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Grey Kidney Sign: A Useful Subordinate Sign for Obstructive Ureterolithiasis

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Abstract

Objective: This study was performed to investigate the sensitivity of reduced attenuation of unilateral kidney, dubbed the 'grey kidney sign', in identification of obstructive urolithiasis.

Materials and methods: In this observational study, 25 patients with symptoms of acute renal colic with unilateral ureteric calculus on CT were included. Attenuation value of each kidney was averaged at 3 poles and attention difference between the 2 kidneys was calculated. Cutoff of 5HU (Hounsfield Units) attenuation difference in the obstructed kidney denoted grey kidney sign.

Results: In the 25 patients with ureteric calculus the mean attenuation in obstructed kidney was 27.9 HU (SD 2.7) and mean attenuation in non obstructed kidney was 33.3 HU (SD 1.9). The difference in attenuation of the obstructed and non-obstructed kidney was on an average 5.3 HU (SD 2.6), with only 2 obstructed kidneys having higher attenuation than contralateral kidneys. Considering the cut-off of 5HU, the sensitivity of grey kidney sign for diagnosis of obstructing ureterolithiasis was found to be 68% (95% CI- 46.5% to 88.0%).

Conclusion: The grey kidney sign is a useful subordinate sign of obstructive ureterolithiasis with good sensitivity which can potentially be helpful in difficult cases such as due to technical factors, confusing phlebolith, passed calculus, etc. This can reduce number of repeat scans and avoid additional patient workup.

Keywords: Grey Kidney Sign, Decreased renal attenuation, Subordinate sign, Ureteric Calculus

Introduction

Acute flank pain is a common presentating complaint in the emergency department with ureteric colic due to ureterolithiasis being typical clinical diagnosis. Unenhanced Computed Tomography(CT) has been shown to have >95% sensitivity, specificity and accuracy in the diagnosis of ureteric calculus.[1,2] Direct visualisation of ureteric calculus on CT is considered diagnostic. However, certain masquerades like

phlebolith can cause difficulty in diagnosis.[3]Technical and patient factors like motion artefact and volume averaging can also cause difficulty in diagnosis of the same. Another important factor is recent spontaneous passage of the calculus which can result is additional investigation for evaluation of cause of acute flank pain, which increases the patient anxiety and healthcare load.

To overcome these challenges many secondary CT features of renal calculus disease have been proposed like dilation of collecting system, renal enlargement, periureteric and perinephric stranding, and grey kidney sign. [4,5]

The Grey Kidney Sign refers to the decrease in attenuation of the obstructed kidney in comparison to non obstructed one. This can be determined either by visual inspection or by measurement of attenuation values (Hounsfield Units).

The purpose of this study is to determine the sensitivity of the grey kidney sign using attenuation measurement technique in diagnosis of obstructive ureterolithiasis.

Methods

Study Population: The study is a hospital based observational study done in the department of Radio-diagnosis, BTGH between January and July 2022 on patients referred to the department with symptoms of acute renal colic for CT study. Patients with unilateral ureteric calculus detected on CT were included in the study. Patients with history of pain longer than 4 weeks were also excluded from the study.

CT study was done using a helical CT technique using Phillips 16 Slice CT machine with 5mm slice thickness and pitch a of 1 with the patient in supine position from the level of diaphragm to pubic symphysis in a single breath hold. No oral or intravenous contrast was used. The scans were studied using abdominal window settings (window level = 50, window width = 350).

The kidney with ureteric calculus with or without other subordinate signs like hydronephrosis was considered obstructed kidney. The other kidney without ureteric calculus and without subordinate signs of obstruction like hydronephrosis/perinephric stranding/periureteric stranding was considered non-obstructed kidney.

Attenuation values of each kidney was determined by placing small Region of Interests (ROI) in upper pole, lower pole and inter polar regions in the posterior part. The upper and lower ROI were placed at the top most and lower most slice showing collecting system respectively and the middle ROI was placed at the level of hilum. The ROIs placed were elliptical in shape and were approximately similar in size. Average of the three values that were obtained was the average attenuation of that kidney, as shown in figure 1. The difference in attenuation was calculated between obstructed and non-obstructed kidney.

Microsoft Word was used to generate tables and data was entered in Excel spreadsheet to produce master chart. Sensitivity was determined using contingency table analysis.

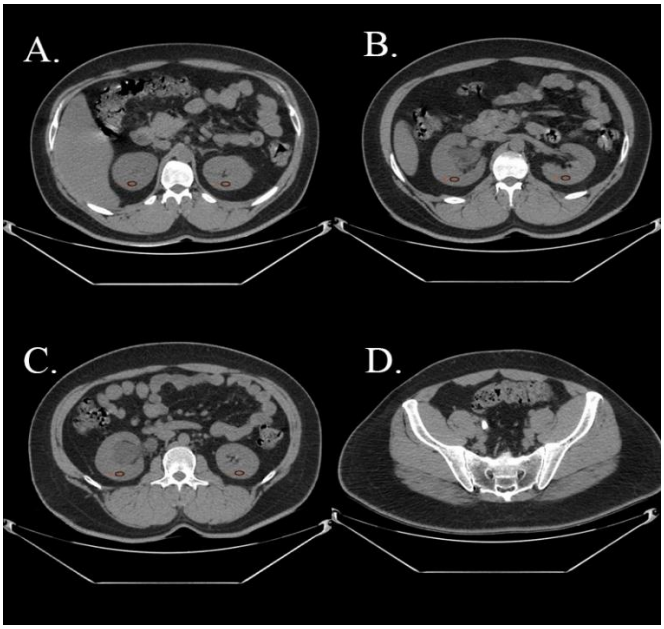

Figure 1: Showing method for determination of average attenuation of each kidney by placing ROI's. Image A, B and C show measurements in upper, mid and lower pole respectively. Image D shows right distal ureteric calculus denoting that right side is obstructed side, consistent with patients symptoms of acute Rt. Flank pain. The average attenuation of right kidney was 24HU and on left side was 30.6HU, with difference in HU of 6.6HU suggestive of grey kidney.

Results

The study population included 25 patients with ureteric calculus, directly visualised on CT who met the inclusion criteria.

The mean attenuation of non-obstructed kidney was 33.3 Hounsfield Units(HU), with a Standard Deviation(SD) of 1.9 and range 29.8 to 38.5. The mean attenuation in obstructed kidney was 27.9 HU, with SD of 2.7 and range 21.9 to 33.6.These findings are summarised in Table 1.

The average difference in attenuation of obstructed kidney was 5.3 HU less than non-obstructed kidney. With SD of 2.6 and range of -2.2 to 8.5. Only 2 patients had an attenuation in obstructed kidney higher than non-obstructed kidney.

On considering cut-off value of 5HU for diagnosis of obstruction 17 patients out of 25 had an attenuation difference of 5HU or more in obstructed kidney, indicating a sensitivity of 68% (95% Confidence Intervals = 46.5% to 88.0%).

	Non Obstructed Kidney (in HU)	Obstructed Kidney (in HU)	Difference in attenuation (in HU)
Mean	33.332	27.96	5.372
Range	29.8-38.5	21.9-33.6	-2.2 to 8.5
SD	1.9	2.7	2.6

Table 1: Distribution of attenuation values (in Hounsfield Units) amongst obstructed and non obstructed kidneys.

Discussion

Renal calculus disease(urolitheasis) occurs secondary to multiple risk factors like low water intake, infections, congenital malformations, metabolic disorders, drugs, etc. Most commonly seen in middle age patients with a slight male predominance. Most calculi present with pain, however some may remain asymptomatic. Other common symptoms are hematuria and those of secondary infection. Clinical differentials include appendicitis, diverticulitis, etc with widely different management necessitating imaging for diagnosis.

Plain X-Ray and ultrasound are most commonly used modalities to diagnose urolithiasis. Some calculi are radiolucent(eg. Uric acid, cystinestines) on X-Ray. Radioopaque calculi are seen in renal fossa or along course of ureter. Phleboliths, Gall Bladder calculi and calcified nodes may mimic renal calculi. On ultrasound the calculi appear as echogenic foci with posterior

shadowing and usually show twinkle artefact on colour doppler. Intrarenal gas and renal artery calcification are mimics but are encountered uncommonly. Ultrasound suffers from its poor sensitivity to small calculi, ureteric calculi, reduced resolution in obese patients and its operator dependence. Intra venous urography (IVU) is another modality but is uncommonly used due contrast risks and availability of CT. Computed Tomography (CT) is now considered the investigation of choice as even radiographically lucent calculi are visualised on CT. Multidetector CT (MDCT) has higher sensitivity than conventional CT and also suffers from fewer artefacts (motion, volume averaging, etc.). Recent advancement in CT technology includes dual energy CT which can be used to determine stone composition, which in turn guides management.

Due to certain limitations of CT like motion and volume averaging artefacts and stone passage use of subordinate signs has been suggested to improve sensitivity.

Complication of urinary tract obstruction include reduction in renal function and secondary infection. Reduction of unilateral renal function can be determined by reduced contrast excretion on IVU and dynamic CT or with renal syntigraphy. Bilateral renal function deterioration causes raised renal creatinine levels. Secondary infection is best assessed using urine culture and microscopy with imaging providing a supportive role.

Grey kidney sign refers to the unilateral decreased attenuation of obstructed kidney compared to the non-obstructed kidney. It has been suggested that this is secondary to renal edema, hyperaemia and increased lymphatic flow leading to interstitial edema. Some investigators used the term Decreased Renal Attenuation (DRD) to refer to the same.

Attenuation difference of 5 Hounsfield Units (HU) has been suggested by multiple studies for the diagnosis of the same. However the reported sensitivity varied from 41% to 89% in various studies. In our study the sensitivity was found to be 68% (95% CI = 46.5% to 88.0%). This reported variation is possibly due to timing of imaging and degree of obstruction.

Georgiades et al.,[6]one of the earliest to describe the sign used visual inspection of 20 cases and 20 controls, by 10 radiologists to determine if the kidney showed reduced attenuation and concluded that in 95% of patients with acute renal obstruction, the affected kidney appeared to beless dense than the unobstructed kidney on visual inspection.

Goldman et al.,[7] used a HU measurement technique similar to our study to determine the grey kidney in a set of 76 cases and 66 controls and reported 61% sensitivity for the same.

Huang, et al.,[8] studied 85 cases with ureteric calculi with 30 controls and reported a sensitivity of 40.3%, considering attenuation difference of 5HU as cutoff. They also used cutoffs of 8HU and 2HU for the same and reported a sensitivity of 12.5% and 76.4% respectively and recommended using cutoff of 2 HU.

Other differentials for grey kidney that has been suggested include pyelonephritis and unilateral acute renal vein thrombosis. Acute Pyelonephritis presents with fever, flank pain and has positive urine culture/microscopy. On non contrast CT, Acute Pyelonephritis shows renal enlargement, perinephric stranding(similar to obstruction) and/or gas(in emphysematous pyelonephritis). On contrast, wedge shaped areas of reduced attenuation involving periphery(negative rim sign), with striated nephrogram in excretory phase.Renal vein thrombosis on the other

hand occurs in the backdrop of thrombogenic states. Contrast enhanced CT in venous phase allows visualisation of thrombus as a filling defect.

Other subordinate signs[4] that have been described include renal enlargement which can be due to dilation of collecting system or due to renal edema secondary to same mechanism as above. Renal enlargement in isolation may be a normal variant(with left kidney being slightly larger than right), compensatory hypertrophy in contralateral renal pathologies(renal artery stenosis, renal injury, etc.).

Periureteric and perinephric stranding are other subordinate signs are possibly due to lymphatic obstruction. This may also be seen in pyelonephritis. Perinephric bridging septa of Kunin suspend the kidney and may mimic perinephric stranding.

Dilation of collecting system(hydronephrosis) which is very useful indicator of obstructive uropathy may not always be seen in acute obstruction depending on compliance of the collecting system. A mildly obstructed system with flaccid system may show marked dilation whereas a completely obstructed system may show only minimal dilation in a low compliance collecting system. Dilatation may also be due to PUJ obstruction, strictures, malignancy, etc. Extra renal pelvis, renal sinus cysts and renal sinus varices can mimic hydronephrosis. Contrast enhanced CT has help diagnose these entities.

Limitations of our study include small population and lack of control group to determine the specificity of the sign.

In conclusion, the grey kidney sign is a useful subordinate sign of obstructive ureterolithiasis with good sensitivity which can potentially be helpful in difficult cases due to technical factors, confusing phlebolith, passed calculus, etc. This has potential to reduce repeat scans and hence radiation dose and also to potentially avoid further workup in case of passed calculus.

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