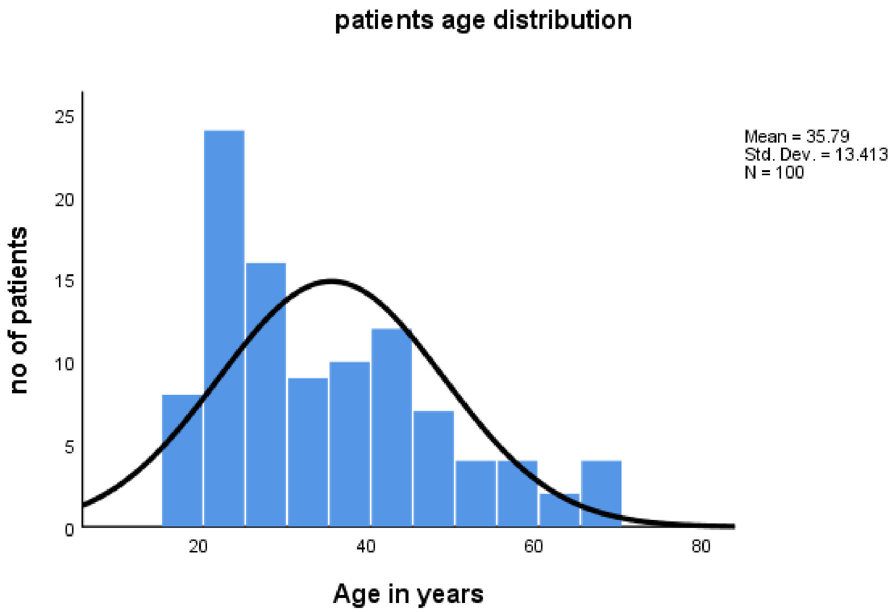

Figure 4 **Bar graph showing patients age distribution**

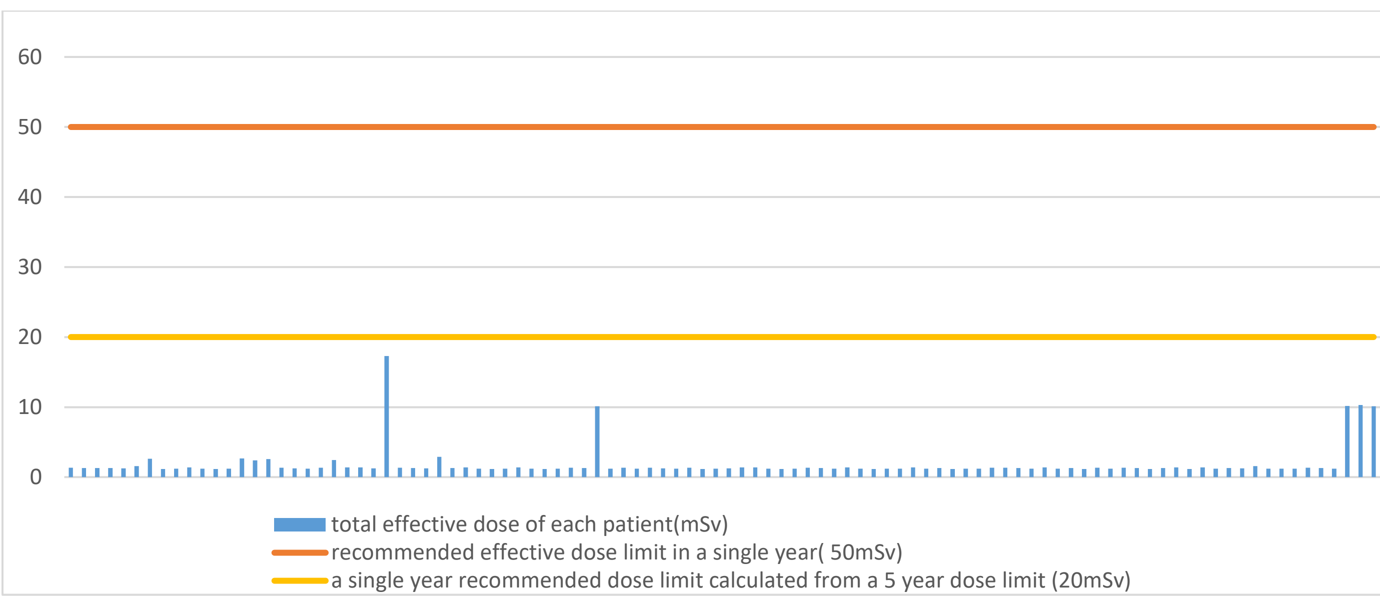

Figure 5 line and bar graph showing total effective dose of all patients in relation to the recommended occupational exposure 50msv in a year and 100msv in 5 year(20msv per year)

Table 2 median and interquartile range of tube current product tube current scan range CTDIvol and dose length product of the evaluated CT scans

	mAs median(IQR)	*mA median(IQR)*	*Scane range median(IQR)*	*CTDIvol median(IQR)*	*DLP median(IQR)*
All CT scans	*18.3(18.3-18.3)*	*30(30-30)*	41.3(46-39.4)	*1.565(1.57-1.56)*	95.4(90.69-80.72)
TASH	*18.3(18.3-18.3)*	*30(30-30)*	42.1(45.75-39.2)	*1.565(1.57-1.56)*	84.22(90.69-80.72
Non TASH	*162(162-162)*	*270(270-270)*	57.89(57.89-57.89)	*10.28(10.28-10.28)*	595.06(595.06-595.06)

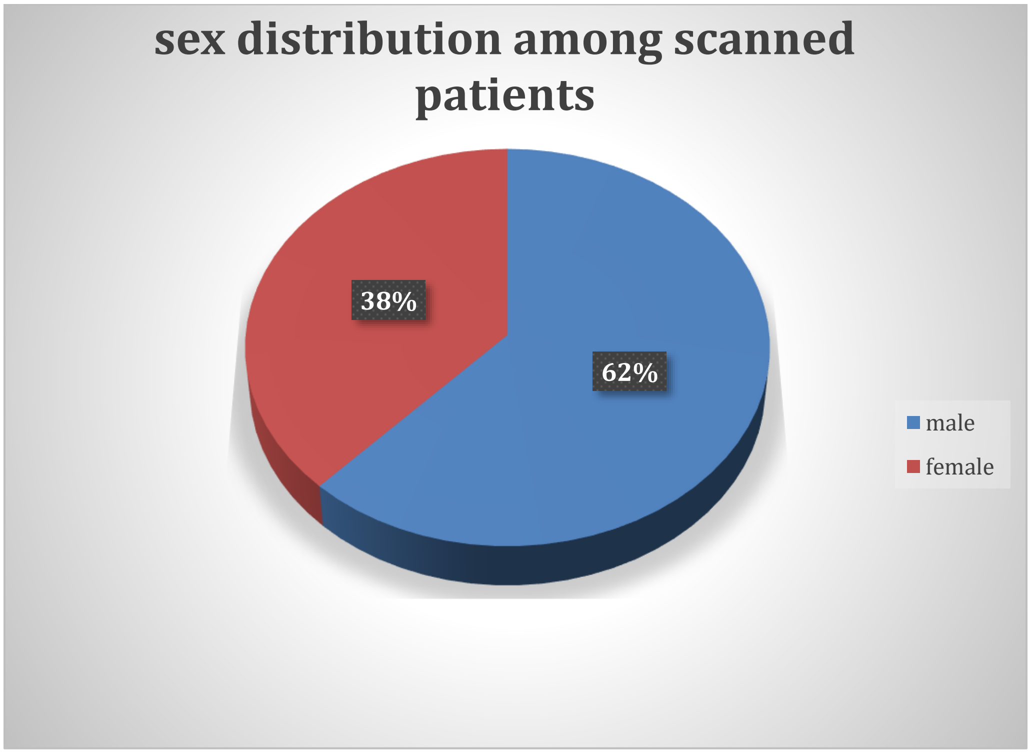

Figure 6 pie chart showing sex distribution of patients

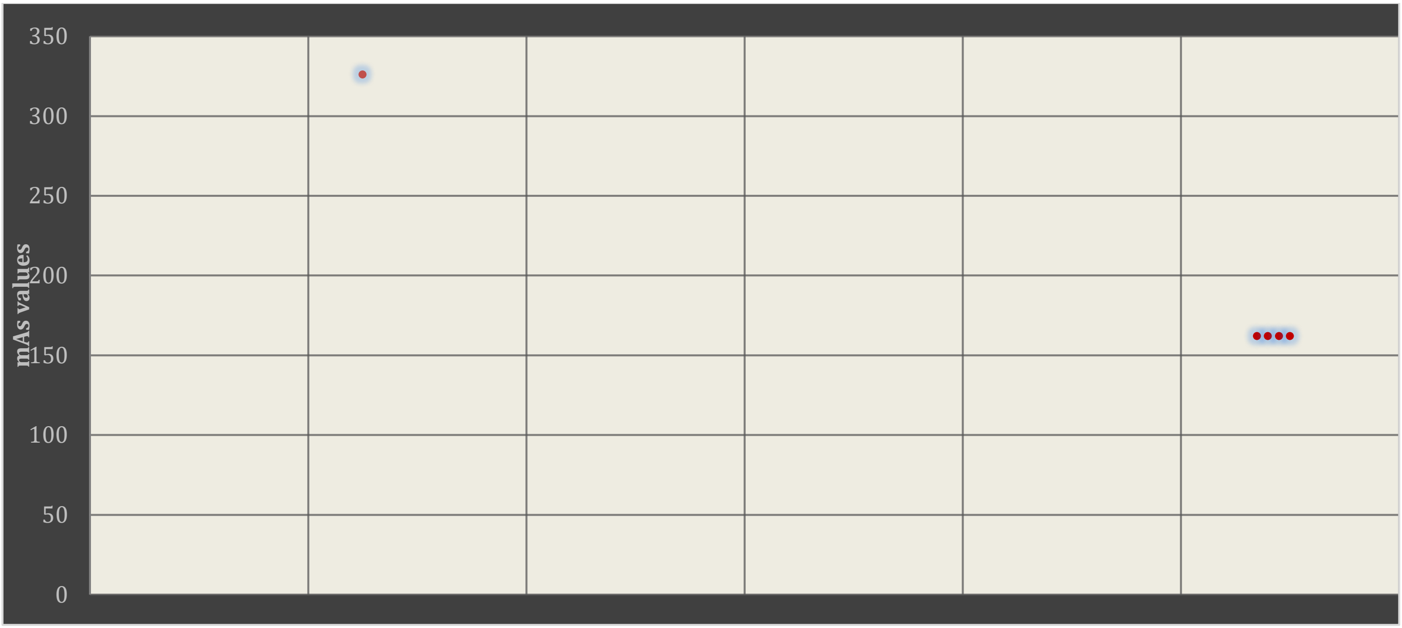

Figure 7 scatter plot showing the variation of tube current product values among all the evaluated CT scans

• scans done in TASH •scans done in NON TASH institution

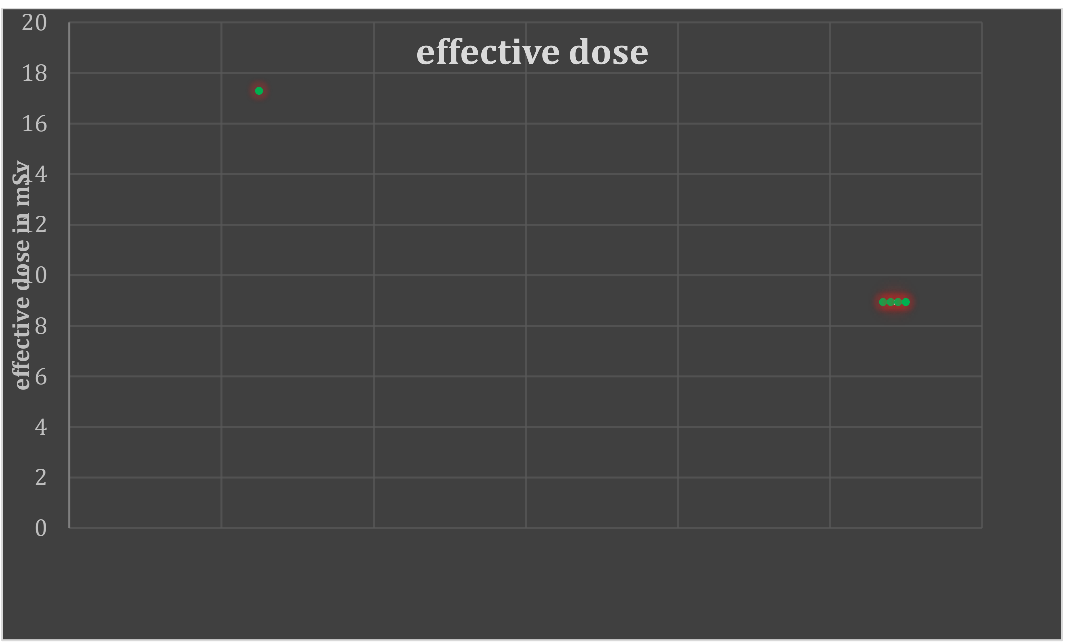

Figure 8 scatter plot showing variation of effective dose among the evaluated CT scans

•*CT done in TASH* •*CT done in NON TASH institution*

Discussion

On this study we have found that most of the patients scanned are middle-age patients and are male(62%).more than 90% of our patients have only one CT scan done and most of the patients had the scan to rule out ureteric stone. None of our patients have exposure more than 50msv per year or 100msv over 5 year.3.6% of our patients have radiation exposure of more 4msv ,which the standard for low dose CT. The median radiation exposure in 1.27mSv per scan. Exposure factors like tube current, tube current product, dose length product, scan range all have similar values with almost null interquartile range.Tube current product was found statistically significant in determining effective dose. To our knowledge, this is the first study to evaluate the amount of radiation that patients with urolithiasis are exposed solely from CT exposure in TASH patients

There is significant variation in the effective dose and exposure factors in CT scans done in TASH and Non-TASH institutions which have reinforced previous researches which indicates a significant variability in radiation exposure among different institutions (23) (25) (26).

In 2019, Tzou et al.done research in California on Computed Tomography Radiation Exposure Among Referred Kidney Stone Patients. They have evaluated 343 CT scans to see how often kidney stone patients exceed the recommended occupational exposure limits before reaching tertiary hospital out of 389 total patients 26% and 6% had an effective dose > 20mSV and >50mSv respectively(23). Similarly, in 2009 a research done in Duke medical center north California on radiation exposure in acute and short-term management of urolithiasis patients found that 20% of patients had radiation exposure of >50mSv in a year(27).In our study, however, none of our patients have radiation exposure >20mSv or >50msv per year especially those patients who had their scan done in TASH have a way lower radiation exposure level from the recommended occupational exposure indicating the CT protocols in TASH are well optimized. Those patients who had close radiation exposure value to recommended occupational exposure have one or two scans done outside TASH. Even though there is no adequate data in our study to give complete deduction but our study highlighted scans done outside TASH may not be adequately optimized.

In 2006 Katz et al. did a study on Radiation Dose Associated with Unenhanced CT for Suspected Renal Colic by determining the incidence of repeated unenhanced CT examinations they have found that 4% had three or more CT examinations in a year and one patient even have 18 scans(28). The research in California on Computed Tomography Radiation Exposure Among Referred Kidney Stone Patients showed 25% of patients had two or more scans in a 5 year period(23). The research in Duke medical center north California on radiation exposure in the acute and short-term management of urolithiasis patients showed that patients on average had 4 examinations per year(27). In our study, only 9% of patients had two scans and none of our patients had scans more than two. This shows a significantly lower rate of repetition of examination compared to previous studies. The possible explanation for these is the relative scarcity of CT in our study area compared to the previous study areas where physicians may prefer to use other diagnostic methods rather than CT for evaluation of patients suspected of urolithiasis.

According to previous studies, low dose CT has comparable sensitivity and specificity compared to conventional CT in detecting stone(3) (29). They used an effective dose of <3mSv and CT dose index of 1.8mGy(3) [7]. In our studies, we used a higher threshold of 4mSv as a cut off for low dose CT and CT-dose index of 2mGy.We found that 3.6% of the scans have radiation exposure >4mSv and similarly 3.6% of the scans have a CT dose index greater than 2mGy these scans that have passed the threshold level are all done outside TASH. The 2019, Tzou et al. research in California showed that 91% of their scans were above the 4mSv threshold level(23). Meanwhile, in 2017, Weisenthal et al.illustrated that >80% of scans labeled ''low dose'' actually were associated with EDoses ˜10mSv(30).compared to this previous studies our study showed that none of the patients who had their scan in TASH have received radiation above the stated 'low dose' protocol parameters indicating well-optimized low dose protocol is being utilized in TASH. All the scans(4) that have passed the threshold level are done outside TASH indicates that scans outside TASH may be sub-optimized low dose protocols or conventional CT protocol is being used even though the amount of data we have may not be sufficient to give concrete conclusion.

Limitations

Our study is limited by its retrospective nature where recall bias can significantly limit our study. Secondly, our study solely focused on radiation exposure from CT but patients can be exposed to radiation through other imaging modalities like KUB or fluoroscopic procedures therefore the radiation exposure presented in our study may be underestimated. Thirdly our study primarily focused on TASH patients therefore is limited by lack of multi institutionality and finally the absence of dose metric data from the patients optical disk drive has also limited our study.

Conclusion and recommendation

Our study showed that TASH's low dose CT protocol for patients with urolithiasis is well optimized and patients are not being overexposed but even with the limited data we have non-TASH institutions are likely using non-optimized CT scans and patients may be a victim of radiation overexposure for either diagnosis or follow of urolithiasis.

The authors, therefore, recommend a large-scale multi institutionalized study on radiation exposure of patients with urolithiasis to include the private setup and other government hospitals.

We also recommended adoption of the TASH's CT protocol for urolithiasis to other institution since it has been shown to be well optimized and nation wide standardized protcol should be developed to decrease inter-institutional variabilty of radiation exposure

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Annexes

Structured checklist

1. ID number
2. Age
3. Sex
4. Region they came from
5. Number of CT scan the patient had
   a. 1
   b. 2-4
   c. >4
6. Date of each ct scans taken
   a. CT scan 1 specify dd/mm/yy
   b. CT scan 2 specify dd/mm/yy
   c. CT scan 3 specify dd/mm/yy
   d. CT scan 4 specify dd/mm/yy
   e. CT scan 5 specify dd/mm/yy
   f. If other ct scans available specify the number of CT scan and the date each has been taken
7. Where was the CT taken
   a. TASH
   b. Other teaching hospitals
   c. Non-teaching government hospitals
   d. Private hospital
   e. Diagnostic centers
   f. Other specify
8. What was the indication to have each abdominopelvic ct
   a. Flank pain

b. Hematuria
c. Known urolthiaisis with other imaging and for treatment planning
d. Abdomainal pain
e. Known urolithiasis patient for follow up
f. Recurrent UTI
g. Other specify____________

9. CT characteristics
    a. Type of CT performed
        i. Single-phase
            1. Non-contrast
            2. Post-contrast
        ii. Multiphasic
            1. Non-contrast and postcontrast
            2. Non-contrast post-contrast and delayed scan
        iii. CT urography
        iv. Low dose CT
    b. Dose parameter characteristics for the CT
        i. DLP specify______mGy-cm
        ii. CTDIvol specify ________mGy
        iii. Effective dose specify ______msv

10. EXPOSURE FACTORS/SCANNING PARAMETERS
    a. CT scanner make and model
        i. GE Medical Systems, Optima CT660
        ii. Philips, Ingenuity
    b. kVp (kV)
    c. mAs
        i. . mAs________________
        ii. . Exposure time (sec)_______
        iii. mA______
        iv. Automatic tube modulation (Yes/No)_____________
    d. Rotation Time (sec)
    e. Slice thickness (mm)
    f. Total Collimation/Scan length (mm)
    g. Pitch