

AUDIT OF CT KIDNEY URETER AND BLADDER (CT KUB): AN EFFORT TO MINIMIZE UNNECESSARY RADIATION EXPOSURE

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ABSTRACT

BACKGROUND: Computed tomography of the kidneys, ureters and bladder (CT KUB) is performed for renal colic chiefly in younger patients hence, radiation dose should be minimized as much as possible without compromising diagnostic adequacy. One way of doing it is via reducing scan field. **FIRST AUDIT STANDARD:** Local departmental policy is to scan from the diaphragm to the symphysis pubis. **OBJECTIVE:** To determine the upper limit of CT KUB scans in terms of vertebral level, at which kidneys are fully imaged. **TARGET:** 100% of the CT KUB scans should be commenced within two vertebral levels above the superior border of the kidney. **MATERIAL AND METHODS:** 100 consecutive CT KUB scans were reviewed retrospectively. Parameters assessed were; Vertebral level at which scan was commenced, vertebral level at which kidneys were fully imaged and patient dose. **RESULTS OF FIRST AUDIT:** 100% of kidneys fully imaged at T10. This was then taken as standard for subsequent audit. Only 34% scans were commenced within set standard. Mean dose=998 mGycm². **SECOND AUDIT STANDARD:** All CT KUB scans to be commenced from T10 vertebral body or diaphragm whichever is lowest. **RESULTS OF SECOND AUDIT:** Six months later, 100 consecutive CT KUB scans were reviewed prospectively. T10 remained as highest vertebral level at which kidneys are imaged fully. 95% scans were commenced within set standard. Mean dose reduced to 897 mGycm². **CONCLUSION:** CT KUB scans should be commenced from T10 vertebral body to decrease patient dose without altering quality; and mean dose values of this audit can provide our National Reference Level (NRL) for CT KUB studies.

Keywords: KUB; renal colic; radiation dose.

Introduction

What exactly is CT KUB? It is a dedicated non-invasive technique of imaging urinary system (kidney, ureters, bladder), chiefly performed for detecting radiopaque calculi along the urinary tract.¹ It is a 'low radiation dose study' because (a) it covers targeted body area only, (b) no multi-phasing required, as it's a non-contrast scan. It is one of the most frequent imaging performed as emergency as well as outpatient basis.¹ It is usually considered as the initial imaging modality for patients presenting with complains of renal or ureteric colic in an emergency setting.^{2,3} Dose is the major concern when it comes to CT

imaging.⁴ Parameter used for quantification is dose length product (DLP) which gives an estimate of dose inculcated to patient. DLP is the product of CT dose index (CTDI_{vol}) and scan length.⁵ As CTDI_{vol} depends on multiple factors and varies with patient habitus and machine settings for getting good quality image, it cannot be altered much. Scan length on the other hand can be reduced to decrease patient dose.⁶ CT KUBs are performed chiefly in younger patients hence; radiation dose should be minimized as much as possible without compromising diagnostic adequacy.^{7,8} Radiation dose can be minimized without altering the

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quality of scan by reducing scan field.⁹

Currently our departmental protocol is to scan from the diaphragm to the symphysis pubis. As diaphragm is a mobile structure, the scan field varies with the inspiratory activity. Kidney positions in the body are different in different patients. This concept is elaborated in (Fig. 1).

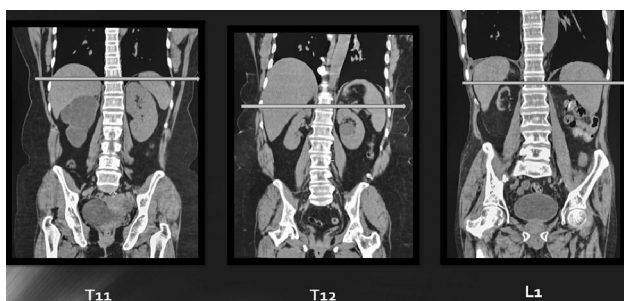


Figure 1: Below are the coronal reformatted CT KUB scans of three random patients, showing variability in levels of superior poles of kidneys. T11 vertebral level marks the lowest vertebra at which both kidneys are completely covered in Patient A. Similarly, T12 and L1 vertebral level marks the lowest vertebrae at which both kidneys are completely covered in Patient B and C respectively.

An audit by Maguire et al. 2015 investigating radiation dose and scan field demonstrated T10 as the lowest vertebral level to image kidneys fully in 100% of their patients.¹⁰ That audit won second prize at annual scientific meeting of Royal College of Radiologists (RCR) held in 2015. Contrary to this, another study performed by Cavenagh T. et al. proposed T11 as the lowest vertebral level to completely image kidneys.¹¹ This audit also won second prize at annual scientific conference of European society of radiology (ESR) held in 2017. Keeping in view these two studies, we performed sequential audits of CT KUB to see highest level of kidneys in our patients in order to set maximum upper limit of CT KUB scan thereby minimizing the radiation exposure.

Inclusion Criteria:

1. Adults over 18 years of age only.
2. Patients undergoing CT imaging with high clinical suspicion of renal/ureteric calculus.

First audit cycle

Standard

Local departmental policy is to scan from the diaphragm to the symphysis pubis.

Objective

To determine the upper limit of CT KUB scans in terms of vertebral level, at which kidneys are imaged fully.

Target

100% of the CT KUB scans should be commenced within two vertebral levels above the superior border of the kidney.

Materials and Methods

100 consecutive CT KUB scans were reviewed retrospectively at Shifa International Hospital, Islamabad from July-Aug 2017 after formal approval by Institutional Review Board and Ethics Committee (IRB & EC) in accordance with the International Conference on Harmonization-Good Clinical Practice (ICH-GCP) guidelines. The scan protocols include Helical scan mode; Thickness: 0.5 x 100; 120 kV; mA settings automatic; Rotation time 0.5 and scan time 5.9 seconds.

Following parameters were assessed:

1. Vertebral level at which scan was commenced.
2. Vertebral level at which kidneys were fully imaged.
3. Patient dose values as DLP.

Spearman rank-order (Spearman's correlation) analysis was used to measure the strength and direction of relationship between 'vertebral level at which scan was commenced' and 'dose'. Statistical significance was accepted at $p < 0.01$. Data was analyzed using Statistical Package for the Social Sciences Software (SPSS) version 25.0.

Results of first audit cycle

The mean age at the time of scanning was 43 ± 16 years, with 36 females and 64 males in first audit. During first audit cycle, maximum upper limit of kidneys of majority of the patients ($n=45$) was at T12 vertebral level and T11 vertebral level ($n=34$). Only two patients ($n=2$) had their kidneys upper pole reaching up to T10 vertebral level, therefore setting T10 vertebral level as the maximum upper limit for CT KUB scans. In other words, confining the scan

length from T10 vertebral level to symphysis pubis can cover KUB system of all the patients under study. This was then taken as standard for subsequent audit.

After the first audit, several placards were posted at CT consoles and history areas about setting new protocol for CT KUB i.e. T10 to symphysis pubis. History taking doctors, referring physicians and radiology technicians were taken on board and explained results of first audit cycle and its possible impact on patient's dose.

Mean dose of CT KUB scan during first audit was 998 mGycm².

Variation in dose with scan starting level is illustrated in the (Fig. 2).

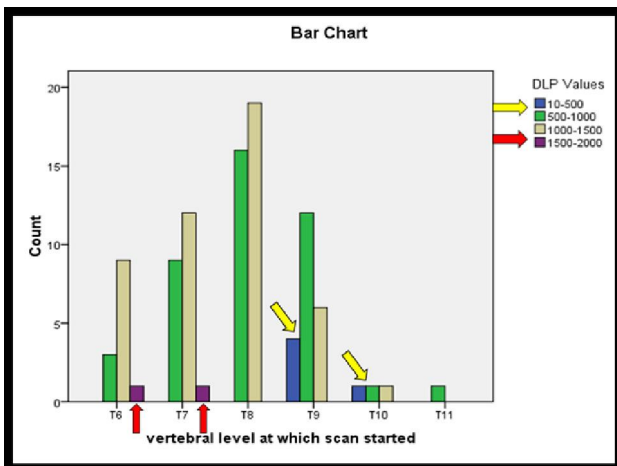


Figure 2: Relationship between mean dose and vertebral level at which the scan was started. Lower the scan starting level, mean dose of the scan shifts towards lower range (yellow arrows, blue bars). Higher the scan starting level, mean dose of the scan shifts towards higher range (red arrows, purple bars).

A Spearman's rank-order correlation showed strong positive correlation between dose and vertebral level at which scan was commenced (with decrease in scan length there is decrease in dose), which was statistically significant ($r_s = +.372$, $p = 0.001$).

Second audit cycle

Standard

Local departmental policy is set to scan from T10 vertebral body to the symphysis pubis.

Objective

1. Compliance with the set upper limit of CT KUB scans i.e. T10 vertebral level.

2. To determine change in dose with decreased scan length.

Target

100% of the CT KUB scans to be commenced from T10 vertebral body or diaphragm whichever is lowest.

Materials and Methods

Re-audit was performed in Jan-Feb 2018. Data was collected from hospitals MIS (Medical Information System). 100 consecutive CT KUB scans were reviewed prospectively at Shifa International Hospital, Islamabad. The scan protocols include Helical scan mode; Thickness: 0.5 x 100; 120 kV; mA settings automatic; Rotation time 0.5 and scan time 5.9 seconds.

Following parameters were re-assessed:

1. Vertebral level at which scan was commenced.
2. Vertebral level at which kidneys were fully imaged.
3. Patient dose values as DLP.

Data was analyzed using Statistical Package for the Social Sciences Software (SPSS) version 25.0.

Results of second audit cycle

Mean age at the time of scanning was 40 ± 15 years, with 34 females and 66 males, in the second audit. Second audit cycle showed upper pole of kidneys of ninety-five patients ($n=95$) line below T10 vertebral level. Upper pole of kidneys of five patients ($n=5$) reached up to T10 vertebral level. None had their kidneys above the set standard (i.e. T10). This further strengthens the set standard of T10 vertebral level as maximum upper limit for CT KUB scan.

During second audit cycle 95% of the scans were performed according to set standard. 5 scans couldn't meet the standard, possibly due to human error as these were performed in early days when the new standard of T10 vertebral level as the upper limit of CT KUB was set.

As national reference levels (NRL) for CT KUB was not available for our country, mean dose of first audit cycle was taken as reference for second audit cycle (i.e. 998 mGycm²). After limiting the maximum upper

limit of CT KUB scans to T10 vertebral level, decrease in mean dose was noted i.e. 897 mGycm² in second cycle.

Discussion

According to study performed by Maguire J. et al., 2015 RCR meeting,¹⁰ highest vertebral level at which kidneys are fully imaged is T10 while Cavenagh T. et al., 2017 ECR meeting reported T11 as highest level in their patient's sample.¹¹ Population under study in our both audits showed T10 as highest vertebral level at which kidneys are fully imaged, which favors the data suggested by Maguire J. et al., 2015 RCR meeting.¹⁰ These facts are computed in (Tab. 1).

	RCR 2015 Maguire J. et al		ECR 2017 Cavenagh T. et al		Current Study	
Setting	Hairmyres Hospital, Scotland, UK		St. George's Hos- pital, London, UK		Shifa International Hospital, Islam- abad, Pakistan.	
AUDIT CYCLES	First Audit Cycle	Second Audit Cycle	First Audit Cycle	Second Audit Cycle	First Audit Cycle	Second Audit Cycle
Vertebral level at which kidneys fully imaged	T10	T10	T11	T11	T10	T10
Scans commenced within set standard	42%	82%	90%	95%	34%	95%
Mean Dose (mGycm ²)	473	407	<460	<460	998	897

Table 1:

Mean dose is described in terms of DLP (Dose Length Product). It is not a true dose, but an estimate of dose given to patient. Point to be cleared here is that DLP values of different states/countries cannot be correlated in terms of their values as it varies greatly according to population statistics like weight, body mass and local machine settings. Countries like UK etc. have reference national DLP values for various scans hence they compared mean dose of their study with their national reference DLP value which was 500 mGycm². Both studies i.e. Maguire J. et al., 2015 RCR meeting and Cavenagh T. et al., 2017 ECR meeting have had their values well in range which further decreased after decreasing scan length (area covered) by limiting scans to T10 as higher upper limit as shown in (Tab. 1).^{10,11} Limitation

of this study is that there is no national reference DLP level for CT KUB in our country, so we compared results of our second audit from first audit. Mean dose was decreased with decrease in scan length as shown in (Tab. 1). This may be taken as national reference level of CT KUB for further audits to be performed in Pakistan and other regional countries in South-Asia.


Conclusion

- All patients undergoing CT KUB scans for renal or ureteric colic should be commenced from T10 vertebral body to decrease patient dose without altering quality.
- We suggest that CT KUB audit should be made part of hospitals quality assurance program and performed after regular intervals to assure decreased dose.
- Our audit won first prize for best paper in Annual conference of Radiological Society of Pakistan, 2017. This audit can potentially provide National Reference Level (NRL) of CT KUB for future studies performed in Pakistan and its neighboring countries in South Asia.

Conflict of Interest: None

References

1. Hiorns MP. Imaging of the urinary tract: the role of CT and MRI. *Pediatr Nephrol.* 2011; **26(1)**: 59-68.
2. Nadeem M, Ather MH, Jamshaid A, Zaigham S, Mirza R, Salam B. Rationale use of unenhanced multi-detector CT (CT KUB) in evaluation of suspected renal colic. *Int J Surg.* 2012; **10(10)**: 634-7.
3. Gottlieb M, Long B, Koyfman A. The evaluation and management of urolithiasis in the emergency department: A review of the literature. *Am J Emerg Med.* 2018; **36(4)**: 699-706.

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4. Rob S, Bryant T, Wilson I, Somani BK. Ultra-low-dose, low-dose, and standard-dose CT of the kidney, ureters, and bladder: is there a difference? Results from a systematic review of the literature. *Clin Radiol*. 2017; **72(1)**: 11-5.
 5. Huda W, Mettler FA. Volume CT dose index and dose-length product displayed during CT: what good are they?. *Radiol*. 2011; **258(1)**: 236-42.
 6. Raman SP, Johnson PT, Deshmukh S, Mahesh M, Grant KL, Fishman EK. CT dose reduction applications: available tools on the latest generation of CT scanners. *J Am Coll Radiol*. 2013; **10(1)**: 37-41.
 7. Renal or ureteric colic - acute; NICE CKS, April 2015 [cited 25 July 2018]. Available from: <https://cks.nice.org.uk/renal-or-ureteric-colic-acute>
 8. Deak PD, Smal Y, Kalender WA. Multisection CT protocols: sex-and age-specific conversion factors used to determine effective dose from dose-length product. *Radiol*. 2010; **257(1)**: 158-66.
 9. McCollough CH, Bruesewitz MR, Kofler Jr JM. CT dose reduction and dose management tools: overview of available options. *Radiographics*. 2006; **26(2)**: 503-12.
 10. Maguire J, Gray K. Computed tomography (CT) kidneys, ureters and bladder (KUB) - how low can you go? *Clin Radiol*. 2015; **70**: S12.
 11. Cavenagh T, editor A dynamic approach to CT KUB scanning field-an audit to minimise radiation dose 2017: European Congress of Radiology 2017.