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Evaluation of the Role of Low Dose Contrast Enhanced MultidetectorCT Urography in Adults Patients with Obstructive Uropathy

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Original Article

ABSTRACT

***Background**: Obstructive uropathy is a common and potentially serious condition that affects people across all ages. A precise and accurate radiological diagnosis is crucial, helps to plan appropriate treatment, and early prevention of adverse outcomes. Computed tomography nowadays have resulted in the ability to image the urinary tract in ways superior to intravenous urogram. **Objective**: To assess the role of low dose contrast enhanced computed tomography urography in patients with obstructive uropathy. **Patients and Methods**: This study conducted at Baghdad teaching hospital, during 2011 and 2012 included 40 adult patients. Ultrasound and Low dose contrast enhanced CTU done for them and the results compared with the surgical findings. **Results**: There were 28 males (70%) and 12 females (30%). 13 patients (32.5 %) showed variable degree of loss in parenchymal thickness while 11 patients (27.5%) exhibited variable degree of obstructive nephro- and pyelogram. The most common cause of obstruction was the stone (87.5 %) and the most common site was lower ureter (23.81%). The incidental findings were noticed in 11 patients (27.5 %) while 15 patients (37.5 %) were found to have mixed renal and extra renal stones. **Conclusion**: Low dose contrast enhanced CTU was highly sensitive, specific and accurate as a low radiation technique of great value in evaluation of patients with obstructive uropathy .*

Keywords: *computed tomography urography, low dose, obstructive uropathy*

1. INTRODUCTION

Obstructive uropathy is an anatomical obstruction caused by a fixed point of narrowing in the urinary tract. However, in functional obstruction, there is no fixed narrowing despite elevated pressures proximally; one example is pelviuretric junction (PUJ) obstruction.[2].

The term hydronephrosis is defined as dilatation of the renal pelvis and calyces resulting from obstruction to the flow of urine. [3].

Dilatation of the urinary tract may or may not be associated with obstruction; the absence of dilatation does not exclude obstruction. Hydronephrosis should be categorized as either obstructive or non obstructive. The degree of dilatation of the pelvicalyceal system is a poor, and potentially misleading, indicator of the severity of obstruction. Hydronephrosis may be graded on a four-point system, where Grade 1 refers to minimal calyceal dilatation, seen following induced diuresis or as a result of abdominal compression. Grades 2–4 refer to mild, moderate and severe hydronephrosis, respectively. [2]

Acute obstruction is usually associated with flank pain that may radiate into the groin. Patients commonly experience nausea, vomiting, and chills. When the obstruction is bilateral and chronic, the patients may present with nonspecific complaints (an increase in abdominal girth, ankle edema, anorexia, headaches, weight gain, fatigue, and shortness of breath). They may also have symptoms reflective of uremia, such as mental status changes, tremors, and gastrointestinal bleeding. [3]

Non-obstructive dilatation : Several conditions cause dilatation of the upper urinary tract in the absence of anatomical obstruction : Reflux, post obstruction dilatation ,megacalyces , polycalycosis , primary megaureter . [2]

Multidetector computed tomography urography (MDCTU): is a diagnostic examination optimized for imaging the kidneys, ureters and bladder. The examination involves the use of multidetector CT with thin-slice imaging, intravenous administration of a contrast medium, and imaging in the excretory phase. Imaging in the excretory phase, either early or delayed, is thus a mandatory part of any CTU protocol. [6]

Contraindications to CTU are generally limited to 1. those patients who cannot receive iodinated contrast because of renal insufficiency, prior severe reaction or pregnancy. [7]

Recommended CTU technique has three phases; initial unenhanced phase, nephrographic phase (acquired 90–100 seconds after administration of a nonionic contrast agent (100–150

mL of 300 mg I/mL at 2–4 mL/s). Imaging (2.5- to 5-mm slice thickness) & pyelographic phase images are acquired 5–15 minutes after contrast administration to evaluate the urothelium from the kidneys to the bladder. [8]

Low dose CT

The biggest potential problem with CTU performed using excretory phase axial image acquisition is the incremental radiation that patients received with multiphase CT. The amount of radiation to which patients are exposed is directly related to mA and kVp, as well as to number of phases acquired. [9]

From the urinary tract evaluation standpoint with CT scanning, it is important to bear in mind that follow-up or recurrent CT imaging (kidney stones) as well as multiphase contrast-enhanced CT increases radiation dose to patients. It is, therefore, important to initiate strategies and efforts to reduce radiation dose associated with CT scanning of the urinary tract. [11]. There is increasingly popular technical modification that allows for radiation dose from CTU to be reduced : split-bolus technique. This involves administering an initial intravenous bolus of contrast material. After a delay (allowing for excretion of the initial bolus into the renal collecting systems and ureters), additional contrast material is injected. Finally, a single series of thin-section contrast-enhanced scans is obtained after a further delay, allowing for the second bolus of contrast material to have enhanced the renal parenchyma homogeneously, while the first bolus has already been excreted into the renal collecting systems. [9] Tube current is the most commonly adjusted scanning parameter for reducing radiation dose in CT. The limitation of the initial low dose CT studies using a fixed tube current was that a single lower tube current is not appropriate for obese patients with the possibility of missing an alternative clinical diagnosis because of insufficient image quality. The introduction of automatic tube current modulation techniques helps in these circumstances. [9] One strategy for reducing the radiation dose during MDCTU includes lowering the tube voltage. .[11] Reducing the number of acquisitions: There is no consensus on the optimal protocol for MDCTU. Previous studies have reported the use of 2-4 phase scanning for MDCTU as different components of the urinary tract opacify with contrast at different time points following administration of iodinated contrast agents. The double excretory or corticomedullary phase is optionally acquired instead of the nephrographic phase. .[11]

2. PATIENTS and METHODS

This was a prospective selective study performed in Baghdad teaching hospital, Baghdad, Iraq, between December 2011 to May 2012 , the study sample consisted from 40 adult patients with sonographic diagnosis of hydroureteronephrosis referred to the radiology department for whom an abdominal ultrasound & a low dose contrast enhanced CT urography has been performed.

Any patient with benign prostatic hypertrophy, renal impairment or urinary tract infection (confirmed by general urine examination and culture) has been excluded from the study.

An informed consent has been obtained from all patients & any history of atopy or previous allergic reaction to contrast media has been recorded. The renal indices and GUE were checked and the patients were prepared prior to examination by withholding foods at least 6 hours prior to examination.

A MDCT examination has been performed using (Philips –Brilliance 64 slice – Nederland). The radiation dose in our examination was: total DLP=104.2 mGy *cm , mAs= 30 , Kv =120 , CTDI vol.=1.94, DLP= 100.8.

The examination started with a native study, then injection of contrast agent (Iohixol (omnipaque*) with a dose of (2mg/ Kg). Then a topogram was taken with patient in prone position after 8 minutes, and if the kidney at site of interest is excreting then the examination was completed while if there is delay in excretion, then another Topo view is taken after 30 minutes, if no excretion is observed then the examination was completed after 120 min.

All patients were followed by urosurgeon & the final diagnosis has been obtained by surgical intervention. Comparison between baseline condition & follow up condition has been performed using statistical analysis chi-square test opus 12 foundation Inc. for calculating the X^2 and P.value, P. values < 0.05 indicate statistical significance.

3. RESULTS

The study sample consisted of 28 male patients (70 %), and 12 female patients (30 %). In 24 patient (60 %) , CT scan showed that the obstruction was in the RT. Side while in the other 16 patient (40 %) , the obstuction was in the LT. side .(**Table 1**). In 35 patient (87.5%), CT

scan showed that the obstructive cause was calculi while in 4 patients (10 %) the cause was congenital PUJ obstruction and in 1 patient (2.5 %) the cause of obstruction was multiple stenosis, (**Table 2**). In 6 patients (14.3 %), CT scan showed that the obstruction was located at PUJ (stone or congenital), and in 4 patients (9.5%), the obstruction was at upper ureter while in 6 patients (14.2 %), the obstruction was at the junction of mid and lower ureter, and in 10 patients (23.8%), it was at lower ureter with the same results obtained by surgical intervention. CT scan showed that in 5 patients (11.9%) the obstruction was at junction of upper and mid ureter by CT in contrast to 4 patients (9.5%) found at operative measure that done for the patient with obstruction at level of midureter in 5 patients (11.9 %) in CT, in contrast to 6 patients (14.3%) during the interventional procedures .Similarly in CT , we detected the obstruction at VUJ in 6 patients (14.3%) in contrast to 5 patients (11.9 %) by intervention. The overall Sensitivity of low dose CT in detection the side , cause and site of obstruction was 98 % , specificity was 95% and the accuracy was 96 % with a significant P. value < 0.001, (**Table 3).** Incidentally, CT scan revealed findings in 11 patient (27 .5 %), (**Table 4**). However, CT images of some patients in our study and their findings are demonstrated in (**Figures 1,2 &3**) findings

Table 1. Comparison of CT and surgical findings regarding side of obstruction .

Variable		**Findings**		**Total**
		CT	**Surgical**	
Side of obstruction	Right side	24 (60 .0%)	24 (60.0 %)	48
	Left side	16 (40.0 %)	16 (40.0 %)	32
Total		40 (100.0%)	40 (100.0)	80
Sensitivity	100.0%			
Specificity	100.0%			
Accuracy	100.0%			

Table 2. Comparison of CT and surgical findings regarding the Obstructive cause

Variable	**Findings**		**Total**
	CT	**Surgical**	

Cause of obstruction	Stone	35 (87.5 %)	35 (87.5%)	70
	PUJ obstruction	4 (10 %)	4 (10 %)	8
	Stenosis	1 (2.5 %)	1 (2.5 %)	2
Total		40 (100.0%)	40 (100.0)	80
Sensitivity	100.0%			
Specificity	100.0%			
Accuracy	100.0%			

Table 3. Comparison of CT versus surgical findings regarding site of obstruction

Site of ureteric obstruction	**CT finding**		**Surgical finding**		**S***	**SP***	**ACC***
	No.	**%**	**No.**	**%**			
PUJ	6	14.3	6	14.6	100%	100%	100%
Upper ureter	4	9.5	4	9.8	100%	100%	100%
Upper and mid-ureter Junction	5	11.9	4	9.8	100%	80%	89%
Mid ureter	5	11.9	6	14.6	83%	100%	92%
Mid and lower ureter Junction	6	14.3	6	14.6	100%	100%	100%
Lower ureter	10	23.8	10	24.4	100%	100%	100%
VUJ	6	14.3	5	12.2	100%	83%	92%
Mean values of validity parameters					**98%**	**95%**	**96%**

***S: sensitivity , SP: specificity, ACC: accuracy

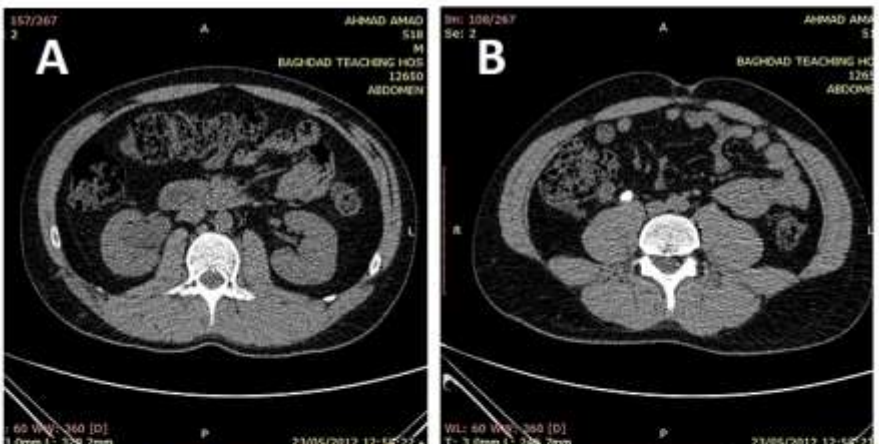

Figure 1. Low dose contrast enhanced CT, A: native phase: moderate Hydronephrosis in right kidney, B: native ,stone in right ureter C: volume rendered 3 D reconstruction, D: MIP in excretory phase

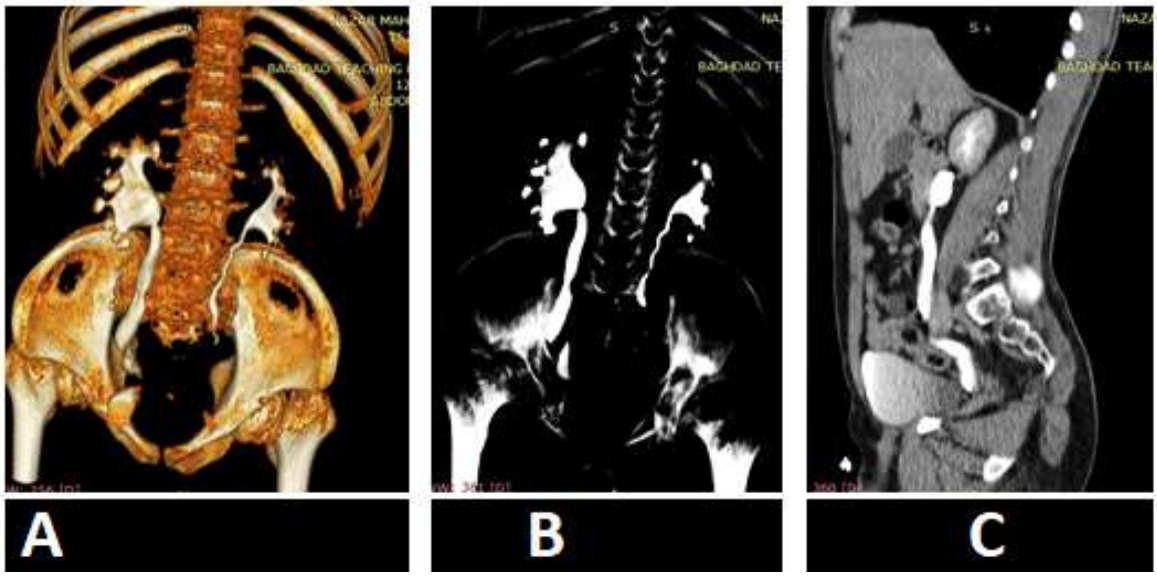

Figure 2. Patient of 35 years old with multiple levels right sided ureteric stenosis; A: volume rendered 3-D reconstruction, B: MIP , C: sagittal section excretory phase

Table 4. Incidental findings among the studied group

Incidental pathology	No. of cases	%
Simple renal cysts	3	27.3

Hepatic hydatid cyst	2	18.2
Papillary calcification	2	18.2
Renal tumour	1	9.1
Complex adnexal mass	1	9.1
Adrenal calcification	1	9.1
Gall stones	1	9.1
Total	11	100.0

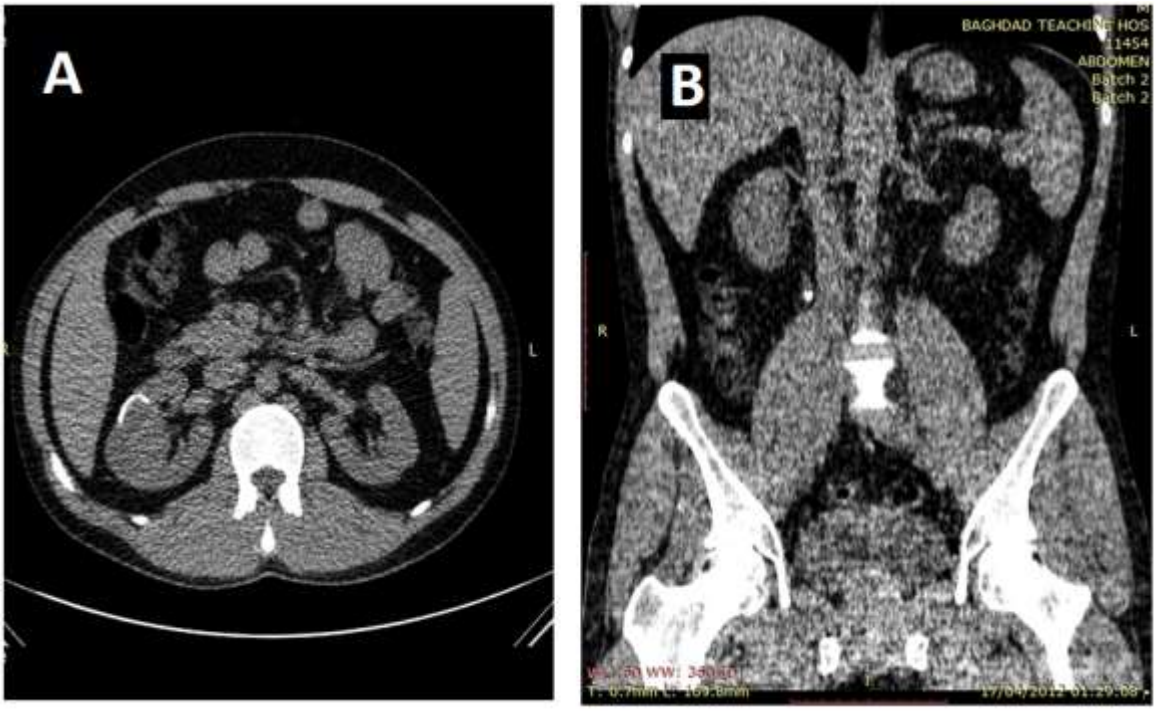

Figure 3. low dose contrast enhanced CT urography in 30 years old patient with right loin pain radiating to the groin and haematuria ; A: native phase :incidental finding of a midcortical well defined soft tissue mass in RT. kidney with arc like calcification . B: The same patient , native phase , coronal section showing mid ureteric stone and mild hydroureter

4. DISCUSSION

Most of the available data from previous researches are concerned about the evaluation of the role of the triphasic contrast enhanced CT urography or the low dose unenhanced CT

urography in patients presented with acute ureteric colic or haematuria or they try to compare between one of these modalities and another modality such as IVU and US. In this study, the patients sample consisted of patients with obstructive uropathy and a comprehensive evaluation of renal parenchyma and the entire urothelium has been performed by contrast enhanced CT urography using a protocol of low dose computerized tomography (by lowering tube current and reducing the number of acquisition) aiming to avoid exposing patients to a substantial radiation dose with a subsequent risk of radiation induced secondary malignancy despite the suspected lowering in image quality.

Regarding Obstructive cause, it was calculi in 35 patient (87.5%), congenital PUJ in 4 patients (10%) and multiple stenosis in 1 patient (2.5%) , possibly due to TB.

The same results were obtained after surgical intervention indicated 100% sensitivity, specificity and accuracy of CT, in detection the cause of obstruction. These findings different than that reported in previous studies; El-Ghar ME *et al* found that among 65 patients, the cause of obstruction was PUJ narrowing in 25 cases, ureteral stone in 21, ureteral stricture in 20 , and extrinsic ureteral obstruction in 4. However, the same 100% sensitivity and specificity were reported in that study; [8]. This discrepancy is probably due to difference in methodology, sample size and inclusion criteria between the 2 studies.

About the sensitivity and specificity of CTU in detecting the ureteric stone, the results of this were similar to several studies Forrest C.Jellison *et al* 2009 found that the overall sensitivity and specificity of low dose computerized tomography in distal ureteral calculus detection were 98 % and 83 % respectively.[9] Niemann *et al* 2008 found that a meta-analysis of seven studies assessing the diagnostic performance of low dose CT for detecting urolithiasis showing 97 % sensitivity and 95 % specificity.[10] Tack *et al* 2003 and Poletti *et al* 2007 evaluated low dose CT examination using a tube current of 30 mA and show that it had a sensitivity of 90-97 % and specificity of 94 -100 %, similar to standard dose CT at 120 or 180 mA for correctly identifying renal stones as well as alternative diagnoses. [11,12] Knopfle E *et al* 2003 reported that the sensitivity and specificity of the low dose helical CT in detecting ureteral calculi were 97.7 % and 96.8 % respectively. The positive predictive value was 99.3 % and negative predictive value 92.4 %. [13] · Sheafor HD *et al* 2000 found that non enhanced helical CT scanning detected ureteric calculi with sensitivity of 96 % and specificity of 100 % . [14] Jia-Hwia Wang *et al* 2007 found that un enhanced CT correctly

depicted ureteric stones in patients suffering from acute flank pain with sensitivity of 98.5 % , and specificity of 100 % .[15]. Ahmed NA *et al* 2003 found that unenhanced CT has a sensitivity of 99 % and specificity of 98 % in the diagnosis of ureteric calculi . [16]

In this study, CT scan showed the obstruction was located at PUJ (stone or congenital) in 6 patients (14.3%) , and the obstruction was at upper ureter in 4 patients (9.5%) while, the obstruction was at junction of mid and lower ureter in 6 patients (14.3 %), and, it was at lower ureter in 10 patients(23.8%) with the same results were obtained by surgical intervention (sensitivity =100%, specificity =100 %, accuracy = 100%).

In 5 patients (11.9%) the obstruction was at junction of upper and mid ureter by CT in contrast to 4 patients (9.5 %) found during surgery (sensitivity =100 %, specificity =80 % , accuracy =89 %)with obstruction at level of midureter in 5 patients (11.90 %) in CT, in contrast to 6 patients (14.3 %) during the interventional procedures (sensitivity = 83 % , specificity = 100 % , accuracy = 92 %) . Similarly in CT , the obstruction has been found at VUJ level in 6 patients (14.3 %) in contrast to 5 patients (11.9 %)by urological intervention (sensitivity = 100 % , specificity = 83 % , accuracy =92 %). The above mentioned discrepancy in location of obstruction regarding the junction of upper and midureter or the PUJ sites can be explained by the possibility of spontaneous passage of stone with gravity and the presence of additional one obstruction at the midureter at surgery more than that exhibited by CT prove this explanation, in addition follow up of the patient explained the difference in obstruction at level of PUJ (with detection of CT to 6 obstructive causes in comparison to 5 by surgery) who passed the stone after a while from the bladder. It is worth mentioned that the number of obstructive causes as detected by CT is 42 as one patient (with a stenosis as a cause) has 3 sites of stenosis. The most common site of obstruction was lower ureter followed by VUJ , PUJ and junction of mid and lower ureter equally. The mean value of test validity parameters was 98% Sensitivity , 95% Specificity and 96% accuracy , (P. value < 0.001). About the most common site of stone impaction, our results are not similar to the following studies, can be possibly attributed to the difference in inclusion criteria or because some cases were bot treated surgically & had a spontaneous expulsion of stone. The most common cause of obstruction varies in different studies, for instance it was VUJ in D Ulahannan *et al* study[17] . while it was Hydroureteronephrosis in M Hammad Ather *et al* study [18] and PUJ narrowing in El-Ghar

ME *et al* study in patients with chronic obstructive uropathy undergone contrast enhanced CT[8] . Some incidental findings were reported in 11 (27.5%), patients of our studied group, These results were not similar to the following studies probably because of the difference in sample size , methodology and inclusion criteria. Bromage SJ *et al* found that 56 % of CT urography examination showing unexpected findings , the most common is diverticular disease , followed by adrenal masses. [19]. D Ulahannan *et al* in a research for the benefit of CT urography in patients with suspected ureteric colic found that significant incidental pathology was observed in 16 % of patients . [17]

5. CONCLUSIONS

Low dose contrast enhanced CT urography can determine the cause, site, degree of chronicity of obstructive uropathy, with high sensitivity, specificity and accuracy. It provides additional information about renal function and detects alternative pathology.

Low dose contrast enhanced CT urography in assessment of patients with obstructive uropathy and normal renal function.

Ethical Clearance: Ethical clearance and approval of the study are ascertained by the authors. All ethical issues and data collection were in accordance with the World Medical Association Declaration of Helsinki 2013 for ethical issues of researches involving humans, informed consent obtained from all patients. Data and privacy of patients were kept confidentially.

Conflict of interest: Authors declared none

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