Intravenous urography supplemented with computerised tomography urogram: A pragmatic hybrid imaging approach to hydronephrosis

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ABSTRACT

Background: Image quality in an Intravenous Urogram (IVU) can occasionally be compromised by variables like bowel preparation, renal function and radiographic factors, posing a challenge to all Uroradiologists. The Computerised Tomography Urogram (CTU) yields better diagnostic information than an IVU, due to its inherent superior anatomic delineation and contrast sensitivity, against a trade-off involving radiation dose and cost. Our study was conducted to assess the utility and timing of performing a single-phase CTU, as a problem-solving tool, to clear the diagnostic dilemma in a selected subset of patients, in whom an ongoing IVU could potentially be inconclusive.

Material and Methods: Five hundred and twelve patients who underwent IVU studies for urologic referrals at a tertiary care hospital, during the period of January to December 2009, formed the subject of the study, of whom 33 patients with inconclusive IVU findings after the first three radiographs underwent a single-phase CTU, to reach definitive imaging diagnoses.

Results: The percentage of inconclusive IVU studies amounted to only 33 / 512 (6.4%), in whom a CTU study revealed definitive diagnoses in 30 patients and no abnormality in three patients, thus conclusively clearing the ambiguities raised on the IVU in all the selected patients.

Conclusions: The concept of a CTU limited to a single-phase study to supplement an inconclusive IVU optimizes the contrast and radiation dose to the affected patients. It is a cost-effective, timely, and definitive ‘imaging intervention’ and should be considered a viable hybrid technique to be utilized selectively and judiciously.

Key words: CT urography, hydronephrosis, intravenous urography, intravenous urogram

INTRODUCTION

The Intravenous Urogram (IVU) is a time-honored, low-cost, conventional radiographic procedure for evaluation of the urinary tract. The IVU images are, however, occasionally limited by variables like patient body habitus, state of bowel preparation, split renal function, and radiographic factors. On the other hand, Computerized Tomography Urogram (CTU) yields better diagnostic information due to three-dimensional imaging capability, excellent anatomic delineation and superior contrast sensitivity of a CT scan compared to conventional radiography.[1] Our study was conducted to study the utility of performing a CT urogram, 30 – 40 minutes from commencement of an IVU, as a diagnostic tool, in selected patients.

MATERIALS AND METHODS

The study was carried out prospectively on 512 consecutive patients referred for IVU study by Urologists, for evaluation of hydronephrosis during the period from January 2009 to December 2009, at a tertiary care super-speciality hospital. Preliminary screening of patients by clinical history, ultrasonography (USG), and radiograph of the Kidney-Ureter-Bladder (KUB) area preceded the IVU study. IVU was performed with the patient fasting overnight, after two days of bowel preparation, and ascertaining that the serum...
creatinine levels were below 1. Out of the total of 512, only 33 patients underwent a corroborative CT Urogram to correlate the inconclusive IVU studies.

After an initial scout radiograph of the KUB area, iodinated, water soluble, non-ionic contrast medium was administered intravenously at a dose of 300 mg Iodine / kg body weight. The preliminary IVU films for each patient were obtained at protocol intervals of 5, 12, and 25 minutes post contrast, with hard copies of the first two films in a supine posture and the third film in a prone position, sequentially monitored by a radiologist with 20 years experience in uroradiology. After these initial three films of the investigation, if the IVU study was found to be potentially inconclusive, the decision was taken by the radiologist to opt for a CTU at a post-contrast timing of 30 – 40 minutes. The CTU was carried out on a 16-slice multi-detector CT (MDCT) scanner (Somatom Sensation 16, Siemens, Germany). After an initial topogram, CTU was performed as a single-phase helical scan of the supine patients KUB region with an abdominal protocol of 5 mm/1.5 mm/24 mm (Display FOV / Detector width / table movement per rotation) using rotation time of 0.42 sec, with 120 kVp and 250 mA technique. The images were reviewed in axial and multiplanar reformatted sections on the work-station. The Maximum intensity projections (MIP) and volume rendered (VRT) images were utilized. After the study, all hard-copy images were interpreted by an experienced radiologist to ascertain if the inconclusiveness of the aborted IVU study was resolved on CTU.

RESULTS

The percentage of inconclusive IVU studies in our study amounted to only 33 / 512 (6.4%). The patients included were 20 males and 13 females, with a peak age group distribution being between the fourth and fifth decades of life. The indications for IVU in the 33 patients included in our study were:

1. Hydronephrosis: 17 (Right — 10; Left — 07)
2. Hydronephrosis with hydroureter: 14 (Right — 09; Left — 05)
3. Postoperative hydronephrosis: 02 (Right — 01; Left — 01)

The CTU, limited to a single-phase study, revealed definitive diagnoses in 30 patients and no abnormality in three patients, as listed in Table 1, thus succeeding in conclusively clearing the ambiguities raised on the IVU in 33 / 33 (100%) patients.

DISCUSSION

The intra-venous urogram (IVU) is a time-honored conventional technique frequently requisitioned in clinical practice for investigating urinary tract structure, function, and pathology. The ease of the procedure, low cost, and relative patient comfort, make it a popular procedure. The IVU study, however, is associated with well-known shortcomings. Being a conventional radiological procedure, the IVU study only yields a two-dimensional projection, which has a potential for over-interpretation or under-interpretation of the findings. The patient’s body habitus, state of bowel preparation, and renal excretion rate are factors contributing directly to the visible radiographic contrast, and can lead to sub-optimal image quality, which universally impedes definitive interpretation in IVU studies. In spite of the evolution of newer imaging modalities whose overwhelming potential had prompted many clinicians to write the epitaph of IVU, the ability of the IVU to yield diagnostic information about the anatomy and the functional status of the urinary system in majority of patients has enabled this procedure to survive till date.[1]

Modern imaging modalities including Ultrasonography, Computed tomography (CT), and Magnetic resonance imaging (MRI) have been used with increasing frequency in uro-imaging to compensate for the limitations of intravenous urography.[2] Among the newer modalities, CT urography (CTU) provides optimal anatomic and functional information, having inherent advantages of a three-dimensional view of the renal morphology, higher contrast sensitivity, and superior detection of the urinary tract calculi.[2,3] CTU delineates the renal collecting system, and also yields extra-luminal information, which is lacking on the IVU.[4]

The modern imaging modalities also have their limitations. Portions of the urinary tract are not visualized with USG; an MRI may not demonstrate calcifications or demonstrate subtle urethelial abnormalities. Both USG and non-contrast MRI with MR Urography do not provide information about the renal function, and suffer interference from bowel contents; furthermore, contrast MRI studies are expensive and time-intensive. CTU, as a primary study modality, requires iodinated contrast and multiple scans to obtain sequential excretory images, which leads to undesirably high radiation exposure for the patient, besides the relatively higher cost of the

| Table 1: Findings on CT urogram |
|-------------------------------|
| **Ureteric Calculi** (not visualized on radiography / USG) | 22 |
| Proximal:2 | (above the level of sacral ala) |
| Mid: 13 | (sacral ala to inferior margin of the sacroiliac joint) |
| Distal: 7 | (Distal to the inferior margin of the sacroiliac joint) |
| **Non-calculous causes** | 08 |
| Stricture: 03 | |
| Partial PUJ obstruction: 02 | |
| Ectopic Ureter: 02 | |
| Ureteric injury with leak: 01 | |
| **No abnormality seen** | 03 |
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George, et al.: Thus, despite the availability of alternative newer modalities, the “ideal” urinary tract examination modality remains controversial.[1,5]

Our study focused on a clinical, problem-solving approach, with an attempt to strike an optimal balance between diagnostic benefit and potential hazard to the patient. Of the 512 patients who underwent an IVU study in the department during the period of the study for evaluation of hydronephrosis, only 33 (6.4 %) patients required CT urography. Thirty of the 33 patients were sent for a CT urogram within 30 to 40 minutes of commencing the IVU study and the remaining three patients were sent after a 60-minute interval. It was deemed by an experienced uroradiologist that in all these patients the IVU study was inconclusive after the first three films and further films or modifications of the IVU were unlikely to yield sufficient diagnostic information. One of the main points of emphasis in the study was to identify the inconclusiveness of the IVU at the earliest, and to stop acquiring further IVU films, which would have increased the radiation dose to the patients, without providing information of diagnostic value.

The point of contention / inconclusiveness was adequately answered on the CT urogram study in all 33 patients (100%). Twenty-two of the 30 patients had radiographically and sonologically non-visualized ureteric calculi, causing proximal collecting system dilatation on the IVU. Their position and size were conclusively demonstrated on the CT urogram [Figure 1]. Conventionally, a non-contrast CT has the highest sensitivity for demonstration of urinary system calculi.[2] Dual-energy CT facilitating iodine-subtraction is the sole experimental technique capable of detecting calculi within a urinary tract opacified by iodinated contrast.[6,7] In our study, we found that the site of obstruction could be determined accurately by tracing the dilated proximal ureter; thereafter, the calculus could be separately visualized from the opacified ureter by adjusting the window settings [Figure 1]. Caution needed to be exercised as regards the potential limitation of this technique when the density of calculi closely approximated that of the contrast opacified urine. The diagnostic utility of the CTU was augmented by using the MIP and VRT images [Figure 2].

Ureteric strictures, following ureterolithotomy were well-demonstrated on the CTU in two patients, including one patient who had developed a ureteric leak causing retroperitoneal collections [Figure 3]. Our study does indicate that in postoperative patients with hydronephrosis, CTU should be the uro-imaging modality of choice. Besides partial pelvi-ureteric junction obstructions, the CTU was instrumental in demonstrating congenital ureteric anomalies, including one patient with ectopic ureter opening into the prostatic urethra [Figure 4]. No abnormality was identified in three patients, probably representing patients in whom ureteric obstruction was spontaneously relieved during the clinical interval of five to seven days between the screening USG and the IVU appointment, the most common clinical setting being the passage of small calculi.

The conclusions drawn from our study were that the IVU still remains a very efficient baseline investigative modality for imaging of the urinary system, as nearly 94% of the patients had sufficient diagnostic information on the basis of the IVU alone. However, in the relatively small subset of patients (6.4% in our study) yielding inconclusive information during an IVU, a CT urogram limited to a single-phase study, best performed 30 to 40 minutes post contrast, could effectively resolve the diagnostic dilemma.

The potential constraints of this hybrid technique would relate to issues of radiation dosage and cost. Conventionally, the standard protocol for CTU involves three volumetric acquisitions of the KUB regions, leading to a higher mean

Figure 1: 34 year old lady with pain Left side of abdomen, and hydronephrosis on USG. a) Scout film KUB area shows no radio-opaque calculus. b) 30 minutes prone IVU film showing hydronephrosis with proximal hydroureter Left side. c) CTU Coronal MIP image clearly showing calculus within Left ureter.
Figure 2: Young adult male with Nephrectomy Left side presented with pain abdomen Right side, and detected to have mild hydronephrosis Right kidney. a) IVU film at 30 minutes showing functioning Right kidney with ‘dilated’ Right ureter in its abdominal segment and surgical staples in Left renal area. b) Coronal MIP image showing no hydronephrosis; c) Coronal volume-rendered image showing normal caliber Right ureter without any ‘standing column’ of ureteric contrast. Final opinion: Normal study for Right kidney and ureter.

Figure 3: Middle aged lady who underwent ureterolithotomy for mid-ureteric calculus on Right side; patient developed progressive abdominal pain and distension from third post-operative day; USG showed hydronephrosis Right side. a, b) Supine and prone films at 10 minutes and 30 minutes respectively of the IVU done to check for possible site of intra-abdominal ureteric leak showed faintly opacified dilated calyeal system and proximal ureter on Right side. c) CTU axial image at the level of L4 transverse process showing site of ureteric injury and leak (straight arrow) and two retroperitoneal collections (curved arrows) containing contrast.

Figure 4: 24 year old male with history of recurrent urinary tract infection; USG showed duplex collecting system Right Kidney with dilated upper moiety. a) IVU done to delineate Right side ureter inconclusive, with only faint visualization of a dilated upper pole calyeal system (arrow). b) CTU axial image of pelvis shows duplicated ureter draining upper moiety with ectopic opening into the prostatic urethra (arrow)
effective dose of 15 mSv, approximately 1.5 times the radiation dose for conventional urography.\textsuperscript{8} In recent times, a novel ‘triple-bolus’ contrast injection technique followed by a single CTU sequence at eight minutes has been reported to provide comprehensive information, with a radiation dose of 9.8 mSv being similar to the effective radiation dose in an IVU.\textsuperscript{9} In comparison, in our study, a single helical scan limited to the KUB region, combined with the advantage of not requiring additional IVU films, reduces the radiation dose to the patient comparably. The second constraint of added cost needs to be viewed pragmatically, because an inconclusive IVU study entails a delay in diagnosis and invariably leads to an alternate imaging technique ‘for further evaluation’ in all such patients, for clinical decision making. Dual-source CT systems utilize a dual-energy CT obtained simultaneously using two orthogonally positioned X-ray tubes and detector sets, to eliminate the need for a separate non-contrast scan, and improve the ability to distinguish between the high-density areas created by iodine from calcium.\textsuperscript{6,7} A dedicated uroradiology suite, incorporating both CT gantry and an overhead radiography tube [Figure 5], wherein a combination of excretory urography and CT urography can be performed without shifting a patient, as practiced at the Mayo Clinic, USA.\textsuperscript{9,10} is another interesting, but expensive alternative. Therefore the concept of a single-phase CT Urography to supplement an inconclusive IVU study is a cost-effective, timely and definitive diagnostic intervention, which optimizes the contrast and radiation dose to the affected patients, and is recommended as a viable imaging combination to be adopted judiciously.

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