Research Article / Araştırma Makalesi

Optimising Imaging Strategies in Suspected Urolithiasis: Effects on Diagnostic and Therapeutic Timelines

Şüpheli Ürolitiazis Vakalarında Görüntüleme Stratejilerinin Optimize Edilmesi: Tanı ve Tedavi Süreçlerine Etkisi

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Abstract

Background: Prompt imaging is essential in the diagnosis and management of urinary stone disease. While international guidelines recommend ultrasonography (US) as the first-line modality due to its safety and accessibility, delays in imaging and treatment are common in overcrowded healthcare systems. This study aimed to compare the clinical timelines and outcomes of patients undergoing initial US versus direct non-contrast computed tomography (NCCT).
Materials and Methods: This retrospective study included 120 adult patients who presented to the urology department of a tertiary care hospital in Türkiye with suspected urinary stone disease. Patients were categorised based on their initial imaging modality. Time intervals from admission to imaging and from admission to definitive treatment were recorded. Treatment rates and return visits were also evaluated. Logistic regression and receiver operating characteristic (ROC) analyses were performed to identify predictors of treatment.
Results: The median time to initial imaging and to definitive treatment was significantly shorter in patients who underwent direct NCCT compared to those who underwent initial US (4 vs. 10 days and 15 vs. 33.5 days, respectively; $p < 0.001$ for both). Multivariate analysis showed that longer imaging delays were independently associated with reduced odds of receiving treatment (OR: 0.859; 95% CI: 0.770–0.958; $p = 0.006$). ROC analysis demonstrated moderate predictive performance (AUC = 0.658).
Conclusions: In resource-limited, high-volume settings, US may lead to diagnostic and therapeutic delays despite guideline recommendations. Direct low-dose NCCT may offer a more efficient alternative without significantly increasing radiation exposure or cost. Imaging strategies should be tailored to local healthcare realities to ensure timely management of stone disease.

Keywords: Computed Tomography, Diagnostic Imaging, Ultrasonography, Urolithiasis

Öz

Amaç: Üriner sistem taş hastalığının tanı ve tedavisinde hızlı görüntüleme büyük önem taşımaktadır. Uluslararası kılavuzlar, güvenliği ve erişilebilirliği nedeniyle ilk basamak görüntüleme yöntemi olarak ultrasonografiyi (USG) önermektedir. Ancak, özellikle yoğun sağlık sistemlerinde görüntüleme ve tedavi süreçlerinde gecikmeler sıkça yaşanmaktadır. Bu çalışmanın amacı, ilk görüntüleme yöntemi olarak USG ile doğrudan kontrastsız bilgisayarlı tomografi (NCCT) uygulanan hastaların klinik zaman çizelgelerini ve sonuçlarını karşılaştırmaktır.
Materyal ve Metod: Bu retrospektif çalışmaya, Türkiye'de bir üçüncü basamak hastanenin üroloji bölümüne üriner sistem taşı şüphesiyle başvuran 120 erişkin hasta dahil edildi. Hastalar, ilk uygulanan görüntüleme yöntemine göre gruplandırıldı. Başvuru ile görüntüleme ve kesin tedavi arasındaki süreler kaydedildi. Tedavi oranları ve tekrar başvuru sıklıkları değerlendirildi. Tedaviyi öngören değişkenleri belirlemek amacıyla lojistik regresyon ve ROC analizleri uygulandı.
Bulgular: İlk görüntüleme olarak doğrudan NCCT uygulanan hastalarda, USG yapılanlara kıyasla görüntüleme ve kesin tedaviye ulaşma sürelerinin anlamlı derecede daha kısa olduğu belirlendi (sırasıyla 4 vs. 10 gün ve 15 vs. 33.5 gün; her ikisi için $p < 0.001$). Çok değişkenli analizde, görüntülemede yaşanan gecikmelerin tedavi alma olasılığını bağımsız olarak azalttığı görüldü (OR: 0.859; %95 GA: 0.770–0.958; $p = 0.006$). ROC analizi, orta düzeyde öngörü performansı gösterdi (AUC = 0.658).
Sonuç: Kaynakların sınırlı olduğu ve hasta yoğunluğunun yüksek olduğu sağlık sistemlerinde, kılavuzlara rağmen USG tanı ve tedavide gecikmelere yol açabilir. Düşük doz NCCT, radyasyon maruziyetini veya maliyeti önemli ölçüde artırmadan daha verimli bir alternatif sunabilir. Taş hastalığının zamanında yönetimi için görüntüleme stratejileri yerel sağlık sistemi koşullarına göre uyarlanmalıdır.

Anahtar Kelimeler: Bilgisayarlı Tomografi, Ultrasonografi, Ürolitiazis, Tanısal Görüntüleme

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Introduction

Urolithiasis is a highly prevalent condition worldwide and remains a significant contributor to morbidity and healthcare burden, particularly in industrialised nations (1). Its lifetime prevalence ranges from 2% to 20%, with higher rates reported in geographical regions characterised by hot climates, dietary risk factors, and limited fluid intake (2–4). Clinically, the most common presentation is acute flank pain, often due to renal colic, which constitutes a substantial proportion of hospital visits related to urological complaints (3,5). Prompt and accurate diagnosis of urinary stone disease is essential not only for effective symptom control, but also for timely initiation of appropriate therapeutic interventions and the prevention of complications such as obstruction, infection, or renal function deterioration (6,7). Imaging plays a pivotal role in the evaluation of suspected urinary stone disease, guiding both diagnostic confirmation and subsequent management decisions (8). Ultrasonography (US), due to its non-invasiveness, absence of ionising radiation, and relatively low cost, is recommended by international guidelines as the initial imaging modality (9). However, despite its advantages, US has notable limitations, including operator dependency and reduced sensitivity for detecting small, radiolucent, or ureteric stones, especially in patients with high body mass index or overlying bowel gas (10). Non-contrast computed tomography (NCCT), on the other hand, is widely recognised as the gold standard imaging technique in urolithiasis, owing to its superior sensitivity and specificity, rapid acquisition time, and ability to detect alternative diagnoses (11,12). In clinical practice, even when US is performed initially, many patients ultimately undergo NCCT to confirm the diagnosis or to plan interventional procedures such as extracorporeal shock wave lithotripsy (ESWL) or endoscopic stone removal (9).

While clinical guidelines advocate US as the first-line imaging modality (9), real-world implementation is often constrained by systemic limitations, particularly in high-volume public healthcare settings. In countries like Türkiye, where public hospitals face significant patient load, access to timely US is frequently delayed due to appointment backlogs and limited radiology resources (13). Consequently, the diagnostic process may be prolonged, and definitive management postponed, especially in cases where US is non-diagnostic and further imaging such as non-contrast CT becomes necessary. These delays not only risk clinical deterioration but may also lead to patient dissatisfaction, loss to follow-up, or treatment being sought at other institutions, thus fragmenting care. Therefore, in practice, the reliance on US as the initial imaging tool, although theoretically justified, may paradoxically contribute to inefficiency in diagnosis and management under certain healthcare conditions.

In light of the aforementioned challenges, a more pragmatic evaluation of imaging pathways in urinary stone disease is warranted, particularly in resource-constrained or high-volume healthcare systems. This study aimed to compare the time to imaging, time to treatment, and treatment rates between patients who initially underwent US versus those who received direct NCCT. Furthermore, we sought to determine whether diagnostic delays influenced the likelihood of patients receiving definitive treatment within the same institution. Through this approach, we aimed to provide practical insight into how imaging strategy may affect the efficiency of care and clinical outcomes in high-volume urological settings.

Materials and Methods

This study was designed as a retrospective observational analysis conducted at a tertiary-care university hospital. The study period covered consecutive patients presenting to the urology department between March 2023 and September 2023 with symptoms suggestive of urinary stone disease. The study was conducted in accordance with the Declaration of Helsinki and ethical approval was obtained from the local ethics committee of Izmir Katip Celebi University (Date: 15.05.2025; Decision number: 0251). This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

The study population consisted of adult patients (aged 18 years and above) who presented to the urology department with symptoms suggestive of renal colic. Eligible patients were required to report one or more of the following typical symptoms: acute onset of flank pain, lower abdominal pain radiating to the groin, gross or microscopic haematuria, nausea, or vomiting. Only those who underwent radiological imaging specifically for the evaluation of suspected urinary stone disease were included. Patients were also required to have complete electronic medical records available, including precise documentation of symptom onset, imaging request and completion dates, and treatment history, if applicable.

Patients were excluded if they were younger than 18 years, were pregnant, had a known history of urinary tract malignancy or congenital urinary tract anomalies, or had prior imaging-confirmed urolithiasis. Additional exclusion criteria included incomplete medical records or missing imaging dates, and patients for whom no diagnostic imaging was ordered at the time of initial presentation.

A total of 60 patients from each of the US-only and direct NCCT groups were included in the final comparison. In addition, patients in the US group who subsequently underwent NCCT were evaluated separately to assess the impact of delayed imaging on treatment outcomes. The choice of initial imaging modality (US or NCCT) was primarily determined by the treating physician's clinical judgement, patient presentation, and imaging availability at the time of admission. In some cases, patient preference and logistical factors (e.g. waiting time for USG) also influenced the decision.

Data were retrieved retrospectively from the hospital's electronic health records. For each eligible patient, the following variables were recorded: age, sex, date of urology department admission, type and timing of the first imaging modality performed, and whether further imaging (i.e., non-contrast computed tomography) was subsequently requested. The interval from the initial presentation to the completion of the first imaging was calculated in days. The definitive treatment status—defined as having undergone either extracorporeal shock wave lithotripsy (ESWL) or surgical intervention—was recorded, along with the time elapsed between presentation and treatment. Additionally, whether the patient re-presented to the emergency department before treatment was also noted, as an indicator of potential delays or inadequate symptom control.

All statistical analyses were conducted using Jamovi software (version 2.6). Descriptive statistics were used to summarise demographic and clinical variables. Continuous variables were assessed for normality using the Shapiro–Wilk test. For normally distributed data, comparisons between groups were performed using the independent samples t-test, while non-normally distributed data were analysed using the Mann–Whitney U test. Categorical variables were compared using the chi-square test.

To evaluate the relationship between the time from admission to imaging interval and the likelihood of receiving definitive treatment, a binomial logistic regression model was constructed. The dependent variable was the presence or absence of ESWL or surgical intervention, and the independent variable was the number of days from initial presentation to imaging. Statistical significance was set at $p < 0.05$.

Results

A total of 120 patients were included in the final analysis, comprising 68 males and 52 females, with a mean age of 50.39±19.08 years. Based on the initial imaging modality performed, patients were divided into three groups: 30 patients (25.0%) underwent US only, 27 patients (22.5%) underwent US followed by NCCT, and 63 patients (52.5%) underwent direct NCCT. The clinical and demographic characteristics of the patients are presented in Table 1.

The median time to both initial imaging and definitive treatment was significantly shorter in patients who underwent direct NCCT compared to those who were initially evaluated with US ($p < 0.001$ for both comparisons; Mann–Whitney U test). The corresponding statistical data are presented in Table 2. Figure 1 illustrates the interval from admission to treatment according to imaging modality.

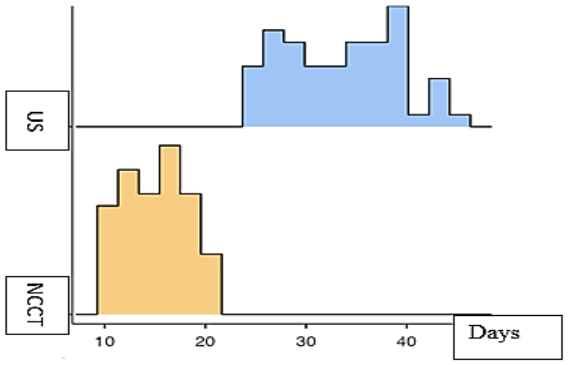

Figure 1. Treatment timelines by initial imaging modality
US: Patients who underwent ultrasonography as the sole imaging modality. NCCT: Patients who underwent non-contrast computed tomography as the initial imaging modality

Table 1. Clinical and Demographic characteristics of the study population

Characteristic	US only (n=30)	US + NCCT (n=27)	Direct NCCT (n=63)	Total (n=120)
Age, years – mean ± SD	49.2 ± 18.9	52.1 ± 19.5	50.7 ± 18.8	50.39 ± 19.08
Sex, n (%)				
Male	17 (56.7%)	15 (55.6%)	36 (57.1%)	68 (56.7%)
Female	13 (43.3%)	12 (44.4%)	27 (42.9%)	52 (43.3%)

US only: Patients who underwent ultrasonography as the sole imaging modality; US + NCCT: Patients who initially underwent ultrasonography followed by non-contrast computed tomography; Direct NCCT: Patients who underwent non-contrast computed tomography as the initial imaging modality.

Treatment was not performed in any of the patients who underwent US alone. In contrast, 66.7% of patients who underwent US followed by NCCT and 65.1% of those who underwent direct NCCT received definitive treatment in the form of extracorporeal shock wave lithotripsy or surgical intervention.

No statistically significant positive correlation was identified between the interval from admission to treatment and the number of emergency department visits during this interval ($p = 0.502$; Mann–Whitney U test).

Binomial logistic regression analysis was performed to evaluate whether the admission to imaging interval influenced the likelihood of receiving definitive treatment. The model revealed that a longer delay in imaging was significantly associated with a reduced probability of undergoing treatment. Each additional day in time to imaging was associated with a 14.1% decrease in the odds of receiving definitive treatment (odds ratio [OR]: 0.859; 95% confidence interval [CI]: 0.770–0.958; $p = 0.006$). The Nagelkerke R^2 value for the model was 0.066, indicating modest explanatory power. Receiver operating characteristic (ROC) analysis demonstrated that the time to imaging had moderate discriminative ability in predicting treatment status, with an area under the curve (AUC) of 0.658. The corresponding statistical data are presented in Table 3 and Figure 2.

Table 2. Comparison of Time to Initial Imaging and Time to Treatment Between US and Direct NCCT Groups

Imaging	N	MT to Imaging	IQR Imaging	MT to Treatment	IQR to Treatment
US	60	10 days	8-12 days	33.5 days	28-39 days
NCCT	60	4 days	3-6 days	15 days	12.8-17.3 days
***p* value**		**<0.001**		**<0.001**	

Comparison of time intervals to initial imaging and treatment between US and NCCT groups. Medians are presented with interquartile ranges. p-values were calculated using the Mann–Whitney U test; MT:Median time, IQR: Interquartile range; US: Patients who underwent ultrasonography as the sole imaging modality. NCCT: Patients who underwent non-contrast computed tomography as the initial imaging modality.

Table 3. Logistic Regression Analysis

Predictor	OR	95% CI	*p* value
Time to imaging(day)	0.85	0.77-0.95	0.006

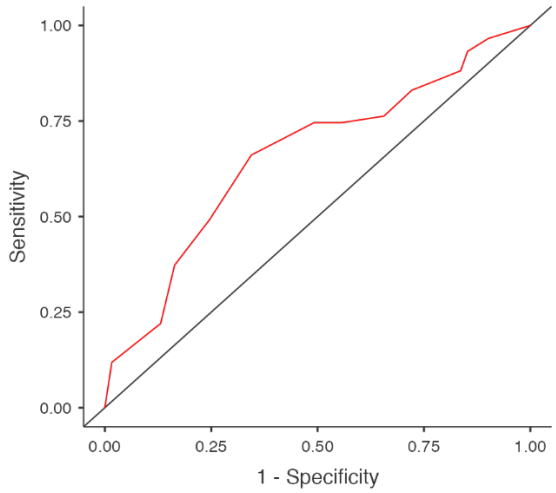

Figure 2. ROC curve demonstrating the predictive performance of time to initial imaging in relation to definitive treatment status

Discussion

This study demonstrated that the choice of initial imaging modality in patients presenting to the urology department with suspected urinary stone disease significantly influenced the timeliness of diagnosis and subsequent treatment. Specifically, patients who underwent direct NCCT reached both imaging and definitive intervention in a significantly shorter time compared to those who were initially evaluated with US. Moreover, multivariate analysis revealed that delays in imaging were independently associated with a reduced likelihood of receiving definitive treatment. These findings underscore the potential clinical consequences of imaging delays and highlight the importance of optimising diagnostic pathways in high-volume healthcare systems.

International guidelines recommend US as the first-line imaging modality in patients with suspected urolithiasis due to its non-invasiveness, low cost, and lack of ionising radiation (9). In particular, the landmark multicentre randomised controlled trial by Smith-Bindman et al., found that initiating evaluation with US resulted in lower cumulative radiation exposure without significant differences in adverse events, hospitalisations, or diagnostic accuracy compared to computed tomography (CT) (14).

However, these findings may not fully reflect the logistical realities in countries like Türkiye, where tertiary-level public hospitals experience significant patient overcrowding and limited imaging resources. In such settings, access to timely US is often delayed due to high demand and radiologist workload. As a result, although theoretically advantageous, US may paradoxically prolong the diagnostic process and defer definitive treatment. In contrast, NCCT, particularly when performed using a low-dose stone protocol, offers both high diagnostic accuracy and a lower radiation burden compared to standard CT, mitigating one of its traditional disadvantages (15).

From an economic perspective, current national reimbursement rates indicate that renal US is reimbursed at approximately 51.24 TL, whereas non-contrast CT of the abdomen costs 131.45 TL under the Social Security Institution (SGK) tariff (based on 2023 reimbursement rates published by the Turkish Social Security Institution). Although CT appears costlier on the surface, it may reduce the need for repeat or sequential imaging and expedite treatment, potentially lowering overall costs by shortening hospital stays and preventing recurrent emergency visits (16).

Our multivariate analysis demonstrated that delays in diagnostic imaging were independently associated with a reduced likelihood of receiving definitive treatment. Specifically, each additional day between presentation and imaging corresponded to a 14.1% decrease in the odds of undergoing ESWL or surgical intervention. This finding highlights the clinical impact of procedural delays beyond mere inconvenience, suggesting that extended diagnostic timelines may lead to treatment attrition—possibly due to patients seeking care elsewhere, experiencing symptom resolution, or becoming lost to follow-up.

Interestingly, while longer delays were expected to increase the likelihood of return visits to the urology department, our analysis did not find a statistically significant correlation between imaging delay and emergency re-presentations. This may reflect a subgroup of patients whose pain resolved spontaneously during the waiting period, resulting in perceived improvement and disengagement from follow-up. However, the absence of acute symptoms does not preclude the risk of silent stone progression or long-term renal impairment in untreated cases, underscoring the importance of timely diagnosis even in clinically quiescent patients (17).

One of the principal strengths of this study lies in its focus on real-world clinical data obtained from a high-volume tertiary care centre in Türkiye, reflecting the operational challenges and diagnostic delays commonly encountered in routine practice. Unlike many previous studies that rely on idealised conditions or prospective protocols, our retrospective analysis captures the natural course of patient management in a system under pressure, thereby enhancing the external validity of our findings.

Additionally, the study design allowed for a balanced comparison between US and direct NCCT by analysing equal-sized groups, which minimised group imbalance and selection bias. The integration of both descriptive and advanced statistical analyses—including multivariate logistic regression and receiver operating characteristic (ROC) curve analysis—provided a multifaceted assessment of the relationship between diagnostic delay and treatment outcomes. These aspects together contribute to a more comprehensive understanding of how systemic workflow inefficiencies may influence the quality and timeliness of care in patients with suspected urinary stone disease.

This study has several limitations. First, its retrospective design inherently limits the ability to establish causality and is subject to potential documentation bias. The reliance on electronic health records may also have introduced variability in data quality, particularly regarding symptom onset and follow-up compliance. Second, the study was conducted in a single tertiary centre, which may limit the generalisability of the findings to other healthcare settings with different referral patterns or imaging capacities. Another important limitation is the potential cumulative radiation exposure associated with repeated low-dose NCCT, particularly in younger or recurrent stone formers. While low-dose protocols reduce individual scan exposure, repeated imaging over time may still pose long-term risks, which should be considered when planning follow-up strategies.

Furthermore, clinical decision-making regarding imaging choice may have been influenced by physician preference or patient factors not captured in the dataset, such as pain severity or prior imaging history. Additionally, the study did not evaluate long-term outcomes such as stone recurrence or renal function deterioration, which may have provided further insights into the consequences of delayed diagnosis. Lastly, although the logistic regression model identified a statistically significant association, the overall predictive power of the model was modest, as reflected by the Nagelkerke R^2 and AUC values.

Conclusion

This study highlights that initial imaging with US, while favoured in clinical guidelines due to its safety and accessibility, may inadvertently contribute to delays in diagnosis and definitive treatment in settings where imaging resources are limited and patient volume is high. Our findings suggest that in such environments, especially within the context of tertiary care centres in Türkiye, direct low-dose NCCT may offer a more efficient diagnostic alternative, facilitating timely intervention without substantially increasing radiation burden or healthcare costs. Future clinical pathways and health policy decisions should consider the balance between diagnostic safety and accessibility, particularly in overburdened systems where delays may translate into diminished patient outcomes.

Ethical Approval: *Ethical approval for this retrospective study was obtained from the local ethics committee of Izmir Katip Celebi University (Date: 15.05.2025; Decision number: 0251).This study was conducted in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki Declaration and its later amendments.*

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