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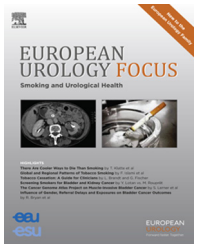

Review – Stone Disease

Imaging for Urinary Stones: Update in 2015

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Abstract

Context: Imaging is essential for the diagnosis and the clinical decision-making process of patients with urinary stones.
Objective: To assess the benefits and limitations of various imaging techniques by specifically focusing on different phases of stone patients' management.
Evidence acquisition: PubMed and Web of Science databases were used to identify studies published in the last 10 yr on this argument. Search terms included 'urolithiasis', nephrolithiasis', or 'urinary stones' in combination (AND) with the terms 'imaging', 'computer tomography', 'ultrasonography', 'intravenous pyelogram', or 'radiation exposure'. Study selection was based on an independent peer-review process of all the authors after the structured data search.
Evidence synthesis: Noncontrast-enhanced computer tomography (CT) provides the highest value of diagnostic accuracy for urinary stones. Stone composition can be specifically assessed through the use of dual-energy CT. When information about the anatomy of the renal collecting system is required or alternative pathologies are suspected, CT with contrast injection is recommended. Low-dose protocols allowed a drastic reduction of the effective dose administered to the patient, thus limiting the biological risk due to ionising radiations. Other strategies to contain the radiation exposure include the dual-split bolus dual energy CT and the adaptive statistical image reconstruction. Abdomen ultrasound may be a valid alternative as an initial approach since it does not change the outcome of patients compared with CT, and should be the imaging of choice in children and pregnant women.
Conclusions: Noncontrast-enhanced CT is the most accurate imaging technique to identify urinary stones. Abdomen ultrasound seems to be a valid alternative in the initial evaluation of urinary colic. New low-dose protocols and strategies have been developed to contain radiation exposure, which is a major issue especially in specific circumstances.
Patient summary: Noncontrast-enhanced computer tomography has been increasingly used for the diagnosis and management of urinary stones. Low-dose protocols as well as alternative imaging should be considered by clinicians in specific circumstances to minimise radiation exposure.

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1. Introduction

Over the last decades the prevalence of urinary stone disease has been dramatically increasing as a consequence of diet changes and lifestyle factors in western countries, growing up to 10.6% and 7.1% among men and women in the USA, respectively [1]. Similarly, the incidence of emergency department visits for acute flank pain increased from 289 to 306/100,000 individuals between 2006 and 2009, leading hospital charges to rise at 5 billion dollars per year [2]. In this context, imaging is the essential component to achieve a definitive diagnosis and guide the clinical-decision making process. Nowadays, plenty of different imaging modalities are available for the evaluation of patients with urolithiasis, with specific pros and cons related to costs, radiation exposure, and diagnostic accuracy of each technique. Noncontrast-enhanced computer tomography (NCCT) has become the standard for diagnosis of urinary stones and has replaced kidney-ureter-bladder (KUB) radiography and intravenous pyelography (IVP), since it guarantees a sensitivity and specificity of 98–100% and it can identify extraurological causes of flank pain in about 10–30% of patients [3–6]. In addition, it does not need injection of a medium contrast and time to perform the study is very short (<5 min). However, the real benefit of using CT as an initial diagnostic evaluation for suspected nephrolithiasis rather than abdomen ultrasonography (US) is still under debate [7] and radiation exposure really represents a major concern, especially in some categories of patients, such as pregnant women, children, and stone formers who are likely to require repeated diagnostic tests over time. For these reasons, various CT protocols such as low-dose unenhanced CT and dual-energy CT (DECT) have been developed in order to contain effective doses administered without compromising diagnostic accuracy and to characterise stone composition [8,9]. The aim of the current review is to report various imaging modalities currently adopted to investigate urinary stone patients, the underlying benefit and limitations of each technique, while discussing new protocols and methods recently introduced in the diagnostic making process to implement treatment planning and monitoring treatment success.

2. Evidence acquisition

Data for this review were identified through a search of PubMed and Web of Science, including studies published in the last 10 yr (2005–2015) in core clinical journals in English. Search terms included 'urolithiasis', nephrolithiasis' or 'urinary stones' in combination (AND) with the terms 'imaging', 'computer tomography', 'ultrasonography, 'intravenous pyelogram', or 'radiation exposure'. Study selection was based on an independent peer-review process of all the authors after the structured data search. Population-based, prospective study, cross-sectional analysis of national survey data as well as prior reviews of literature and pilot studies have been included and selected to form the body of evidence synthesis. The list of articles has been implemented by significant manuscripts not previously found in this search or outside the time period of the initial search and identified from an extensive cross-check of the references of selected articles and prior reviews.

3. Evidence synthesis

3.1. Stone detection

3.1.1. Computed tomography

The use of NCCT in the diagnostic process of urolithiasis was initially reported in the late 1970s just for the evaluation of radiolucent stones [10,11]. Nowadays, CT is recommended as the first line investigation for any kind of urinary stones in the USA, with an increase in the utilisation of CT to assess patients with flank pain from 4–21% to 42.5–71% according to the different reports over 10 yr [12,13] and a significant reduction in the use of US (from 5–2.4%) and X-rays (from 48–17%) in the same period [12,13].

The widespread use of CT scans in this field lies in the proven superiority of CT compared with other imaging modalities, in terms of higher diagnostic accuracy, faster imaging acquisition by nonmedical personnel, and shorter evaluation time, and in the increasing availability of scanners in the emergency departments [14–19]. Moreover, CT can reveal indirect signs of urolithiasis, such as hydronephrosis, periureteric, perirenal oedema, impaired renal function when medium contrast is injected and a delay in nephrographic and excretory phase is observed, and detects alternative causes of acute flank/abdominal pain [6,20].

The main concern about the indiscriminate use of CT scans for urolithiasis is the biological risk linked to radiation exposure, which is increased by 600% over the last 3 decades per each individual as a direct consequence of this trend [21]. This is of particular relevance for young recurrent stone formers, who have an even more higher likelihood of needing many CT during their lifetime, with higher cumulative effective doses compared with patients with a single episode of nephrolitihiasis [22], and for men with a high body mass index (BMI) (30 kg/m^2), whose effective dose absorbed during CT is more than threefold higher than nonobese patients (24 kg/m^2) [23]. The correlation between ionising radiation and the risk of malignancies seems to be unquestionable, although no-large scale epidemiologic studies have been conducted and all the information on this argument come from reports on survivors of the atomic bomb detonations in Japan in 1945 [24] and risk models based on the National Research Council's 'Biological Effects of Ionising Radiation' report and organ-specific radiation doses derived from a national survey estimated that approximately 29,000 future cancer cases could be related to CT scans performed in the USA in 2007 [25]. Moreover, the linear no-threshold model, which is widely accepted and stated that x-radiation damage is cumulative and that there is no threshold below which ionising radiations are not harmful, lead to consider the age of exposure as a major predictor of radiation-induced malignancies over time [26,27], and this is of dramatic importance since the greatest increase of emergency department visits for

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