RESEARCH
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ROLE OF DISTAL URETER DENSITY IN PREDICTING IMPACTION IN URETERAL STONES

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ABSTRACT
A prospective study of patients with ureteral calculi operated by ureteroscopy. Using a noncontrast CT KUB, the density of the ureter just below and above the stone was calculated. 528 patients underwent ureteroscopy in which 94 patients were qualified as having impacted ureteric calculi. There was no statistical difference between the two groups in the parameters such as age, gender, density of the stone and density of the ureteric soft tissue just above the stone (p value 0.39,0.36,0.63 and 0.14 respecively). There was a statistical difference between the two groups in the parameters such as longest diameter of the stone and density of the ureteric soft tissue just below the stone (p value 0.03 and 0.001 respectively). In patients who exceeded the ureteric density cut off value of 26 HU just below the calculi, impaction was found with asensitivity of 86%, specificity of 85%, positive predictive value of 85%, and negative predictive value Using logistic regression models and adjusting for the stone size, patients with higher HU under the stone had a higher probability of developing impaction (p value = 0.001). CT KUB scan showing ureteral soft tissue density just below the stone of more than 26HU is associated with calculus impaction, which could help in deciding the management of ureteric calculus.
KEYWORDS
ureter soft tissue density, impacted ureteral stones, Hounsfield units, predicting impacted stones, Computed Tomography

INTRODUCTION

Computed Tomography imaging can be used to determine variables such as site and size of the stone, stone constituent, degree of hydronephrosis, ureter wall thickness (1,2,3). In this study, we examined the relationship between radiological characteristics of the stone, ureteric soft tissue density and stone impaction.

OBJECTIVE

To determine whether radiological findings on a Computed tomography scan could help predict calculus impaction in ureteral stones.

MATERIALS AND METHODS

Prospective study of patients with ureteral calculi operated by ureteroscopy, done at the Department of urology, Saveetha medical college, between March 2022 and February 2023. Inclusion criteria – patients with ureteric calculi aged above 18 years treated by ureteroscopic lithotripsy. Patients were divided into two groups: those with non impacted ureteral calculi and those with impacted ureteral calculi, by findings on semirigid ureteroscopy. Definition of non-impacted ureteral calculi - mild edema of ureteric mucosa, calculus that can be dislodged with minimal irrigation without pressure and free floating stones in the ureter (Fig. 1). Moderate ureteric edema, requiring moderate irrigation under pressure to dislodge, stone embedded within ureteral tissue, guidewire and contrast unable to negotiate proximaly were considered as impacted stones (Fig. 2). Exclusion criteria included patients under 18 years of age, pregnant patients (as CT scan and fluoroscopy was not used), vesicoureteric junction stones as distal ureteric HU (Hounsfield Units) could not be calculated and patients undergoing secondary procedure after urinary diversion in the form of prior double J stenting or percutaneous nephrostomy. Using a noncontrast CT KUB, the density of the ureter just below and above the stone was calculated by measuring the HU at 5x magnification in the coronal view- abdominal window. A comparison of the two groups between the impacted and the nonimpacted ureteric calculi was made using demographic data, intraoperative variables and ureteric soft tissue density measurements Using SPSS statistical software v.25. Logistic regression and student t test were used for statistical analysis. p value of <0.05 was taken as statistically significant

RESULTS

528 patients underwent ureteroscopy for the management of ureteric calculi in the above period in which 94 patients were qualified as having impacted ureteric calculi by ureteroscopy and they were compared with 94 consecutive patients (control group) with non impacted ureteric calculi [Table 1]. There was no statistical difference between the two groups in the parameters such as age, gender, density of the stone and density of the ureteric soft tissue just above the stone (p value 0.39, 0.36, 0.63 and 0.14 respecively). The average age in the impacted ureteric calculi group was 38 and the average age in the non impacted calculi group was 36 (p value = 0.39). The average stone density (HU) in the impacted ureteric calculi group was 830 and the average stone density (HU) in the non impacted calculi group was 865 (p value = 0.63). The average ureteric density (HU) above the stone in the impacted ureteric calculi group was 12 and the average ureteric density (HU) above the stone in the non impacted calculi group was 14(p value = 0.14) There was a statistical difference between the two groups in the parameters such as longest diameter of the stone and density of the ureteric soft tissue just below the stone (p value 0.03 and 0.001 respectively). The ureteric soft tissue density (Fig 3,4,5) just distal to the impacted stone was significantly higher (33 HU vs. 18 HU, P =.001) The average size (longest diameter) of the impacted stone was slightly higher than the non impacted ureteral stone (8mm vs 7 mm, p value =0.03). Furthermore, variations in the average duration between the date of the CT scan and the ureteroscopic lithotripsy was also found to be statistically nonsignificant, with averages for the impacted ureteral calculi and the non impacted ureteral calculi control groups being 19 days and 18 days, respectively (P =.93). In patients who exceeded the ureteric soft tissue density cut off value of 26 HU just below the calculi, impaction was found with a sensitivity of 86%, specificity of 85%, positive predictive value of 85 %, and negative predictive value of 84%. Using logistic regression models and adjusting for the stone size, patients with higher HU just distal to the stone had a higher probability of developing impaction (p value = 0.001) [Table 2]

DISCUSSION

Computed Tomography imaging can be used to determine variables such as site and size of the stone, stone constituent, degree of hydronephrosis, ureter wall thickness (1,2,3). In this study, we examined the relationship between radiological characteristics of the stone, ureteric soft tissue density and stone impaction. Impacted stones are associated with higher incidence of infected hydroureteronephrois, ureteric wall edema, ureteric wall hypertrophy, ureteric polyp formation (4). Hence ureteroscopy and intracorporeal lithotripsy for impacted ureteral stones poses higher incidence of complications such as hemorrhage, ureteric avulsion, ureteric perforation and lower stone free rates (5,6). Also the association of ureteric strictures is more with impacted ureteric stones due to (i). Inflammation caused by the impacted stone and secondary fibrosis, (ii). Thermal injury to the ureteric wall caused by laser lithotripsy, (iii). ureteric wall injury caused by various other forms of intracorporeal litotripsy such as pneumatic lithotripsy. Also impacted ureteric stones tend to require a prolonged ureteric stent to maintain ureteral drainage until the inflammation caused by the impaction subsides (7). Additionally, even while anticoagulants and antiplatelet medications seem safe for patients to take during ureteroscopy, surgeons may be more likely to hold these drugs to prevent the increased bleeding that comes with an impacted stone (8).

Ibrahim et al. investigated the role of stone surface as a predictor of conservative management of ureteric calculi and discovered that irregularly shaped stones are more likely to spontaneously pass than smooth-surfaced ones (9). They suggested that irregularly shaped stones are less likely than smooth stones to become fully impacted, and that urine can travel around the surface to the distal ureter, improving ureter flushing and facilitating stone progression. Additionally, the irregular surface may increase the irritation to the ureteric wall, which in turn may promote peristalsis. The stone will get more deeply embedded in the ureteral wall as a result of the edematous changes that develop over time due to the stone's continued placement and the escalating inflammatory changes it causes on the ureteric wall. During ureteroscopy, the likelihood of submucosal wire passage or perforation is increased in the presence of an edematous, inflammatory ureter (10). This would necessitate the need for hydrophilic guidewires and at times a percutaneous antegrade approach. A group of 163 individuals who underwent mini perc (percutaneous nephrolithotripsy) for impacted proximal ureteral stones was documented by Long et al (11). With a follow-up of at least six months, their findings included a 95.7% stone-free rate, no ureteral perforations, and no postoperative strictures. Viers et al examined 120 individuals undergoing elective ureteroscopy for renal stones, reviewing 154 renal units (12). A larger pelviureteric junction (5 mm vs. 4 mm), prior ipsilateral stent placement, stone surgery, and a ureter that was >50% opacified on 10-minute delayed pictures were all predictive factors of effective therapy. 247 individuals who had ureteroscopy with intractable renal colic due to a ureteral stone were studied by Tran et al (13). Their treatment failure rate was 18%, and the inability to reach the stone was the reason for 95% of the failures. One of the failure predictors was an increased ureteric soft tissue density located distal to the stone. The study did not examine the distal ureteric soft tissue density's predictive value for stone impaction, despite the authors' hypothesis that a larger periureteral density would be indicative of a reduced stone free rate. Elibol et al. demonstrated that the ureteral wall thickness where the stone had been found to be buried into the wall was highly informative to predict the impaction (14). These results clearly show that because of the tissue changes brought on by an inflammatory response on the wall of the affected ureter, ureteral stones that remain in the same portion of the ureter for a comparatively longer period of time will further bury into the ureteral wall, or get embedded into the ureteric wall. The existence and severity of these alterations will determine how much the ureter thickens, a process that is both time- and stone-dependent and may, of course, objectively reflect the degree of impaction. Finally, 2650 individuals with impacted stones were included in a global ureteroscopy database examined by Legemate et al (15). Here, they observed that the following factors were linked to stone impaction: female gender, ASA Score >1, greater stone size, positive bacterial preoperative culture, and prior ipsilateral ureteroscopy. Based on univariate analysis, we discovered that a couple of parameters were predictive of impacted stones. These included the distal ureteral density and stone size. Only distal ureteral density, continued to be a significant predictor of stone impaction on multivariate analysis (odds ratio 1.1, p value =.001). A cut-off value of 26 HU was determined by sensitivity and specificity analysis for the ureter's density distal to the stone. This cutoff showed 85% positive predictive value, 84% negative predictive value, sensitivity of 86% and specificity of 85%. An impacted stone found by ureteroscopy may indicate increased tissue edema and inflammation, which could be reflected in a higher density ureter. An impacted stone was formerly described as one through which antegrade or retrograde contrast is difficult to pass and there was no standardised way of predicting stone impaction on preoperative CT scan. An impacted stone, according to other series, is one that has not moved farther than two months. However, this has been contested because endoscopic results typical of impacted stones are known to appear in less than two months. A drawback of our study is that a large number of patients with ureteral stones at the vesicoureteric junction were disqualified since it was unable to measure the ureter's soft tissue density distal to the stone. Consequently, this metric's use might be limited to proximal and midureteral stones. Notwithstanding these drawbacks, the study is distinctive in that it identifies HU distal to the stone as a novel predictor of stone impaction, which may enable better results by identifying patients with impacted stones and help in guiding further management

Table 1: Demographic and clincical data comparison

Parameter	Impacted ureteral calculi group, n=94	Non impacted ureteral calculi group, n=94	p value
Age (average)	38	36	0.39
Male sex	52	57	0.36
Average density of the stone(HU)	830	865	0.63
Longest diameter of the ureteric calculi(mm)	8	7	0.03
Ureteric density just above the calculi	12	14	0.14
Ureteric density just below the	33	18	0.001

calculi			
Days between CT scan and ureteroscopy	19	18	0.93

Table 2: Logistic regression analysis

Parameter	Odds ratio	p value
Longest diameter of the ureteral calculi(mm)	1.1	0.2
Ureteric density just below the calculi	1.1	0.001

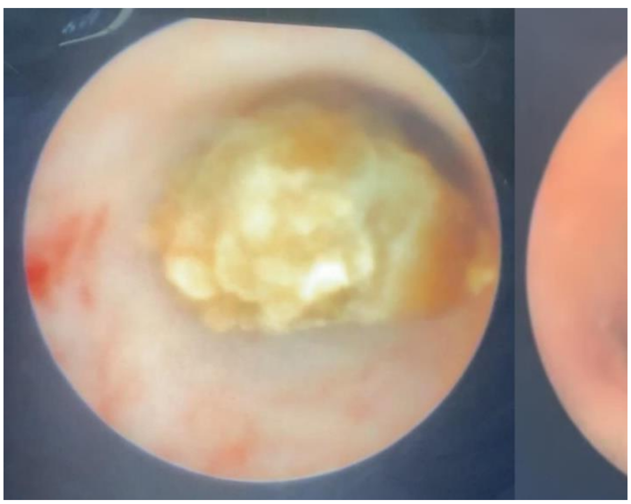

Fig. 1: Non impacted ureteric stones found on ureteroscopy

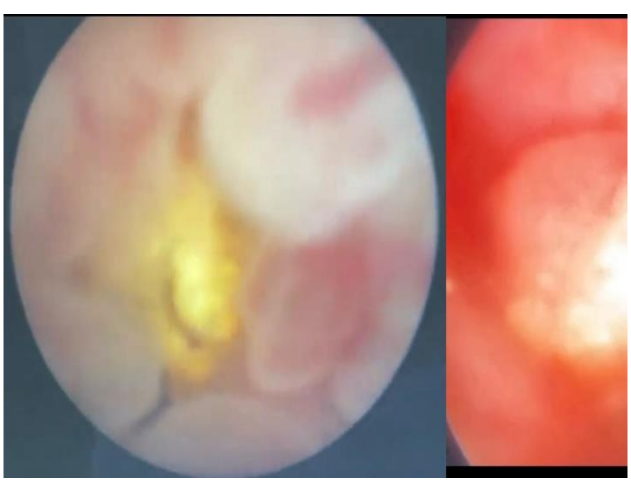

Fig. 2: Impacted uretric stones found on ureteroscopy

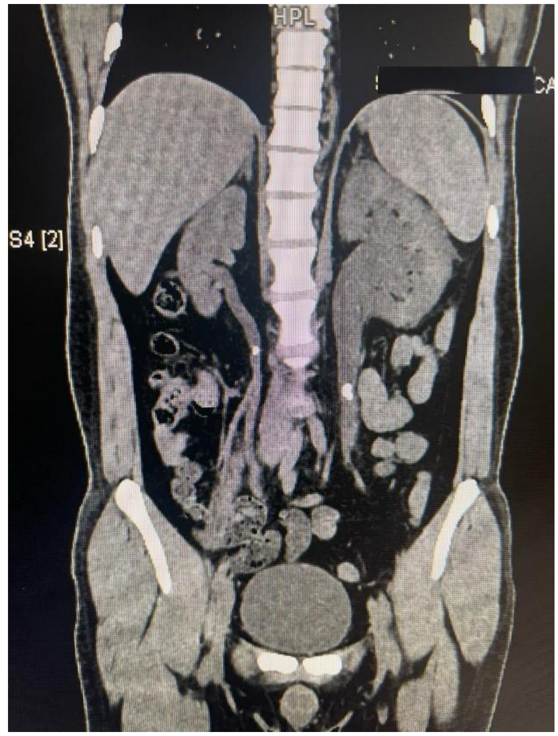

Fig.3: Coronal view of CT abdomen showing nonimpacted bilateral ureteric stones (nonimpacted stone as per ureteroscopy) with distal ureteric soft tissue density of 19HU(Hounsefield Units) on the right side and 18HU on the left side

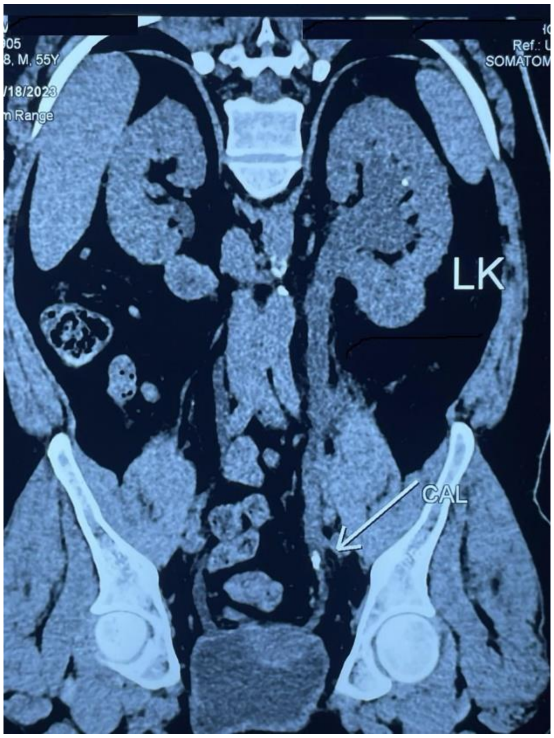

Fig.4: Coronal view of CT abdomen showing nonimpacted left ureteric stone (nonimpacted stone as per ureteroscopy) with distal ureteric soft tissue density of 21HU(Hounsefield Units)

Fig. 5: Coronal view of CT abdomen showing nonimpacted left ureteric stone with distal ureteric soft tissue density of 16HU(Hounsefield Units) and right impacted ureteric stone with distal ureteric soft tissue density of 30HU

CONCLUSION

Radiological findings on a non contrast CT KUB scan could help predict calculus impaction in ureteric stones. Ureteric soft tissue density just distal to the stone of more than 26HU is associated with calculus impaction, which could help in deciding the management of ureteric calculus.

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