ORIGINAL PAPER

UROLITHIASIS

Emergency computed tomography in acute renal colic is essential for correct diagnosis and shortens time to treatment and stone-free status

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Introduction This study aimed to evaluate the clinical impact of implementing routine emergency computed tomography (eCT) for all patients presenting with suspected acute renal colic at the emergency department (ED).

Material and methods We did a retrospective observational study of all patients who underwent eCT for suspected acute renal colic at the ED in Helsingborg between May 9, 2023 and May 8, 2024 and compared with a 2019/2020 cohort not using routine eCT.

Results Of 66,540 ED visits during the study period, 1,566 patients underwent eCT for suspected acute renal colic; 1,261 were included in the analysis after exclusions. In 57% of patients, no symptomatic stone was identified; nevertheless, one fifth required hospital admission for alternative diagnoses. A radiologically proven stone explaining their symptoms was found in 43% of patients. Compared with the 2019/2020 cohort, the 2023/2024 cohort had more treatments (33% vs 21%), and significantly shorter time to both treatment ($p = 0.01$) and clinical closure ($p < 0.001$). Stone size, location, type of treatment and number of visits to the ED were comparable between the two cohorts.

Conclusions Acute renal colic in its clinical presentation appeared to be less diagnostically reliable than previously assumed. The use of eCT ensured accurate diagnosis of urolithiasis, significantly shortened time to treatment, and to a stone-free patient as well as reduced the use of stents. We propose that eCT should be implemented as a routine procedure in the management of acute renal colic.

Key Words: urolithiasis ‹› acute renal colic ‹› emergency medicine ‹› urology ‹› computed tomography

INTRODUCTION

Urolithiasis has affected humans throughout recorded history and remains a growing clinical concern. In Sweden, diagnosed cases increased by 66% between 2008 and 2023, from 16,673 to 27,603 [1], mirroring trends in other Western countries [2, 3]. Global prevalence varies according to dietary, genetic, climatic, and ethnic factors [4]. The increasing prevalence may be attributed to changes in underlying causes, such as lifestyle factors, but may also partly reflect improved diagnostics.

Acute renal colic typically manifests as severe flank pain with restlessness and vomiting, prompting emergency department (ED) visits. Standard management involves analgesia and, if effective

and with no signs of severe renal impairment or infection, discharge with planned computed tomography (CT) follow-up in 2–4 weeks. Spontaneous passage occurs in 64% of cases [5] with rates of 75% for stones <5 mm and up to 95% for stones <4 mm [6, 7]. However, this conservative management strategy delays definitive treatment in patients who will ultimately require active treatment. Low-dose CT has replaced radiography as the preferred modality, offering 93% sensitivity and 97% specificity with radiation <3 mSv [8]. Ultrasound remains an alternative. However, due to its low sensitivity, particularly in detecting ureteral stones, its use in Sweden remains infrequent [9]. In line with this, the European Association of Urology (EAU) guidelines [10] designate CT as the gold standard for the evaluation of suspected renal colic.

In October 2022, Sweden introduced national guidelines on urolithiasis in the upper urinary tract, recommending emergency CT (eCT) despite the absence of large-scale randomised trials [11]. Accordingly, eCT was implemented at our institution, Helsingborg Hospital, on May 9 2023.

In a previous study, data were presented on patients diagnosed with urolithiasis in the ED at Helsingborg hospital during 2019/2020 [6]. This cohort, from the period prior to routine eCT, serves as a historical control.

This study evaluates the first year with routine eCT. The primary aim is to determine the proportion of patients presenting with suspected acute renal colic who are diagnosed with urolithiasis, including analysis of stone size and anatomical location. Secondary aims include assessing changes in ED visits, CT utilisation, time to treatment and closure, subsequent eCT introduction, as well as estimation of false-positive urolithiasis diagnoses in the 2019/2020 cohort and comparison of the two cohorts from 2019/2020 and 2023/2024.

MATERIAL AND METHODS

This retrospective study included all patients who underwent an eCT at the Department of Radiology in Helsingborg with a clinical query of urolithiasis between May 9, 2023, and May 8, 2024. These patients were recorded in a dedicated database maintained by the Radiology department. The database was reviewed daily by staff at the Urology Outpatient Clinic in Ängelholm.

Data collection encompassed patient demographics (age and sex), date of ED visits, number of ED visits and CT scans, treatments, and date of medical closure. Medical closure was defined as the date on which the patient was confirmed to be stone-free. For patients undergoing ureteroscopy (URS), this was defined as the date of surgery; for all other patients, it was defined as the date of follow-up CT. Patients were considered stone-free in the absence of residual stone fragments. Additional variables collected included stone size and location, follow-up, and intervention such as stent placement or nephrostomy, as well as stone treatment modality: URS, extracorporeal shock wave lithotripsy (ESWL), or percutaneous nephrolithotomy (PCNL).

Stone measurements were performed according to the guidelines issued by the Swedish Society of Urogenital Radiology [12]. Stone length and width were measured in the coronal plane. In the axial plane, stone height was measured. If a stone was located on the contralateral side or in a renal calyx it was considered asymptomatic and incidental.

"Emergency CT (eCT)" was defined as imaging performed within 24 hours of presentation to the ED. Inpatient CT referred to imaging performed in patients already admitted to the hospital, whereas outpatient CT applied to those not hospitalised at the time of scanning. Serum creatinine was analyzed for most patients upon arrival at the ED.

When comparing the cohorts from 2019/2020 [6] and 2023/2024, it is important to acknowledge the differences in diagnostic practices between the two time periods. In 2019/2020, both eCT (43%) and deferred CT (57%) were used. Thus, in the 2019/20 cohort, 57% of urolithiasis diagnoses were based solely on clinical presentation.

Statistical analysis

Categorical variables were presented as frequencies and percentages (%), while continuous variables were expressed as mean with standard deviations (SD) for normally distributed data, and as medians with interquartile range (IQR) for non-normally distributed data. Comparisons of normally distributed continuous variables were performed using Student's t-test, whereas the Mann-Whitney U test was applied for non-normally distributed variables. Categorical variables were compared using the chi-square test or Mantel-Haenszel chi-square test for linear-by-linear association. A p-value of <0.05 was considered statistically significant. Statistical analyses were conducted using SPSS software, version 28.

Bioethical standards

Ethical approval was granted by the Swedish Board of Ethics (EPN 2024-01345-01 Stockholm).

RESULTS

Between May 9 2023 and May 8 2024, a total of 66,540 visits to the ED were recorded. Of these, 2.4% (1,566) underwent eCT for suspected acute renal colic. Ninety patients were excluded due to incorrect inclusion, including those with pre- or post-operative imaging or repeated visits for the same stone episode. An additional 215 patients were excluded after review, because they did not present with pain. Consequently, 1,261 patients were deemed eligible for analysis. A flowchart of patient inclusion is shown in Figure 1.

Symptomatic urolithiasis was diagnosed in 43% (546/1,261) of patients. In 44% (553/1,261), no stone was detected, and in 13% (162/1,261) urolithiasis was found but considered asymptomatic and incidental. Stones were considered asymptomatic and incidental if located in a renal calyx or on the contralateral side of the pain. The latter two groups were combined into the category "no symptomatic urolithiasis."

Descriptive data on age, sex, admission status, CT details, and serum creatinine levels are summarised in Table 1. Statistically significant differences were observed between patients with symptomatic urolithiasis and those with non-stone-related symptoms in all variables except age.

Among patients with symptomatic urolithiasis, the majority had only one ED visit, 79% (431/546), one eCT, 90% (492/546) and completed follow-up in 81% (444/546). One-third, 33% (182/546) underwent ac-

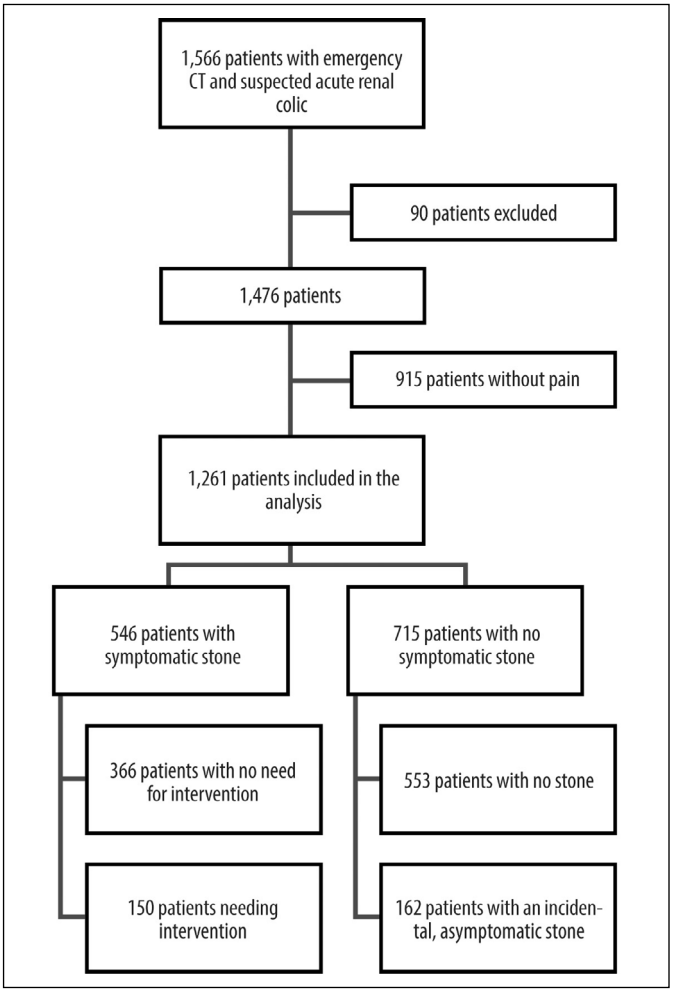

Figure 1. *Flowchart of eligible participants.*

Table 1. *Descriptive parameters of patient with suspected acute renal colic at the Emergency Department (ED) in Helsingborg May 9, 2023, to May 8, 2024*

Parameter	Total	Urolithiasis	No symptomatic urolithiasis	Diff. (95% CI)	p-value
Numbers (%)	1,261	546 (43)	715 (57)		
Mean age, years (SD)	50 (19)	50 (17)	51 (20)	0.7 (–2.7–1.4)	0.5
Gender male/female (%)	707/554 (56/44)	379/167 (70/30)	328/387 (46/54)		<0.001
Admission, (%)					
No admission	950 (75)	409 (75)	541 (76)		<0.001
Admission due to stone	132 (11)	132 (24)	0		
Already admitted	41 (3)	3 (0.5)	38 (5)		
Admission due to other reason	138 (11)	2 (0.5)	136 (19)		
CT referral (%)					
ED	1,205 (96)	542 (99)	663 (93)		<0.001
Inpatient/ ward	40 (3)	3 (0.5)	37 (5)		
Outpatient	16 (1)	1 (0.5)	15 (2)		
Creatinine, median (IQR) (mmol/l)	92 (73–114) Missing 28	98 (82–120) Missing 5	84 (68–108) Missing 23		<0.001

ED – Emergency Department; IQR – interquartile range; SD – standard deviation

tive treatment. Among those treated, 64% (117/182) underwent URS, 32% (59/182) received ESWL, 3% (5/182) underwent PCNL, and one patient required pyeloplasty due to obstruction at the pelviureteric junction. Details are provided in Table 2 and Figure 2.

Data from this cohort were compared with those from our recently published article [6], covering the period 2019/2020, to assess the impact of implementing routine eCT for suspected acute renal colic. Statistically significant differences were observed between the two periods regarding the proportion of patients receiving treatment, stent placement, and time to closure, as seen in Table 2. These findings are further elaborated in the discussion. Notably, patients in 2023/2024 underwent more treatments, received fewer stents, and achieved shorter times to closure. When excluding patients who were admitted for acute surgery within three days, we also observed a statistically significant difference in time to treatment, with the difference remaining in time to closure.

Among 194 patients initially assessed with stones measuring <4 mm, reassessment performed by a urologist identified 31 patients with stones measuring 4–5 mm and two patients with stones >5 mm. The discrepancy likely stems from differences in measurement methodology. In the study, assessment included measurements across three anatomical planes, whereas radiology reports typically relied on only one or two projections.

Of the 1,261 patients included in the study, 1,250 had clearly documented pain. In 11 cases, it remained uncertain whether the patient had experienced pain, typically due to conditions such as dementia or an ambiguous clinical presentation.

The diagnoses of patients having an eCT without symptomatic urolithiasis were reviewed and classified according to ICD-10-SE (International Classification of Diseases), Swedish version. ICD diagnosis was missing for nine patients. Half of the group, 52% (365/706), had a diagnosis from "Symptoms, signs and abnormal clinical and laboratory find-

Table 2. *Comparison between the two cohorts 2019/2020 and 2023/2024*

Variable	2019/2020	2023/2024	P-value
Numbers of patients with the diagnosis of urolithiasis	612*	546	
Numbers of ED visits (%)			
1	469 (76)	431 (79)	0.5
2	102 (17)	77 (14)	
>2	41 (7)	38 (7)	
Numbers of CT at the ED (%)			
0	295 (48)	0	<0.001
1	293 (48)	492 (90)	
2	19 (3)	49 (9)	
>2	5 (1)	5 (1)	
Hydronephrosis, yes/no (%)	Missing	370/176 (68/32)	
Stone location (%)			
Kidney	13 (4)	24 (5)	0.9
Upper ureter	121 (37)	209 (38)	
Lower ureter	190 (59)	313 (57)	
Stone size, max in mm, mean (SD)	5.5 (3.1)	5.5 (3.6)	
Stone size, max in mm, grouped (%)			
1–3 mm	81 (25)	161 (30)	
4–5 mm	116 (36)	197 (36)	
6–9 mm	98 (30)	142 (26)	
>9 mm	29 (9)	46 (8)	
Treatment, yes/no (%)	120/492 (20/80)	182/364 (33/67)	<0.001
Acute treatment, yes/ no (%)	19/101 (16/84)	39/143 (21/79)	0.2
Treatment (%)			
URS	68 (57)	117 (64)	**
ESWL	50 (42)	59 (32)	
PCNL	2 (1)	5 (3)	
Other (pyeloplastic)	0	1 (1)	
Stent (%)			
None	247 (76)	477 (87)	<0.001
JJ	62 (19)	20 (4)	
Nephrostomy	15 (5)	48 (9)	
Follow up (%)			
Completed	442 (72)	444 (81)	<0.001
No referral	75 (12)	59 (11)	
Patient absent	36 (6)	23 (4)	
No need ***	58 (10)	20 (4)	
Days to treatment, median (IQR)			
Total	33 (8–60)	21 (3–39)	0.005
URS	22 (2–53)	9 (2–40)	
ESWL	35 (23–72)	29 (16–36)	
PCNL	159****	64 (48–94)	
Days to closure, median (IQR)			
Total	34 (21–59)	27 (20–51)	<0.001
No treatment	34 (27–57)	26 (22–35)	
URS	34 (2–79)	19 (2–55)	
ESWL	112 (55–179)	71 (46–110)	
PCNL	225****	64 (48–94)	

* In 2019/2020, 612 patients were coded as urolithiasis but only 324 had a radiological proven stone on computed tomography (CT), the rest were considered having spontaneously passage of the stone.

**Statistical analysis was performed exclusively on ESWL and URS, as the number of PCNL and other treatment was insufficient for meaningful comparison.

***No need includes those who did an emergency CT without urolithiasis but were still given the diagnosis of urolithiasis 2019/2020, and patients residing outside the hospitals's geographic coverage.

****Delay due to patient preference and COVID pandemic

ED – Emergency Department; ESWL – extracorporeal shockwave lithotripsy; IQR – interquartile range; PCNL – percutaneous nephrolithotomy; URS – ureteroscopy

ings" most often, abdominal pain (R104). The second largest group, 34% (241/706), consisted of diagnoses from "Diseases of the genitourinary system". Details are provided in Figure 3.

DISCUSSION

In this retrospective observational study, we evaluated the implementation of eCT imaging for patients presenting with suspected acute renal colic. Only 43% of patients undergoing eCT for suspected acute renal colic were found to have symptomatic urolithiasis. When compared to the 2019/2020 cohort, the number of ED visits, as well as stone size, stone location, and treatment distribution, remained similar. However, in 2023/2024, we observed a higher rate of treatments, reduced use of ureteric stents, a higher rate of follow-up, and shorter time to both treatment and closure. To the best of our knowledge, this is the first publication to systematically assess emergency CT in acute renal colic and compare it with a cohort managed without routine eCT.

Our findings challenge the traditional approach stating that clinical presentation alone is adequate for diagnosing symptomatic ureteral stones, since only 43% of referred patients had urolithiasis confirmed on eCT. The 43% prevalence of confirmed urolithiasis in our cohort is somewhat lower than the 63% reported in a systematic review and meta-analysis by Dahm et al. [13]. However, more recent single-centre studies have shown lower rates, such as 50% reported by Anderson [14] and 54% by Aljawad [15]. It must be acknowledged that assessing the level of rigour applied in the evaluation of patients in the ED is challenging. There is a potential risk of excessive utilisation of eCT in patients presenting with abdominal or flank pain despite a low clinical suspicion of acute renal colic, which may be considered a methodological limitation.

According to current EAU guidelines [10], immediate imaging is recommended when there is diagnostic uncertainty, fever, or a solitary kidney. We propose that all patients presenting with suspected acute renal colic should be regarded as diagnostically uncertain and therefore qualify for immediate imaging with eCT.

A common argument against eCT is radiation exposure. However, 57% (715/1,261) of patients, the group with no symptomatic urolithiasis, were nonetheless exposed to the same radiation dose, and the use of eCT rather than deferred CT allowed for accurate

Table 3. *Treatment and time to treatment and closure when acute treatment (within 3 days) was removed*

Time to treatment and closure	2019/2020	2023/2024	P-value
Days to treatment, median (IQR)			
Total	37 (21–69)	30 (15–47)	0.010
URS	39 (13–66)	29 (9–58)	
ESWL	35 (23–72)	29 (16–36)	
PCNL	159	64 (48–94)	
Days to closure, median (IQR)			
Total	34 (23–60)	29 (22–55)	<0.001
No treatment	34 (27–57)	26 (22–35)	
URS	48 (30–90)	37 (16–78)	
ESWL	112 (55–179)	71 (46–110)	
PCNL	225	64 (48–94)	

ESWL – extracorporeal shockwave lithotripsy; IQR – interquartile range; PCNL – percutaneous nephrolithotomy; URS – ureteroscopy
Number of patients receiving acute treatment (2019/2020: n = 19; 2023/2024: n = 39).

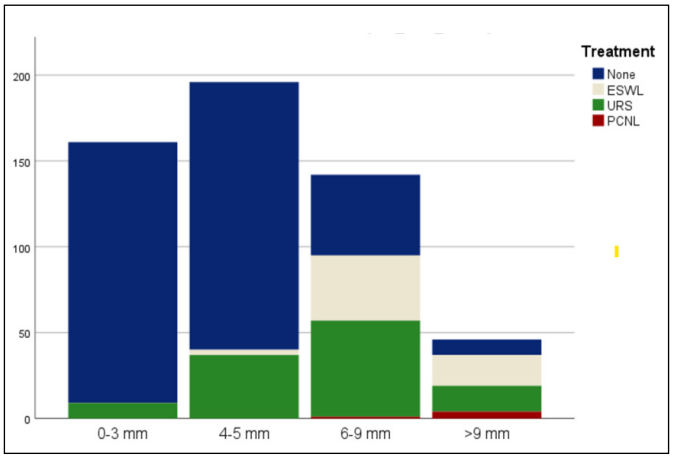

Figure 2. *Overview of number of treatments and the maximum size of the stone.*

ESWL – extracorporeal shockwave lithotripsy; PCNL – percutaneous nephrolithotomy; URS – ureteroscopy

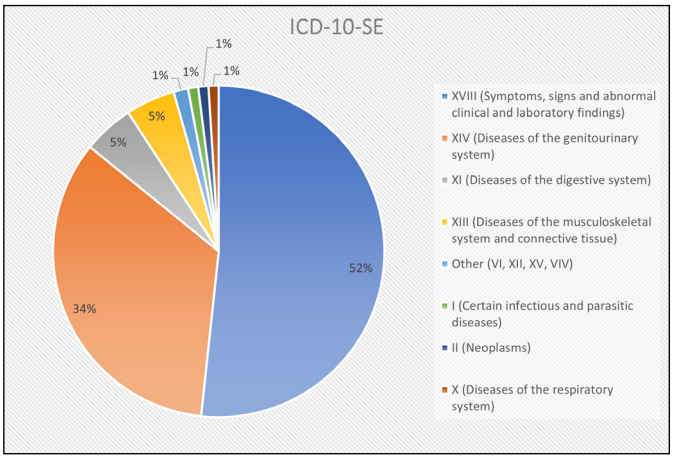

Figure 3. *Overview of ICD code in the group with no symptomatic urolithiasis.*

ICD – International Classification of Diseases

diagnosis and appropriate management. For stones that require treatment, particularly those measuring ≥6 mm, (treatment rates are approximately 67% for stones 6–9 mm and 80% for those >9 mm), eCT enables timely decision-making. The only subgroup that may derive limited benefit from eCT, is that of patients with small calculi, for whom treatment rates are considerably lower (in our dataset 6% for <4 mm and 20% for 4–5 mm). Further studies are warranted to establish optimal follow-up protocols for this patient group.

The fact that one fifth of patients without symptomatic urolithiasis were hospitalised, raise an important question: what other diagnoses are we missing by not performing eCT? Further analysis of this and timing of eCT within the current 24-hour window, will be evaluated and presented in a future publication.

Interestingly, fewer patients were diagnosed with urolithiasis in 2023/2024 (546) than in 2019/2020 (612), which is counterintuitive given the general increase in both ED visits and urolithiasis incidence nationally. According to data from the Swedish National Board of Health and Welfare, the number of patients diagnosed with urolithiasis increased by 6% from 2019 (26,127) to 2023 (27,603) [1]. Similarly, the number of ED visits in Helsingborg increased by 4% over the same period (from 64,263 to 66,540). Assuming a 5% increase of urolithiasis in the population, and basing calculations on the more reliable 2023/2024 data (with radiologically confirmed stones), the 2019/2020 cohort likely included approximately 520 true stone cases. This means that nearly 100 patients were misdiagnosed with urolithiasis in the earlier period. They may have been advised on lifestyle changes (excess intake of fluid and dietary restrictions) and evaluated for conditions such as hyperparathyroidism, gout and urinary infection, despite never having had urolithiasis. The observed increase in urolithiasis, seen both nationally and internationally, may be multifactorial, reflecting population growth, a rising prevalence of metabolic syndrome, demographic changes due to immigration and an increased use of CT. However, part of the increase might also be explained by overdiagnosis, as suggested by our data on patients who did not undergo eCT but were nevertheless considered as having stones.

One anticipated benefit from the implementation of eCT, was the potential to reduce return visits by enabling patients to manage their pain at home, with reassurance. However, our data do not support this hypothesis, as no significant difference was found in the rate of ED return visits for stone-related symptoms.

Comparing the number of CT examinations between the two periods presents some challenges. In 2023/2024, all patients underwent CT, while in 2019/2020, performing an eCT (43%) or planning a deferred CT (57%) was at the discretion of the ER physician. Despite these differences, stone characteristics (location and maximum size) and treatment distribution were largely consistent across cohorts, supporting the comparability of the two groups. However, one would have expected a lower proportion of smaller stones in the 2019/2020 cohort, considering the likelihood of spontaneous passage of smaller stones in the group with deferred CT. A trend towards more URS and less ESWL was observed in our cohort, in line with other reports [16–18], but this needs to be further evaluated in future studies.

Treatment rates were higher in 2023/2024 (182 vs 120, $p < 0.001$), raising concerns about overtreatment. The difference may partly reflect false positives and spontaneous stone passage in 2019/2020, but aligns with previous reports of increased intervention following immediate imaging [19]. In 2023/2024, 6% (9/161), of patients with stones measuring 1–3 mm underwent treatment, compared with 20% (40/197) in the 4–5 mm group, for details see Figure 2. In 2019/2020, the corresponding proportion were 5% (4/81) and 22% (26/116) respectively. However, there is an inherent difficulty in comparing these figures as the cohorts differ. In 2023/2024, we observed a lower proportion of patients requiring stents, 13%, compared with 24% in 2019/2020. Among those in need of stents, there has been a shift towards a higher use of nephrostomies and fewer JJ stents. We believe that the use of acute CT enables us to plan subsequent treatment more appropriately, in other words, to choose nephrostomy for larger proximal stones that may later require antegrade surgery. The increased proportion of acute URS may partly explain the reduced need for JJ stents. However, we also consider that acute imaging allows us to reserve the JJ stents for cases with impending obstructive uropathy, while for the remaining patients we can prioritise definitive treatment at an earlier stage when clinically indicated.

The significant reductions in time to treatment ($p = 0.01$) and time to closure ($p < 0.001$) are attributed entirely to the implementation of eCT, as no other major organisational changes were made. The implementation of eCT at our clinic was carried out in cooperation with the Departments of Emergency and Radiology. Both departments reported eCT as an efficient pathway that simplified patient care and reduced administrative burden.

A major strength of this study lies in its comprehensive evaluation of diagnostic accuracy in all pa-

tients presenting with suspected acute renal colic at a single-centre ED. Additionally, all CT examinations were systematically reviewed, and stone measurements reassessed using a consistent protocol. However, several limitations should be acknowledged. First, there are inherent limitations of a retrospective trial. Second, the comparison between 2019/2020 and 2023/2024 is challenged by non-equivalent diagnostic pathways, with the former including patients diagnosed clinically, with emergency or deferred imaging, while the latter relies on immediate CT confirmation. This limitation might be the most important one to have in mind when we compare the two cohorts. Third, the study was conducted at a single centre, which may limit generalisability. Fourth, it would have been valuable to know the exact timing of eCT within the 24-hour window, that is, whether the stone had already passed in patients undergoing eCT closer to the 24-hour mark. Finally, the study did not explore the accuracy of alternative diagnoses, cost-effectiveness or patient-centred outcomes such as symptom relief or satisfaction.

CONCLUSIONS

In conclusion, the implementation of eCT has improved diagnostic accuracy and reduced time to both treatment and closure, although a risk of overtreatment of smaller stones remains. Given its benefits, we recommend eCT as a routine procedure in the management of acute renal colic. Future studies including eCT should focus on optimising management strategies and follow-up for small stones, as well as evaluating cost implications, and long-term clinical and patient-reported outcomes.

CONFLICT OF INTERESTS

The authors declare no conflict of interest.

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ETHICS APPROVAL STATEMENT

The study was approved by the Swedish Board of Ethics (EPN 2024-01345-01 Stockholm).

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