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Role of Artificial Intelligence in Detection of Renal Stones in Plain CT KUB Using a Deep Learning U-Net Model

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Abstract: ***Renal stone disease is a significant clinical problem requiring accurate imaging for timely diagnosis. Computed Tomography of the Kidney, Ureter, and Bladder (CT KUB) is the imaging modality of choice due to its superior sensitivity. The integration of Artificial Intelligence (AI), particularly deep learning models such as the 3D CNN U-Net, has shown promise in automating the detection and analysis of renal calculi. This study evaluates the diagnostic accuracy of a 3D CNN U-Net model in detecting, localizing, and characterizing renal stones on CT KUB. Among 70 patients with suspected nephrolithiasis, AI achieved a sensitivity of 94.8% and specificity of 82.1%. The model demonstrated high concordance with radiologist interpretations and significantly reduced reporting time. AI-based tools could revolutionize the diagnostic workflow in radiology by enhancing accuracy and efficiency.***

Keywords: Artificial Intelligence, CT KUB, Renal Calculi, Deep Learning, Hounsfield Units

1. Introduction

Renal calculi, or kidney stones, represent a common urological condition necessitating rapid and precise diagnosis. CT KUB is the gold standard for stone detection due to its high resolution and ability to detect radiolucent stones. However, interpretation of CT images is labor-intensive and subject to inter-observer variability. With advances in AI, particularly convolutional neural networks (CNNs), automated stone detection offers a new frontier in diagnostic radiology.

2. Literature Survey

AI applications in radiology have demonstrated impressive capabilities in various domains. U-Net-based architectures, specifically 3D CNNs, have achieved state-of-the-art results in image segmentation and object detection. Several studies, including those by Längkvist et al. and Yildirim et al., report over 95% accuracy in detecting ureteric and renal stones. Deep learning models trained on annotated datasets can outperform traditional CAD systems in terms of sensitivity and specificity.

3. Problem Definition

Manual interpretation of CT KUB scans is time-consuming and subject to variability among radiologists. There is a pressing need for an automated solution to enhance diagnostic throughput while maintaining high accuracy. This research explores the application of a 3D CNN U-Net model to automate the detection, localization, and characterization of renal stones.

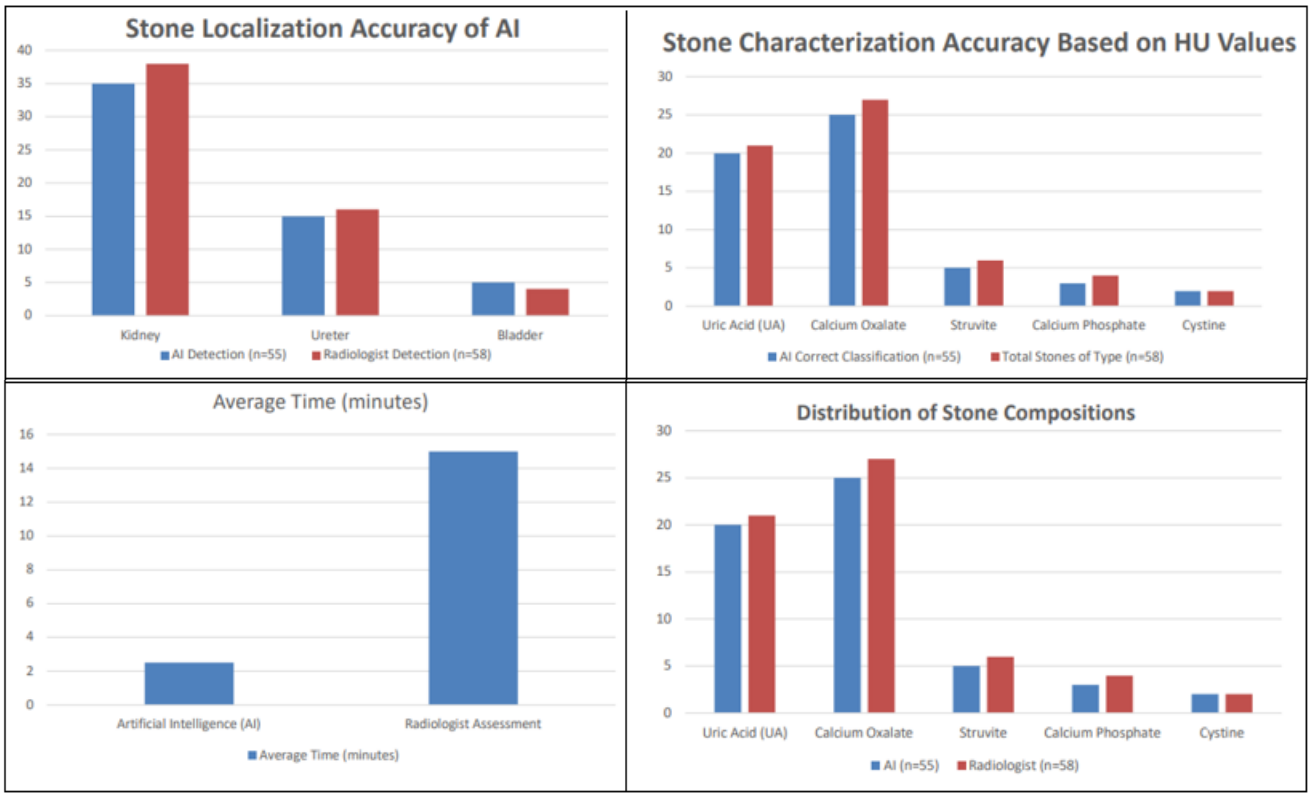
4. Methodology / Approach

A prospective cross-sectional study was conducted at Sri Siddhartha Medical College involving 70 adult patients presenting with symptoms of nephrolithiasis. CT KUB scans were analyzed using a 3D CNN U-Net AI model developed by Biocliq. The AI output was compared against radiologist findings, evaluating key metrics: sensitivity, specificity, stone localization, HU-based composition analysis, and turnaround time.

5. Results & Discussion

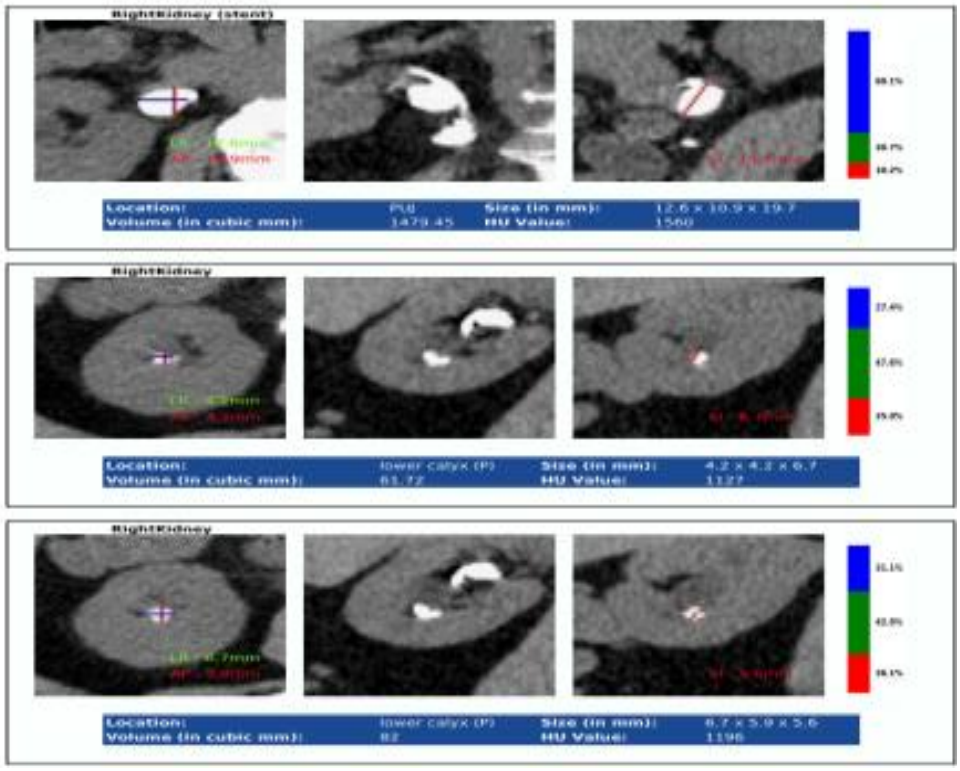
The AI model achieved:

- Sensitivity: 94.8%
- Specificity: 82.1%
- AUC: 0.88 (HU cutoff: 500)
- Localization accuracy: 93.3% for kidney and ureter stones, 80% for bladder stones
- Composition accuracy: Uric acid (95.2%), Calcium oxalate (92.6%)
- Strong correlation with radiologist stone size (r = 0.89) and volume (r = 0.85)
- 83.3% reduction in reporting time

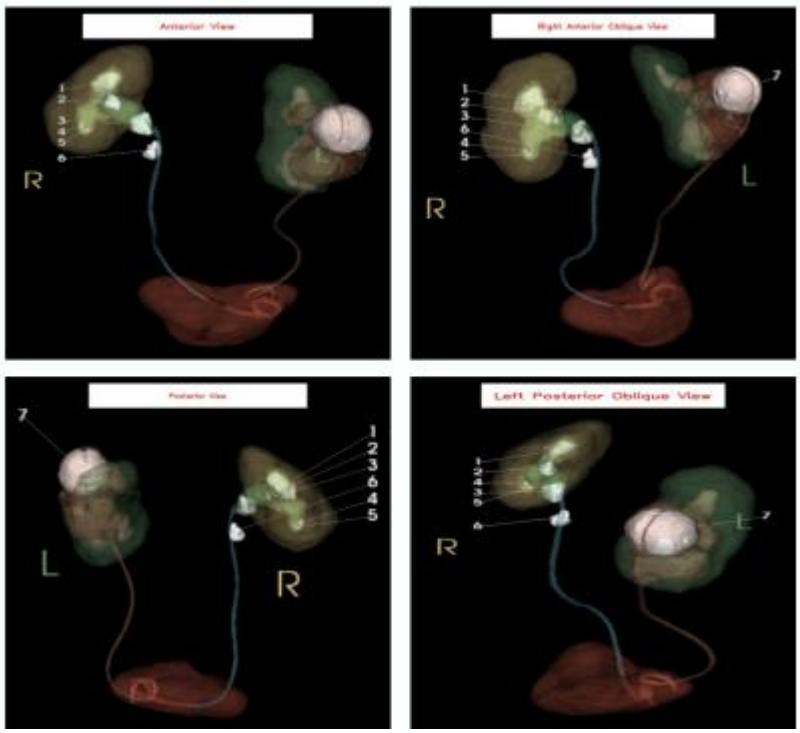


6. Illustrative Case

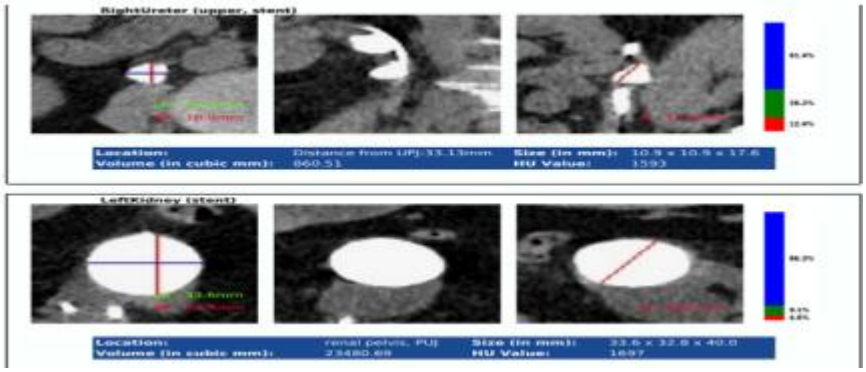
Non-contrast axial CT KUB demonstrating staghorn calculus in right renal pelvis extending into multiple calyces



UrologiQ AI – based detection of right renal pelvis calculus with extent, volume, HU and associated findings annotated. A calcified cyst seen in left mid pole.



Showing calcified cyst wall and right ureter calculi:



7. Conclusion

The application of AI, particularly a 3D CNN U-Net model, in detecting renal calculi on CT KUB scans significantly enhances diagnostic accuracy and reduces reporting time. AI can support radiologists by automating routine interpretations and ensuring consistent quality in diagnostic imaging.

8. Future Scope

Future enhancements could include expanding the dataset to improve generalizability, incorporating multimodal imaging data, and validating the model across multiple centers. Real-time deployment in radiology departments could assist in triaging and prioritizing emergency cases.

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