Value of Kidney-Ureter-Bladder Radiography in the Erect Position in Addition to Standard Intravenous Urography Examination

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Key Words

Intravenous urography · Kidney-ureter-bladder radiography · Nephroptosis

Abstract

Objectives: To determine if additional kidney-ureter-bladder radiography in the erect position can improve the diagnostic yield of standard intravenous urography (IVU) examination. **Subjects and Methods:** This prospective study was conducted from March to July 2007 on 108 consecutive patients (65 males and 43 females, age ranging from 20 to 50 years) who were referred to the Department of Radiology, Al-Amiri Hospital, Kuwait, for IVU examinations. After 15 min, a film was done in the erect position in addition to the routine IVU protocol. **Results:** Additional information was demonstrated in the erect radiograph as follows: detecting nephroptosis in 18 (17%) patients, improved visualization of the ureters in 58 (54%) patients, and differentiation between phleboliths and ureteric stone was possible in 12 (11%) patients. **Conclusions:** Our study demonstrated significant additional findings in the erect position (at 15 min) compared to the supine position.

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Introduction

Intravenous urography (IVU), which allows visualization of the renal collecting system and urinary tract region, is a commonly performed radiological investigation since the 1930s [1]. The common indications for performing IVU include hematuria, pre- or post-therapeutic evaluation of renal stone disease, chronic infections, tumor, trauma and malformations of the urinary tract [1–4]. Details of the standard film sequence during the IVU imaging modality have been reported with optional images associated with each sequence [1, 5]. The imaging sequence, as shown in table 1, is routinely used to take advantage of the time of maximum opacification of the various parts of the urinary tract [5]. Like any other imaging modality, IVU imaging should ideally be tailored and additional projections might be applied to answer a specific clinical question [6], to obtain the maximum information needed without having to perform an additional radiological procedure, thereby maximizing the diagnostic yield. Upright (erect) films, although occasionally obtained to compare the findings with the supine kidney-ureter-bladder (KUB) image(s), are not routinely performed in a standard IVU examination.

Fig. 1. Nephroptosis not seen in the right kidney in the supine radiograph (a) but visualized on the erect radiograph (b).

Fig. 2. Better opacification of the lower pole calyces on the right side; not as well seen in the supine radiograph (a) as compared to the erect radiograph (b). This patient had an obstructed kidney due to right pelviureteric junction calculus.

Table 1. Routine imaging sequence for performing IVU examination including the additional (erect) position (No. 6)

Film No.	Type of film
1	Preliminary (scout) film
2	Immediate film (0 min)
3	KUB film (5 min)
4	KUB film with binder (10 min)
5	KUB film (supine 15 min)
6	KUB film (erect 15 min)
7	Full bladder film (20 min)
8	Postvoid film

Few case reports have been done using the erect position for IVU [7, 8]. Hence, this study was performed to determine if additional KUB radiography in the erect position can improve the diagnostic yield of standard IVU examination.

Subjects and Methods

This prospective study was conducted on 108 consecutive patients (65 males, 43 females, age range 20–50 years) who were referred to the Department of Radiology, Al-Amiri Hospital, Kuwait, for IVU examinations from March to July 2007. The clinical indication for performing the study included pyelonephritis (1 patient), pain or stone or hydronephrosis (92 patients), hema-

turia (7 patients), and dysuria or renal cyst (8 patients). After 15 min, a film was done in the erect position in addition to the routine protocol as shown in table 1, using Polydoros (Siemens system), with the exposure factors of 75 kVp, 25 mAs and a source image distance of 100 cm. Delayed images (up to 3 h) were taken as required to demonstrate the site of ureteric obstruction [9].

Using a picture archiving and communication system (Agfa Impax 4.5; Agfa Healthcare, Belgium), two qualified radiologists (R.A. and C.Y.) independently evaluated the images. One radiologist (R.A.) viewed the routine IVU study and the other (C.Y.) viewed the study with the additional 15-min erect radiograph. The results were recorded in evaluation forms with attention given to the following points: presence of nephroptosis (defined as an abnormal movement of the kidney of more than 5 cm or two vertebral bodies between the two radiographs) (fig. 1); improvement in the visualization of the calyces (fig. 2) and the ureters (fig. 3), and the ability to differentiate phleboliths from ureteric calculi (fig. 4). The picture archiving and communication system operation for image retrievals, collection of the forms and data entry was independently performed to eliminate any bias. The studies were finally reviewed by both radiologists to confirm the findings observed on the erect KUB film. Any disagreement in the findings was resolved by consensus.

To calculate additional radiation burden to the patient due to the additional (erect position) view, the MonteCarlo software program was used to measure the effective dose (in mSv). Measurements were obtained using the exposure factors and entrance skin dose. The entrance skin dose was measured by standard geometry procedures using the noninvasive evaluation of radiation output system.

We used the χ^2 test to calculate the significant association between two categorical variables.

Fig. 3. The left lower ureter and the right mid ureter are not well seen on the supine radiograph (a) but seen on the erect radiograph (b). This patient had a partially obstructing calculus in the left pelviureteric junction.

Fig. 4. Phleboliths (opacities seen adjacent the left ischial spine) are not differentiated from ureteric stones in the supine radiograph (a), but the location outside the ureter is clearly demonstrated on the erect radiograph (b).

Results

Our analysis (χ^2 test) revealed that the erect radiograph was useful in detecting nephroptosis in 18 (17%) patients ($p < 0.05$), and improved visualization of the calyces and the ureters in 65 (60.2%) patients. Of these 65 patients, 58 (89.2%) showed improved visualization of the ureters and 7 (10.8%) of the calyces. Differentiation between phleboliths and ureteric stone was possible in 12 (11%) patients ($p > 0.05$) (table 2). The calculated effective dose for the whole examination including erect position was 5.87 mSv compared to 5.13 mSv for the standard IVU examination, hence the additional radiation burden to the patient was 0.74 mSv.

Discussion

IVU examination is an essential diagnostic tool in the evaluation of the urinary system. Using IVU in conjunction with other imaging modalities, like ultrasound and computed tomography, increases the accuracy of both diagnostic tests and surgical planning decisions [2]. The information gathered is used as a guidance in further treatment plan for the patient.

Although there are no definite studies that show the usefulness of the erect radiograph in an IVU series, there are however case reports that suggested that without per-

Table 2. Additional findings noted on erect radiographs that were not seen in the routine IVU study

	Unilateral	Bilateral	Total number of patients
Nephroptosis	12	6	18
Better visualization and filling of calyx	6	1	7
Better visualization and filling of ureters	38	20	58
Diff. between phleboliths/stone	12	0	12

forming the erect film, some findings would be missed and hence affect patient management [7, 8]. The erect radiograph has the advantage of adequately filling and therefore opacifying the calyces and the ureters. Visualization of the ureters helps to differentiate ureteric calculi from other pelvic opacities and in addition aids in diagnosing the nonobstructing lesions of the ureter. Similarly calyceal lesions like clots, tumors and lucent stones are easily identified when the calyces are full. Therefore, erect positioning makes differentiation easier by modifying superpositioning of different structures. In our study, the erect film improved the visualization of the ureters in 53.7%, which made it possible to differentiate between phleboliths and calculi in 11%. The opacification of the distal ureter and visualization of the course of the ureter

in relation to a suspected opacity in the pelvis establishes the diagnosis on erect films when adequate demonstration of the lower ureters was not obtained on the standard views. The calyces were satisfactorily seen in 6.5% of patients.

Acute conditions in a ptosed kidney can simulate some nonrenal conditions like acute appendicitis or other obstetric and gynecological pathologies [10]. Hence it is important to recognize this condition. Renal movement to diagnose nephroptosis can only be assessed by obtaining a radiograph in the erect position in addition to the supine film [11]. In our study, nephroptosis was observed in 17% of cases.

Finally the additional amount of added radiation burden of 14.4% (0.74 mSv) is probably outweighed by the clinical benefit. Furthermore, the information obtained from this extra exposure would probably help to avoid

any high radiation dose studies, such as computed tomography urography that could increase the radiation dose significantly.

Conclusion

Our study demonstrated significant additional findings noted in erect 15-min IVU images compared to the supine position. We therefore recommend that every routine IVU examination should include 15-min erect images in order to minimize the possibility of missing important findings like nephroptosis, or in order to obtain improved visualization of certain anatomical features like the calyces and/or ureters, and differentiation between phleboliths and ureteric stone, that can affect a patient's treatment plan.

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