

## ORIGINAL RESEARCH

# Findings of Non-enhanced Abdominal Computed Tomography for Pain Management of Acute Renal Colic Patients in the Emergency Department

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**Abstract**

**Study Objectives:** To identify non-enhanced computed tomography (NECT) findings related to repeated requirement of painkiller, hospitalization and revisits within 5 days of discharge among acute renal colic patients. **Patients and methods:** A retrospective observational study was performed for all patients (age > 18 years) with acute renal colic who visited the emergency department (ED) between 2012 and 2015. NECT findings of acute ureterolithiasis (size, location, hydronephroureter, perinephric infiltrations and soft-tissue rim sign) were analysed for their relationships to repeated administration of painkiller, hospitalization and ED revisit. **Results:** Of total 862 patients enrolled, 305 (35.4%) required repeated administration of pain medication. In the NECT findings, hydronephroureter was more prevalent in the repeated administration of painkiller group (61.3% vs. 53.7%), but did not show independent relationship. Sixty-eight (7.9%) were hospitalized and 44 (5.1%) returned to the ED. The significant findings associated with hospitalization were hydronephroureter (OR [Odd Ratio] 1.92, 95% CI [Confidence Intervals] 1.04–3.54) and mid (5–7 mm) / large-size (> 7mm) ureteral stones (OR 2.66, 95% CI 1.49–4.76 and OR 4.78, 95% CI 1.80–12.70). The soft-tissue rim signs (OR 2.16, 95%CI 1.07–4.37) and proximal/mid location of stones (OR 3.21, 95% CI 1.26–8.20 and OR 2.53, 95% CI 1.19–5.37) were independently associated with ED revisit. **Conclusions:** Among the NECT findings of acute ureterolithiasis, hydronephroureter and stones > 5 mm in size were independently associated with the need of hospitalization. The soft-tissue rim sign and proximal/mid location of stones were independently associated with ED revisit within 5 days.

**Keywords**

Urolithiasis, Renal colic, Computed tomography, Radiology, Emergency departments

## 1. Introduction

Urinary tract stones are a common condition. The incidence of symptomatic urolithiasis is 13% in men and 7% in women [1, 2]. Acute renal colic caused by urolithiasis is an increasing problem in patients who present to the emergency department (ED) [3]. Appropriate diagnosis and acute management are essential. Radiological imaging plays a primary role in the evaluation of the presence of urinary tract stones. Multiple modalities, including simple radiography, intravenous urography, ultrasonography and non-enhanced computed tomography (NECT), can be used to identify urinary tract stones. Currently, NECT is superior to other diagnostic modalities for diagnosis of urinary tract stones [4–7]. Studies have reported a NECT specificity of nearly 100% and sensitivity ranging from 96% to 98% for identifying stones [8–10]. NECT can also provide information about the location and size of stones [10, 11].

In addition to faster and more accurate diagnosis of urinary

tract stones, an appropriate disposition plan must be established in the ED [4], and methods of pain control, need for urologic consultation, hospitalization and a disposition plan must also be considered. NECT findings, such as the stone size and its locations, are known to be related to spontaneous passage of renal stones. However, this information is not always determinable from other imaging modalities.

We hypothesized that radiological findings from NECT would be useful for establishing a pain management strategy and disposition plan in the ED. The aim of this study was to identify the NECT findings associated with the repeated administration of painkillers, hospitalization, and recurrent visits to the ED in patients with acute renal colic seen in the ED.

**TABLE 1. Baseline characteristics of the enrolled patients (n = 862).**

	Value
Age, mean (SD)	44.4 (13.5)
Male, No (%)	569 (66.0)
CVAT, No (%)	837 (97.1)
<b>NECT findings</b>	
<b>Stone Size</b>	
< 5 mm, No (%)	697 (80.9)
5-7 mm, No (%)	137 (15.9)
> 7 mm, No (%)	28 (3.2)
<b>Location of stone</b>	
proximal, No (%)	250 (29.0)
mid, No (%)	88 (10.2)
distal, No (%)	524 (60.8)
<b>Secondary signs</b>	
soft tissue rim sign, No (%)	159 (18.4)
perinephric infiltration, No (%)	207 (24.0)
hydronephroureter, No (%)	486 (56.4)
Length of stay at ED (min), mean (SD)	134.7 (50.1)
No. of painkiller, median (IQR)	2 (1,3)
Repeated administration of painkillers, No (%)	305 (35.4)
Hospitalization, No (%)	68 (7.9)
5-days ED visit, No (%)*	44 (5.5%)

*SD: standard deviation; CVAT: costovertebral angle tenderness; NECT: non-enhanced computed tomography; ED: emergency department; IQR: inter-quartile ranges, \* among the discharged patients at ED (n = 794).*

## 2. Methods

This was a retrospective, cross-sectional observational study. Subjects were recruited from October 2012 to October 2015 at an urban university medical centre. During the study period, all adult patients aged > 18 years with an acute urinary stone diagnosed using NECT in the ED were enrolled. The exclusion criteria included patients with a known urinary tract anomaly, serious comorbidities (diabetes nephropathy or neuropathy, cardiovascular disease, underlying renal failure, liver failure or malignancy), combined urinary tract infection, acute kidney injury caused by obstruction, anuria or a diagnosis of recent urinary stone within the past 3 months.

The demographic, clinical data and NECT findings of the study subjects were collected from the electrical medical chart and included age and sex, clinical data (presence of costovertebral angle tenderness [CVAT]), length of stay in the ED, administration of painkillers, hospitalization, 5-day ED revisit after discharge. We summarized the CT data from the radiologist's report and the NECT findings as follows: stone size, stone location, presence of the soft-tissue rim sign, perinephric infiltration (fluid collection or fat stranding) and hydronephroureter.

The stone location was categorized into three groups: 1) proximal (from the renal pelvis to the top edge of the sacrum),

2) mid (from the top edge to the lower edge of the sacrum) and 3) distal (from the lower edge of the sacrum to the urinary bladder) [12]. The soft-tissue rim sign was considered to be present when the ureteral stone had an obvious surrounding rim of soft tissue [13]. When the outer wall of the ureter could not be seen because of the absence of a clear fat plane at the level of the calcification on CT, the sign was categorized as 'negative'. Perinephric infiltration was defined as an obvious fluid collection or fat stranding. Obvious fluid collection was defined as discrete, rounded areas of fluid collection within the perinephric space. More than 1 cm diameter of fluid collection was considered positive for a perinephric fluid collection and < 1 cm diameter of fluid collection was considered as 'negative' [14]. Obvious perinephric fat stranding was defined as several thick or circumferential linear areas of soft-tissue attenuation in the perinephric space. Hydronephroureter was defined as obvious dilatation of the urinary collecting system of the kidney (the intra-renal pelvis or renal calyces) along with dilatation of the ureter compared with the contralateral side [15].

During the study period, the initial diagnostic workup and management were performed by the attending emergency physician. Pain control was achieved primarily using non-steroidal anti-inflammatory drugs and narcotics were added if pain was intractable. The need for hospitalization was determined after consultation with the urologist for those patients with intractable pain/vomiting or those stones with minimal possibility of spontaneous passage. Patients discharged from the ED were given discharge instructions and a follow-up outpatient appointment 5–7 days after discharge from the ED.

The study outcomes included: 1) the need for repeated administration of painkillers in the ED, 2) hospitalization from the ED and 3) revisiting the ED within 5 days after discharge. To identify associations between NECT findings and clinical outcomes, univariate and multivariate logistic regression testing were performed. Independent Student *t* tests were used to compare normally distributed data, which are presented as mean and standard deviation. Mann–Whitney *U* tests were used to compare non-normally distributed data, which are presented as median and interquartile range. Statistical analyses were performed using SPSS Statistics 17.0 (SPSS Inc., Chicago, IL). A two-sided *p* value of <0.05 was considered significant.

## 3. Results

### 3.1 Baseline data of study

During the study period, 981 patients were diagnosed as having an acute urinary stone using NECT in the ED. Of these patients, 119 were excluded because of a urinary tract anomaly (n = 6), presence of comorbidities (n = 64) a diagnosis of a recent urinary stone within 3 months (n = 15), urinary or other infections (n = 22), or acute renal injury or anuria (n = 12). A total of 862 patients were enrolled. The demographic features, NECT findings, laboratory findings and clinical outcomes are presented in Table 1.

**TABLE 2. Comparisons of baseline characteristics between the repeated administration of painkiller group and the non-repeated administration of painkiller group.**

	Repeated administration of pain medication		p-value
	Yes (n = 305)	No (n = 557)	
Age, mean (SD)	44.7 (13.3)	44.1 (13.6)	0.501
Female, No (%)	110 (36.1)	183 (32.9)	0.367
CVAT, No (%)	302 (99.0)	535 (96.1)	<b>0.011</b>
<b>NECT findings</b>			
<b>Stone Size</b>			
< 5 mm, No (%)	240 (78.7)	457 (82.0)	0.213
5-7 mm, No (%)	51 (16.7)	86 (15.4)	
> 7 mm, No (%)	14 (4.6)	14 (2.5)	
<b>Location of stone</b>			
proximal, No (%)	85 (27.9)	165 (29.6)	0.266
mid, No (%)	38 (12.5)	50 (9.0)	
distal, No (%)	182 (59.7)	342 (61.4)	
<b>Secondary signs</b>			
soft tissue rim sign, No (%)	57 (18.7)	102 (18.3)	0.927
perinephric infiltration, No (%)	81 (26.6)	126 (22.6)	0.211
hydronephroureter, No (%)	187 (61.3)	299 (53.7)	<b>0.031</b>
Length of stay at ED (min), mean (SD)	145.7(52.9)	128.7 (47.4)	<b>&lt; 0.001</b>

SD: standard deviation; CVAT: costovertebral angle tenderness; NECT: non-enhanced computed tomography; ED: emergency department.

### 3.2 Factors associated with repeated administration of pain medication in the ED

Of the 862 patients, 305 (35.4%) required repeated administration of painkillers. Stone size, stone location, soft tissue rim sign and perinephric infiltration were not associated with repeated administration of painkiller. Costovertebral angle tenderness was also associated with hospitalization and only hydronephroureter was more prevalent in the repeated administration of pain medication group among NECT findings (Table 2).

### 3.3 Factors associated with hospitalization in the ED

During the study period, 68 patients (7.9%) were hospitalized from the ED. NECT findings associated with the need for hospitalization were stone size and presence of obvious hydronephroureter. In addition to NECT findings, older age and female sex were also associated with hospitalization (Table 3). In the multivariate regression analysis female sex (OR [Odd Ratio] 1.72) repeated administration of painkillers (OR 1.85), stone size (5–7 mm: OR 2.66, > 7 mm size: OR 4.78) and hydronephroureter (OR 1.92) were independently associated with hospitalization (Table 4).

### 3.4 Factors associated with 5-days ED revisit

During the study period, 794 patients (92.1%) were discharged from the ED and 44 (5.5%) revisited the ED. NECT findings

associated with 5-day ED revisit were proximal/mid stone location and presence of the soft-tissue rim sign (table 3). In addition to NECT findings, female sex and repeated administration of painkiller were associated with 5-day ED revisit (table 4). In the multivariate regression analysis, female sex (OR 2.32), repeated administration of painkiller (OR 4.94), stone location (proximal: OR 3.21, mid: OR 2.53) and the soft-tissue rim sign (OR 2.16) were independently associated with 5-day ED revisit (Table 4).

## 4. Discussion

NECT is now used almost exclusively for the diagnosis of patients with acute renal colic. However, no trials have evaluated the relationships between NECT findings and clinical outcomes (need for repeated administration of painkiller, need for hospitalization and ER revisits after discharge) during the acute treatment phase. We studied the role of NECT findings beyond diagnosis to establish an emergency care plan for patients with urinary stones. Our results show that mid/large sized stones (> 5 mm) and the presence of obvious hydronephroureter are independently associated with the need for hospitalization, and proximal/mid stone location and the soft tissue rim sign are independently associated with 5-day ED revisits. This information might be useful for emergency physicians when establishing the treatment and disposition plans for patients with urinary stones.

Pain management is important for management of acute renal colic during the ED stay. The repeated administration of

**TABLE 3. Comparisons of baseline characteristics in the hospitalization group versus no hospitalization group and the 5-days ED revisit group versus non-revisit group.**

	Hospitalization			5-days ED revisit after discharge		
	Yes (n = 68)	No (n = 794)	p-value	Yes (n = 44)	No (n = 750)	p-value
Age, mean (SD)	47.9 (14.3)	44.1 (13.4)	<b>0.026</b>	45.1 (14.6)	44.0 (13.3)	0.578
Female, No (%)	33 (48.5)	260 (32.7)	<b>0.011</b>	22 (50.0)	238 (31.7)	<b>0.019</b>
CVAT, No (%)	67 (98.5)	770 (97.0)	0.714	44 (100)	726 (96.8)	0.638
NECT findings						
Stone Size						
< 5mm, No (%)	39 (57.4)	658 (82.9)	<b>&lt; 0.0001</b>	33 (75.0)	625 (83.3)	0.124
5-7 mm, No (%)	21 (30.9)	116 (14.6)		8 (18.2)	108 (14.4)	
> 7 mm, No (%)	8 (11.8)	20 (2.5)		3(6.8)	17 (2.3)	
Location of stone						
proximal, No (%)	18 (26.5)	232 (29.2)	0.179	20 (45.5)	212 (28.3)	<b>0.001</b>
mid, No (%)	3 (4.4)	85 (10.7)		9 (20.5)	76 (10.1)	
distal, No (%)	47 (69.1)	477 (60.1)		15 (34.1)	462 (61.6)	
Secondary signs						
Soft tissue rim sign, No (%)	15 (22.1)	144 (18.1)	0.417	15 (34.1)	129 (17.2)	<b>0.008</b>
perinephric infiltration, No (%)	23 (33.8)	184 (23.2)	0.055	8 (18.2)	176 (23.5)	0.581
hydronephroureter, No (%)	52 (76.5)	434 (54.7)	<b>0.001</b>	28 (63.6)	402 (53.6)	0.215
Repeated administration of painkillers, No (%)	35 (51.5)	270 (34.0)	<b>0.005</b>	31 (70.5)	239 (31.9)	<b>&lt; 0.001</b>
Length of stay at ED (min), mean (SD)	142.6 (47.3)	134.0 (50.3)	0.175	143.2 (51.6)	133.5 (50.2)	0.216

SD: standard deviation; CVAT: costovertebral angle tenderness; NECT: non-enhanced computed tomography; IQR: inter-quartile ranges 25% to 75%; ED: emergency department.

**TABLE 4. Significant factors for associating with hospitalization at emergency department and 5-day revisit after discharge from emergency department (all p-value < 0.05).**

	Adjusted OR for need of hospitalization (95% CI)	Adjusted OR for 5-day revisit (95% CI)
Female	1.72 (1.01-2.92)	2.32 (1.20-4.46)
Repeated administration of painkiller	1.85 (1.10-3.08)	4.94 (2.50-9.78)
Location of stone		
proximal	Baseline	3.21 (1.26-8.20)
mid	2.66 (1.49-4.76)	2.53 (1.19-5.37)
distal	4.78 (1.80-12.70)	Baseline
Soft tissue rim sign	1.92 (1.04-3.54)	2.16 (1.07-4.37)

CI: confidence interval.

painkillers is indicative of uncontrolled pain. In this study, we found that NECT findings related to uncontrolled pain was the presence of obvious hydronephroureter, not the size or location of the ureteral stone. Physicians caring for patients with obvious hydronephroureter may anticipate the possibility of intractable pain and the need for the administration of multiple painkillers.

For patients with urinary stones in the absence of complications, the need for hospitalization has been traditionally based on the severity of symptoms and the possibility of spontaneous passage [4]. The size of a ureteral calculus is a well-known factor for spontaneous passage [12, 14]. In a

systematic review by the European Association of Urology Nephrolithiasis Guideline Panel, the stone-passage rate was estimated as 68% for stones measuring  $\leq 5$  mm and 47% for stones measuring  $> 5$  and  $\leq 10$  mm [16]. In this study, the stone size of  $> 5$  mm was independently associated with hospitalization. Physicians are more likely to recommend hospitalization for patients with larger stones.

Hydronephroureter is one of the most frequently observed CT findings of acute ureterolithiasis and is a sign of ureteral obstruction. In this study, 486 of 862 patients (56%) with NECT evidence of ureteral calculi showed hydronephroureter, similar to that in a previous report by Katz *et al* [17]. In this

study, obvious hydronephroureter was an independent finding associated with hospitalization. A previous study has reported that hydronephroureter was not significantly associated with spontaneous stone passage [14]. Considering the relationship between hydronephroureter and repeated administration of painkiller in our study, the higher hospitalization rate in the presence of hydronephroureter may not be explained by delayed spontaneous stone passage but rather by intractable pain.

The NECT findings associated with 5-day ER revisits might suggest delayed stone passage. In our study, stone location and soft tissue rim sign were two NECT findings that were independently associated with 5-day ED revisits. Proximal or mid ureteral stone was highly associated with 5-day ED revisits, similar to a previous study that evaluated the 30-day revisit rate for patients with ureteral stones [18]. In addition, we found that the soft-tissue rim sign is significantly associated with 5-day ED revisits. The soft-tissue rim sign appears as a surrounding rim of soft tissue around a calcific density, representing ureteric wall edema [12]. The soft-tissue rim sign is traditionally used to diagnose ureteric stones and distinguish a ureteric calculus from a phlebolith [19]. Previous studies reported that the prevalence of the soft-tissue rim sign did not differ between patients with spontaneous stone passage and those who failed conservative management [14], and was not associated with the stone location or degree of obstruction [13, 20]. However, recent research on ureteral wall thickness (UWT) suggests that the soft tissue rim sign may be associated with delayed stone passage. Yoshida et al. reported that higher UWT (> 2.7 mm) is associated with failed 4-week spontaneous stone passage [21]. In our study, we considered the soft tissue rim sign as positive when there is an obviously visible rim of soft tissue surrounding the ureteral stone, suggesting that only ureteral stones with a higher UWT were categorized as having a soft tissue rim sign. The soft tissue rim sign may indicate stone impaction and delayed spontaneous stone passage, and therefore can explain the association between the soft tissue rim sign and more frequent 5-day revisits.

In addition to the NECT findings, we found that women required significantly more hospitalizations and more frequently revisited the ED than men. We could not determine the exact cause in this retrospective study, but it may be that women have a greater ability to discriminate painful sensations, higher pain ratings, and a lower tolerance for pain than men [22]. Although the incidence of ureteral stones is higher in men, women seem to be more symptomatic.

This study has several limitations. First, physician preferences regarding hospital admissions for patients with renal colic might have affected the outcomes of this study. Second, our study results cannot be generalized since it reflects a single ED experience. No international standard guidelines have been established for pain control and hospitalization for patients with renal colic. Even if patients present with similar clinical symptoms, decisions may differ between medical institutions and between nations because of differences in culture or medical systems. In addition, our ED had a basic policy of short-term outpatient follow-up of 5–7 days, which we used to define the time for the revisit. Other hospitals have used a different follow-up time after ED discharge [18]. Therefore, the revisit

results of our study may have limited applicability to other institutions.

## 5. Conclusion

NECT findings are useful for predicting clinical outcomes in the ED in patients with renal colic. Hydronephroureter and large/mid-size stones were independently associated with the need of hospitalization, and proximal/mid stone location and the soft tissue rim sign were independently associated with 5-day ED revisits.

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## CONFLICT OF INTEREST

All authors declare that they have no conflict of interest.

## ETHICS APPROVAL

This study protocol was reviewed and approved by the institutional review board of the Konkuk University Medical Centre (KUH1260028). All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

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