Evaluation of the sensitivity of scout radiographs on unenhanced helical CT in identifying ureteric calculi: a large UK tertiary referral centre experience

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Objective: Unenhanced helical CT for kidney, ureter and bladder (CT KUB) has become the standard investigation for renal colic. This study aims to determine the sensitivity of scout radiographs in detecting ureteric calculi using CT KUB as a standard reference.

Methods: A retrospective review of consecutive patients who presented with acute flank pain and were investigated using CT KUB. 201 patients with positive ureteric calculi were included. Two radiologists independently reviewed the scout radiographs with access to CT KUB images. Each observer recorded the presence or absence of calculi, location, size and mean Hounsfield units of each calculus.

Results: 203 ureteric calculi were analysed from 201 patients. The overall sensitivity of scout radiographs for Observer A was 42.3% and for Observer B 52.2%, with an interobserver reliability κ -value of 0.78. The significance of mean Hounsfield units and size between two groups of patients with visible stones and those not visible were tested; the p -value for both variables was <0.0001 , which is statistically significant. The study found that calculi in the upper ureter and larger than 4 mm are more likely to be seen on the scout radiograph.

Conclusions: Usage of CT scout radiography should be encouraged and reported routinely in conjunction with CT KUB as a baseline for treatment follow-up.

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Unenhanced helical CT for kidney, ureter and bladder (CT KUB) has become the standard investigation for renal colic [1, 2]. Its superior sensitivity and specificity has led to the demise in popularity of intravenous urogram (IVU) [3–5], although there remain some concerns about radiation dose [6]. At our institution, CT KUB has been the first-line investigation for patients suspected of having acute renal colic since 2006 [7]. Serial plain abdominal radiographs (KUB) however remain useful baseline and follow-up investigations to track the passage of stones unless the calculi are radiographically occult, in which case CT KUB or ultrasound will then be the investigations of choice.

Digital CT scout radiographs are produced routinely to assist in positioning patients before axial images are acquired. They are taken from the level of the xiphoid sternum to the level of the pubic symphysis. The scout view is often overlooked and deemed not to be of diagnostic quality. However it has been proposed that careful study of the scout radiograph may identify the calculus and negate the need for a baseline plain abdominal KUB radiograph [8].

In our institution, only a small number of patients who had ureteric calculi diagnosed on CT KUB had baseline

plain radiographs at the same clinical presentation; the timing of the baseline plain KUB radiographs taken differs depending on varying urologists' clinical practices. This has posed a real clinical dilemma as the absence of calculi on follow-up plain KUB taken several days after the initial presentation could be due either to the successful passage of calculi or to a radiographically occult stone. As a consequence, repeat CT KUB is occasionally performed in order to clarify the position of the calculi. We postulate that, if scout radiographs have sufficient sensitivity to detect calculi, they can be reported in conjunction with all the CT KUB examinations and patients will have a clear follow-up pathway with either plain KUB or ultrasound at the time of presentation.

Although there are several recently published series that evaluate the sensitivity of scout radiographs, the number of patients used was relatively small [8–11]. The primary aim of this study was to determine the sensitivity of CT KUB scout radiographs in detecting ureteric calculi using CT KUB as a standard reference and comparing this against the recently published series. Factors that may affect the sensitivity of detection on scout radiographs will be evaluated. The secondary end point was to assess the sensitivity of plain radiographs in detecting ureteric calculi compared with scout radiographs using CT KUB as the gold standard. The potential saving on the cost of plain radiographs and radiation dose will be discussed.

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Table 1. Locations of the visible calculi on scout radiographs

Location	Number (%)	
	Observer A	Observer B
Vesico-ureteric junction	69 (34)	72 (35.5)
Distal-ureter	57 (28)	50 (24.6)
Mid-ureter	68 (33.5)	40 (19.7)
Proximal	6 (3)	31 (15.3)
Pelvic-ureteric junction	3 (1.5)	10 (4.9)

Methods and materials

This is a retrospective study for which our local ethics committee does not require ethics approval. Patients who underwent CT KUB for acute flank pain between May 2006 and March 2007 were identified from our radiology patient information system. The CT reports were reviewed and 201 consecutive patients selected based on a criterion of positive ureteric calculi.

Patients were examined using either a Siemens Sensation-16 TM 16-detector row (Siemens Medical Solutions, Erlangen, Germany) with 5 mm section thickness and 3 mm reformat, or a Philips Mx8000 Quad 4-detector row (Philips Medical Systems, Eindhoven, The Netherlands) with 5 mm section thickness. CT was performed from the lower chest to the symphysis pubis with no oral or intravenous contrast medium administered. All scout radiographs were produced using the manufacturer's default setting at 120 kVp and 50 mAs.

201 unenhanced CTs were reviewed independently by 2 of the authors (WWY and JB). Once the ureteric calculi were identified on CT using a PACS (picture archiving communication system) workstation, the scout radiographs were viewed at the workstation using the optimal window setting for each patient. The observers were able to map the level of the calculi from CT KUB onto the scout views using software on the workstation. The observers were not blinded to the findings on CT KUB when the scout radiographs were reviewed as this reflects our true clinical practice. Each observer recorded the presence or absence of the calculus on the scout view of each patient with no consensus. Independent observations were then made in terms of location, size and mean Hounsfield units of the calculus.

Calculi were measured in an axial plane on CT KUB; the maximum cross-sectional diameters were recorded. The sizes were divided into diameters of <4 mm, between 4 and 8 mm and >8 mm. The reason for the division is that stones <4 mm are likely to pass spontaneously and a 'watch and wait' approach is normally adopted. Those >8 mm have less than a 50% chance of spontaneous passage and are more likely to need intervention [12]. The renal tracts were divided into proximal, middle, distal and vesico-ureteric junction. Locations of the calculi were

Table 2. Mean Hounsfield units (HU) of visible and not visible calculi on scout radiographs

Observer	Mean HU visible on scout (range)	Mean HU not visible on scout (range)
A	581 (1599)	318 (1175)
B	548 (1423)	297 (1412)

Table 3. Sizes of visible calculi on scout films

Diameter of calculi visible on scout	<4 mm	4–8 mm	>8 mm
Observer A	38/121 (31%)	37/64 (58%)	11/18 (61%)
Observer B	58/130 (45%)	38/60 (63%)	10/13 (77%)

recorded based on the above division. The mean Hounsfield units for each calculus was measured by placing the cursor over the calculus.

The subgroup of patients who had plain KUB examination during the same attendance was identified and their radiographs examined. When the observers analysed the plain radiographs, they were blinded to the CT scout findings but were aware of the location and position of the stone.

The sensitivity of scout radiographs and plain KUB was calculated using CT KUB as the gold standard.

Statistical analysis

The data were analysed using SPSS v.16.0. Descriptive data were expressed using means, median and standard deviation. Sensitivity was calculated at the 95% confidence interval. The mean size and Hounsfield units of the calculi not visible were compared with those definitely visible using the Mann–Whitney *U*-test. A *p*-value <0.05 was considered significant.

Results

Patient demographics

203 ureteric calculi were analysed from 201 patients. Two patients had two symptomatic calculi each on the same side but at different locations within the ureter. Of the 201 patients 153 (76%) were male and 48 (24%) were female. The male-to-female ratio was as expected as the incidence of renal stones is higher in the male population. The mean age of our study population was 44.7 years (range 17–84 years). A total of 95 calculi were in the right ureter and 108 were in the left.

Location, mean Hounsfield units, sizes of calculi and sensitivity of scout radiographs

Tables 1–3 show results of both observers based on the location, Hounsfield units and sizes of the calculi. The significance of mean Hounsfield value and mean size between the two groups of patients with visible stones on the scout view and those not visible was tested using the Mann–Whitney *U*-test. The *p*-value for both variables

Table 4. Sensitivity of scout films

	Observer A (WWY)	Observer B (JCB)
Sensitivity	86/203=42.3%	106/203=52.2%

Interobserver reliability $\kappa=0.78$.

Table 5. Visibility of calculi on plain abdominal radiograph based on location

Visibility of calculi on abdominal radiograph	Location of ureteric calculi			
	Distal ureter (n=12)	VUJ (n=15)	Mid-ureter (n=17)	Proximal ureter (n=1)
Visible	8	10	15	0
Not visible	4	5	2	1

VUJ, vesico-ureteric junction.

Table 6. Visibility of calculi on plain abdominal radiograph based on size

Visibility of calculi on abdominal radiograph	Diameter of the ureteric calculi		
	<4 mm (n=30)	4–8 mm (n=14)	>8 mm (n=1)
Visible	20/33	12/33	1/33
Not visible	10/12	2/12	0/12

for both observers was <0.0001 , which is statistically significant.

The sensitivity of scout radiographs in detecting ureteric calculi was 42.3% by Observer A and 52.2% by Observer B. This is illustrated in Table 4. The inter-observer reliability was good and $\kappa=0.78$.

Sensitivity of plain KUB and comparison with scout radiographs

In our study cohort, 45 of the 203 cases (22.2%) had plain KUB radiographs performed at the time of CT KUB. The sensitivity of abdominal radiographs in detecting calculi in our cohort was 73% (33/45). The results of the plain abdominal radiograph findings are summarised in Tables 5 and 6.

All the calculi that were visible on digital scout radiographs were visible on KUB. However, in 12/46 radiographs, the calculi were visible on KUB but not on CT scout radiographs.

Discussion

The increased use of CT KUB in the investigation of acute renal colic has prompted the possible inclusion of CT scout radiographs as part of the management algorithm. Scout views are obtained routinely as part of the unenhanced helical CT. There are several previous studies looking at the sensitivity of the scout view in detecting renal calculi: Chu et al [8] found this to be 49%; Assi et al [10] further compared the sensitivity of CT scout radiographs and plain radiographs and found this to be 47% and 60%, respectively. Ege et al [11] looked at a group of 111 patients, and showed that 40% of all stones were visible on CT scout radiographs and 52% on plain radiographs. The more recent series by Johnston et al [9] showed that the sensitivity of scout radiographs was 47% when 108 ureteric calculi were assessed. Our results have shown that the sensitivity of CT scout radiographs in detecting ureteric calculi when interpreted in conjunction with the CT KUB is between 42% and 52%, which is similar to other published series illustrated above.

In our study, the two independent observers had approximately 2 years difference in radiology experience; Observer B (JB) has been reporting CT scout radiographs routinely as part of the CT KUB examination for several years. The sensitivity obtained was higher than that of Observer A, which implies that there is improvement in accuracy of reporting with experience when reporting scout radiographs. This issue has not been illustrated in previous studies. In spite of a difference in experience, the interobserver agreement remains at an acceptable level with $\kappa=0.78$.

There are several factors that determine the visibility of the calculi on CT scout radiographs. The mean size and Hounsfield units of the visible and non-visible stones showed a statistically significant difference when they were compared, implying that size and Hounsfield units are two important variables that have to be considered when interpreting a CT scout radiograph (Figure 1a,b). Our experience tells us that visibility also depends on overlying bowel gas and bowel wall or folds (Figure 2a,b). A possible explanation for the discrepancy

Figure 1. A large calculus is seen on (a) an unenhanced helical CT for kidney, ureter and bladder, and is clearly seen on (b) the scout radiograph (black arrow).

Figure 2. A calculus in the left proximal ureter on (a) an unenhanced helical CT for kidney, ureter and bladder. (b) The calculus is not visible on the corresponding scout radiograph owing to overlying bowel gas and bowel wall.

could be that the interpretation of digital CT scout radiographs requires training and optimal settings to be used depending on the patient's size, location of the stones and overlying structures (Figures 3a,b).

It is well documented that visualisation of renal calculi on scout radiographs will be enhanced when using a low kilovoltage setting, which is illustrated in Chu et al's [8] phantom experiment. It has been suggested that the less dense stones can be detected by using low peak kilovoltage techniques [8]. A lower peak kilovoltage will cause a higher percentage of photoelectric reactions between X-rays and the calcium within the stones. They

therefore recommended the use of 80 kVp and 200–300 mAs to improve the detection rate.

The majority of calculi (98%) <5 mm in diameter have been shown to pass spontaneously especially when they are in the distal ureter [13]. Based on this assumption, we calculated the sensitivity for the detection of stones <4 mm in diameter by CT scout radiographs to be 31%. CT scout radiographs are less sensitive when used as a baseline investigation for stones <4 mm. However, this group of patients is unlikely to need intervention and hence follow-up imaging. As a result, the low sensitivity will not have a significant

Figure 3. A small calculus in the right vesico-ureteric junction (black arrow) on (a) an unenhanced helical CT for kidney, ureter and bladder, is clearly visible on (b) the scout radiograph.

(a)

(b)

Figure 4. A calculus in mid ureter (black arrow) on (a) an unenhanced helical CT for kidney, ureter and bladder, is clearly visible on (b) the scout radiograph.

clinical impact and symptomatic management of these patients may be more appropriate.

Our results show that the sensitivity of detection based on location is 43% when the stones are located in the upper tract (intrarenal and upper ureter combined) (Figure 4a,b) and 35% when located in the distal ureter and vesico-ureteric junction. Upper tract stones are more likely to need follow-up as they are likely to be treated if they are large and they have the potential to cause obstruction if the stones migrate distally. Hence, our findings potentially have important clinical relevance. CT scout radiographs can therefore be used as a baseline investigation, if the stone is visible.

One of the other important findings in our study is that all the patients whose calculi were visible on CT scout radiographs were detected on plain KUB (Figure 5a–c). The sensitivity of the abdominal radiograph in detecting calculi is 73%, which is much higher than that reported previously of 59% [14]. This is because of our small sample size and our interpretation of the plain radiographs with access to and knowledge of CT KUB findings, although without knowledge of the scout radiograph findings, unlike the previously published group.

As only 22% of patients who have renal calculi had a plain KUB as a baseline study at the time of CT KUB, it would be useful for radiologists to report CT scout radiographs in conjunction with CT KUB. This will avoid the dilemma of deciding whether a patient has passed a stone when the stone is no longer visible on subsequent plain KUB or whether the stone is radiographically occult. If calculi are visible on CT scout radiographs, baseline plain KUB can be avoided and a clear follow-up pathway will then need to be followed. On the other hand, if calculi are not visible on scout radiographs, radiologists can recommend that plain KUB is performed at the time of the CT KUB. The follow-up investigation will then depend on the visibility of the calculus on plain

KUB. We recognise however that the sample size of those who have both CT KUB and plain KUB is small ($n=45$).

Another advantage of reporting CT scout radiographs in conjunction with reporting unenhanced CT KUB is the potential cost saving. In our institution, each plain abdominal radiograph costs £20 and the radiation dose to the patient is approximately 1 mSv. As the sensitivity of scout radiographs in detecting ureteral calculi is between 43% and 52%, we could potentially save 50% of baseline plain radiographs, which clearly has cost implications and the added advantage of reducing radiation dose to this relatively young population.

Our institution is a large UK-based tertiary referral centre and our series is similar to other published data. Although there have been several published series on this topic, the difference between these and our study is that we have shown not only that CT scout radiographs have adequate sensitivity to serve as a baseline study, but that there is a learning curve when reporters start to report CT scout radiographs. This potentially has training implications. The reporters should also bear in mind that the locations of the calculi affect the sensitivity, which differs from the findings of Johnston et al [9].

The limitations of this study are that it is a retrospective one and the observers were not blinded to the findings on the unenhanced helical CT. However, we felt that our study should reflect how scout radiographs and CT are reported in true clinical practice. In addition, the study was performed on 16-slice CT scanners, which may not reflect the current radiology practice as newer scanners with 64 slices are utilised. We acknowledge that scout radiographs vary tremendously in quality depending on the manufacturer's settings on the different scanners and individual institution scanning protocols. Nevertheless, the study is sufficient to point out the benefit of reporting CT scout radiographs in conjunction with unenhanced helical CT. It may be possible to encourage manufacturers

Figure 5. A small calculus in right mid ureter (black arrow) on (a) an unenhanced helical CT for kidney, ureter and bladder, is visible on (b) the scout radiograph and (c) the corresponding plain radiograph.

to have a uniform setting on their scanners for scout radiographs to avoid wide variability in quality. However, it should be emphasised that this study is not intended to recommend CT scout radiographs to be reported independently as they have insufficient sensitivity because of the factors illustrated above. Scout radiographs should be reported in conjunction with the knowledge of helical CT findings and should be utilised as an adjunct in the management of ureteric calculi.

There is potential for future research in this area where we could alter the manufacturer's default peak kilovoltage and milliamperes seconds setting and assess if there is an improvement in the sensitivity of detection on scout radiographs. The new 64-slice scanners may also improve detection rates.

Conclusion

Our study has shown that the sensitivity of CT scout radiographs in detecting ureteric calculi is similar to other published data. We have in addition shown that there is a potential learning curve when starting to report scout radiographs. The sensitivity depends on mean Hounsfield units, location and size, and these factors affect clinical management. The usage of CT scout radiographs therefore should be encouraged and reported routinely in conjunction with CT KUB as a baseline for treatment follow-up but bearing in mind that plain radiographs have higher sensitivity and should be utilised whenever there are doubts about the visibility of calculi on scout radiographs. Further larger prospective studies are needed to assess the optimal peak kilovoltage and milliamperes seconds for CT scout radiographs in order to increase the detection rate for ureteric calculi.

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