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ORIGINAL ARTICLE

CT KUB scans for renal colic: Optimization of scan range to reduce patient radiation burden.

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ABSTRACT… Objective: To optimize the scan range of CT KUB scans for renal colic to reduce patient radiation while maintaining diagnostic accuracy. **Study Design:** Cross-sectional study. **Setting:** Department of Radiology, Tertiary Care Hospital, Sargodha. **Period:** January 2024 to June 2024. **Methods:** A total of 95 adult patients (age ≥ 18 years) who received CT KUB due to the suspicion of renal colic with complete imaging data were included. Data collection encompasses demographic information (age, gender) and CT scan parameters (scan range, slice thickness, and radiation dose). Scan range optimization involved reviewing CT images to determine the optimal range covering kidneys, ureters, and bladder. Radiation dose metrics, including the dose-length product (DLP) and effective dose were measured for each CT KUB scan following standard protocols and utilizing dose estimation software. The collected data were subsequently processed and analysis was done via the use of IBM SPSS version 27.0. **Results:** Among the 95 scans analyzed, 51 (53.7%) were female and 44 (46.3%) were male, with a mean patient age of 43.8 ± 14.6 years. Only 27 scans (28.4%) had less than 10% overscan above the highest kidney target, while 68 scans (71.6%) exceeded this threshold. The mean total scan length was 454 mm (SD = 53.6 mm). The mean overscan above the kidney measured 64.5 mm (SD = 22.2 mm), accounting for 14.3% of the total scan length. Over-scanning ranged from 16 mm (3.9%) to 123 mm (33.2%). **Conclusion:** This study validates initiating the CT KUB scan at the upper border of the T11 vertebra and concluding at the symphysis pubis to minimize unnecessary radiation exposure while preserving diagnostic accuracy. This optimized scan range effectively reduces over-scanning and enhances patient safety.

Key words: CT Scan, KUB, Renal Colic, Optimization, Scan Range, Radiation Exposure, Patient Safety.

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INTRODUCTION

Renal colic is a painful condition marked by severe flank pain resulting from the obstruction of urine flow from the kidneys to the bladder. This obstruction is mostly caused by kidney stones but can also result from blood clots, tumors, or strictures.[1,2] The prevalence of renal colic varies widely, ranging from 5% to 15%, depending on geographical factors.[3,4]

The primary cause of renal colic is often kidney stones, with a prevalence of stone formation ranging from 5% to 10% in industrialized countries.[5] Acute renal colic accounts for 0.9% of outpatient care visits. It is caused by renal stones in 56% of cases, with 6.2% of these patients requiring hospital admission.[6] In Pakistan, a study reported that 36 out of 195 patients (18%) had acute renal colic, highlighting a significant burden of the condition in the local population. The global incidence of renal colic is estimated at 1–2 cases per 1,000 individuals annually. Over a lifetime, an estimated 12% of men and 6% of women suffer from renal colic caused by kidney stones.[7]

The symptoms of renal colic typically present as sudden, severe pain radiating from the flank to the groin or lower abdomen on the affected side.[8] Imaging studies—such as ultrasound, CT scans, intravenous pyelograms (IVP), and CT KUB (Computed Tomography of the Kidneys, Ureters, and Bladder)—are essential diagnostic tools for evaluating patients with suspected renal colic.[9]

One method to reduce radiation exposure in CT KUB scans is by optimizing the scan range to focus solely on the affected area. By limiting the scan to the kidneys, ureters, and bladder, radiologists can obtain diagnostically accurate images with the additional benefit of minimizing radiation exposure to surrounding organs.[10]

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This optimization strategy not only reduces patient radiation exposure but also aligns with the ALARA (As Low As Reasonably Achievable) principle, which emphasizes balancing diagnostic quality with minimizing radiation dose.[11]

This research will enhance existing literature by offering evidence-based guidelines for optimizing CT KUB protocols; and addressing the current knowledge gap in radiation dose reduction strategies for renal colic imaging. Ultimately, it has the potential to improve clinical practice and support ongoing efforts to optimize imaging protocols in healthcare settings.

METHODS

After approval from the hospital's ethical review board (ERB) vide letter number MSF(H)/308/3/1/Trg, this cross-sectional study was conducted at the Radiology Department of Tertiary Care Hospital, PAF Hospital Mushaf, Sargodha.

Inclusion Criteria

Adults (aged ≥ 18 years) who went through CT KUB for the suspicion of renal colic and had complete imaging data available were included in the study.

Exclusion Criteria

Patients with incomplete imaging data, those younger than 18 years, individuals with a history of renal surgery, pregnant patients, and those with known malignancies affecting the renal system were excluded from the study. Data collection included demographic information such as age and gender. CT scan parameters—such as scan range, slice thickness, and radiation dose—were recorded.

Additionally, radiological findings, including the presence, size, and location of kidney stones, were documented. The optimization of scan ranges involved reviewing CT images to determine the most efficient range that encompassed the kidneys, ureters, and bladder. Radiation dose metrics, including the dose-length product (DLP)—a measure of total radiation exposure calculated by multiplying the dose per slice by the scan length in centimeters and the effective dose[21], were calculated for each CT KUB scan using standard protocols and dose estimation software.

The collected data was processed and analysis was done via IBM SPSS, version 27.0. Categorical variables are stated as frequencies and percentages, continuous variables are presented as means and standard deviations (SD). The results were visualized using bar charts where applicable to facilitate easier interpretation.

RESULTS

A total of 95 scans were studied retrospectively, comprising 51 (53.7%) female and 44 (46.3%) male patients. The mean patient age was 43.8 ± 14.6 years. Of the total scans, 27 (28.4%) met the standard of less than a 10% overscan above the highest kidney target, while 68 (71.6%) scans did not meet this criterion. Among the 68 scans that did not meet the criteria, the percentage of over-scanning varied as follows: 33 (48.5%) scans exceeded the upper pole of the highest kidney target by 10–14.99%, 24 (35.3%) exceeded by 15–19.99%, and 11 (16.2%) exceeded by more than 20% [Table-I].

The mean total scan length was 454 mm (SD = 53.6 mm) from the top to the bottom of the scan field. The mean overscan calculated above the kidney was 64.5 mm (SD = 22.2 mm), accounting for 14.3% of the total scan length. The minimum overscan observed was 16 mm (3.9% of the patient's total scan length), while the maximum was 123 mm (33.2% of the patient's total scan length), as presented in Table-II.

In this study, the upper pole of the kidneys in most patients was located at the T12 vertebra level (n = 44) and the L1 vertebra level (n = 41). Only six patients (n = 6) had their kidney's upper pole reaching the T11 vertebra level. In other words, 100% of the kidneys scanned in this study were positioned below the upper border of the T11 vertebra (i.e., along the T11 vertebral body or lower), with 93.7% located at or below the T12 level. The lowest kidney position observed was at the L2 vertebra in four patients, supporting the T11 vertebra's upper border as the maximum upper limit for CT KUB scans [Table-III].

However a total of 66.3% scans were done at or above T10 vertebral level which was set as their upper scan margin, with one scan extending as high as T7. Scans conducted at higher vertebral levels consistently showed the most excessive over-scanning, highlighting that although the upper scan level varied considerably, the kidneys were consistently located below the upper border of the T11 vertebral body. In contrast, over-scanning below the pubic symphysis was significantly lower, with an average overscan of 6.31 mm (SD = 7.19 mm), accounting for only 1.39% of the mean total scan length.

The average radiation dose was 286 mGy/cm. A positive correlation (correlation coefficient = 0.680) was observed between the extent of the excess over-scanning and the total radiation dose received by the patient (Figure-1).

FIGURE-1

Correlating with the total radiation dose taken by the patient during the procedure (r=0.680)

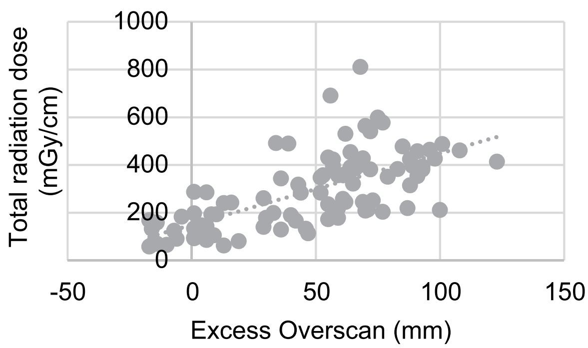

TABLE-I		
Distribution of scans according to standard guidelines		
	n	%
Scans with the reference standard of 10%.	27	28.4%
Overscan (> 10% of standard guidelines)	68	71.6%
10 - 14.99%	33	48.5%
15 - 19.99%	24	35.3%
20% and more	11	16.2%

TABLE-II			
Summary statistics of scan length and overscan above kidney			
	Mean ± SD	Minimum	Maximum
Total Scan Length (mm)	454.01 ± 53.56	321	573
Over Scan above Kidney (mm)	64.49 ± 22.23	16	123

TABLE-III		
Distribution of scans based on vertebral level of the upper pole of the kidney		
Level of the Upper Pole of the Kidney	n	%
Below the upper border of T11	95	100%
Below the upper border of T12	89	93.7%
Below the upper border of L1	45	47.4%
Below upper border of L2	4	4.21%

DISCUSSION

Effective management of renal colic necessitates both minimizing radiation exposure and maintaining diagnostic accuracy. Achieving this balance is crucial in ensuring patient safety without compromising diagnostic outcomes. Optimizing the CT KUB scan range presents a promising strategy to address this challenge. By precisely adjusting the scan range to include only the relevant anatomical regions, clinicians can significantly reduce patients' radiation exposure while still obtaining essential diagnostic information. This approach prioritizes patient safety and corresponds with the goals of improving efficiency and resource utilization within healthcare systems.[11,12]

In our study of 95 scans, the gender distribution was balanced, with 53.7% female and 46.3% male participants, and a mean age of 43.8 ± 14.6 years. However, only 28.4% of scans adhered to the recommended overscan limit (<10% above the highest kidney), while 71.6% exceeded this limit. Among the non-compliant scans, 48.5% had over-scanning between 10–14.99%, 35.3% between 15–19.99%, and 16.2% exceeded by more than 20%.

Our findings are consistent with those of Sarfaraz et al. (2018), who reported a mean patient age of 43 ± 16 years, closely aligning with our mean age of 43.8 ± 14.6 years. Both studies identified the T12 vertebral level as the most common upper limit of the kidneys.However, while Sarfaraz et al. observed only two patients with kidneys extending up to the T10 vertebral level, our study revealed a much higher proportion (71.6%) of scans exceeding the recommended overscan limit above the highest kidney.[13]

Similarly, Alrosan et al. (2024) reported widespread deviations from best practice guidelines in renal CT imaging, with 100% of their patients failing to meet recommended criteria. In their study, 63% of scans exhibited a 20–40% overscan, highlighting a substantial departure from optimal scanning protocols. This aligns with our findings, where 71.6% of scans surpassed the overscan limit, causing 48.5% to surpass the upper pole of the highest kidney by 10–14.99%.[14]

Our study found that the majority of kidneys had their upper limits at the T12 vertebral level, with 93.7% located below T11, establishing T11 as the maximum upper limit for effective scanning. In comparison, Uldin et al. (2020) reported that 83.8% of scans had their superior limit at or below T10, indicating a trend toward using lower vertebral levels to optimize the scan range. Additionally, they observed that 53 out of 88 scans (58.9%) had their superior limit at or below T10, suggesting that setting the scan range at successively lower vertebral levels can reduce over-scanning.[15]

This assemblage of data matches with previous studies by Uldin et al. (2015) and Cavenagh et al. (2017), which used T10 as a reference point to minimize over-scanning. However, our study suggests that selecting T11 as the upper scan limit could further reduce overscan without risking under-scanning, as none of the kidneys in our sample extended above the upper border of the T11 vertebra. This underscores the importance of selecting precise vertebral landmarks in CT KUB scanning protocols to effectively optimize the scan range and enhance patient safety.[16,17]

Our study revealed a mean total scan length of 454 mm, with an average overscan above the kidney of 64.5 mm, accounting for 14.3% of the total scan length. These findings are consistent with those of Ghoshal et al. (2021), who reported a mean overscan of 65.9 mm, representing 16.4% of the total scan length.[18] Additionally, our results align with Sarfaraz et al. (2018), who observed that reducing scan length directly correlated with a decrease in radiation dose, highlighting the importance of optimizing scan parameters to minimize patient exposure.[13]

Further supporting this approach, studies by Maguire et al. (2015) and Cavenagh et al. (2017) demonstrated significant reductions in over-scanning when the upper scan limit was restricted to the T10 vertebral level, underscoring the effectiveness of this strategy in minimizing unnecessary radiation exposure.[17,19]

Our study revealed a significantly lower average overscan below the pubic symphysis (6.31 mm, accounting for 1.39% of the mean total scan length) compared to over-scanning above the highest kidney. This finding is consistent with Ghoshal et al. (2021), who reported a similarly low amount of inferior over-scanning (1.54%) relative to superior over-scanning (16.4%). Additionally, our observation aligns with Macguire et al. (2016), who found that all kidneys in their study were positioned below the T10 vertebral level, reinforcing the consistency of kidney positioning relative to vertebral landmarks across studies.

Our findings support previous research emphasizing the need to reduce radiation exposure in CT scans while maintaining diagnostic accuracy, particularly in the evaluation of renal colic. We observed a mean radiation dose of 286 mGy/cm and determined a positive correlation (correlation coefficient = 0.680) between the extent of over-scanning and the total radiation dose received by patients. This aligns with the findings of Rob et al. (2017), who demonstrated that radiation doses could be reduced without compromising the detection of renal calculi. These results highlight the critical importance of optimizing scan protocols to minimize radiation exposure, ensuring patient safety while preserving diagnostic efficacy.[20]

Our study provides valuable insights into the correlation between excess scanning and radiation dose in CT scans for renal colic, contributing to the growing body of literature on radiation optimization in diagnostic imaging. However, some limitation in the accuracy of data or biases may be present due to the use of restrospective data necessitating cautious interpretation of the findings. This highlights the need for prospective studies to validate our results.

CONCLUSION

Our study supports starting the CT KUB scan at the upper border of the T11 vertebra and ending at the symphysis pubis to reduce unnecessary radiation exposure while maintaining diagnostic accuracy. This optimized scan range effectively minimizes over-scanning and ensures patient safety.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

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AUTHORSHIP AND CONTRIBUTION DECLARATION	
1	**Fria Maqsood:** Data collection.
2	**Salahuddin Balooch:** Drafting.
3	**Rida Fatima:** Literature search.
4	**Irshad Ahmad:** Data entry.
5	**Wajeeha Ahad:** Data analysis.
6	**Narmeen Khan:** Study design.