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ROLE OF SPLIT-BOLUS PORTAL VENOUS PHASE CT UROGRAPHY FOR KIDNEY AND URINARY TRACT DISEASES

Radio-Diagnosis

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ABSTRACT

Background: The conventional CT Urography technique involves a single bolus of injection with three acquisitions leading to multiple exposures. Split bolus CT Urography involves acquisition of parenchymal and excretory phases in a single scan thus reducing the number of scans and radiation dose. We propose to introduce novel split-bolus portal venous phase protocol that allowed to provide synchronous visualization of the renal corticomedullary, nephrographic, and excretory phases with good tumor and vascular enhancement in a single acquisition. **Materials And Methods:** Hospital based observational study carried out in the department of Radiodiagnosis, together with the help of department of urology, department of pediatrics and pediatrics surgery, SMS medical college, Jaipur on 100 patients including both pediatric and adult population . **Results:** Out of total 100 cases, maximum 33 cases were of bosniak cysts. Amongst them 28 were bosniak type I , 3 of bosniak type II and one case each of bosniak type III and type IV. Bosniak cysts were followed by 15 cases of ureteric strictures, with 12 amongst them were post-op cases and remaining having tubercular etiology. Next maximum number of cases were of PUJ Obstruction and CT urography was done to rule out vascular crossings as a cause of PUJO. Four out of the 9 cases were associated with vascular crossing causing PUJ obstruction. **Conclusion:** Single phase split bolus CTU protocol used in our study provides excellent renal parenchymal enhancement and adequate opacification of the collecting system for evaluation of kidney and urinary tract in children and adults in most of the cases with good diagnostic accuracy and minimal radiation exposure. It is also helpful in accurately diagnosing complications such as infections and renal strictures in these patients. It can be used as an alternate diagnostic tool in resource limited settings where MRI is not available.

KEYWORDS

Split bolus CT urography, urinary tract opacification, renal parenchymal enhancement

INTRODUCTION

Rapid developments in MDCT technology have enabled multiplanar reconstruction of isotropic images and high-resolution CT urography. The high diagnostic accuracy of unenhanced CT for stones, nephrogenic phase CT for renal masses, and excretory phase CT for upper urinary tract urothelial cell carcinoma makes CT urography the preferred initial imaging investigation for patients. However, a high radiation dose (10–66.3 mSv, depending on the number of phases) is the main barrier to the widespread use of CT urography, particularly when it is performed according to a multiphase technique.

Various CT urography protocols and techniques have been studied. Although split-bolus CT urography has been suggested as reducing the number of scan series, protocol features are not yet standardized.

The goal of CT urography protocols is to obtain images of fully opacified and distended collecting systems and bladder, with adequate image quality of renal parenchyma, tumor enhancement, and vascular anatomy and with the lowest number of scans as possible. To our knowledge, no standard CT urography protocol has been widely accepted for patients with renal or urinary tract diseases. We propose to introduce novel split-bolus portal venous phase protocol that allowed to provide synchronous visualization of the renal corticomedullary, nephrographic, and excretory phases with good tumor and vascular enhancement in a single acquisition

MATERIALS AND METHODS

Our study was a hospital based observational study conducted at S.M.S Medical College and Hospital, Jaipur (Raj). A total of 100 patients with suspected kidney and urinary tract pathology were included in the study. After approval from the institutional ethical committee, patients referred from department of pediatrics, pediatric surgery and urology with suspected kidney and urinary tract pathologies were included in the study on first come first serve basis.

All CT scans were acquired using Philips Ingenuity 128 Slice Multi Detector CT Scanner. A total of 2-2.5 ml/kg of non-ionic contrast medium (Iohexol, 300mg) was injected. Approximately 50% of the total contrast was given as a first IV bolus. The remaining 50% of total contrast volume was given after 10-15 minutes of the first bolus at the same rate. Saline flush was given after each injection. The nephrourographic phase was acquired 80 seconds after the Second injection.

RESULTS

Out of total 100 cases, maximum 33 cases were of bosniak cysts. Amongst them 28 were bosniak type I , 3 of bosniak type II and one case each of bosniak type III and type IV. Bosniak cysts were followed by 15 cases of ureteric strictures, with 12 amongst them were post-op cases and remaining having tubercular etiology. Next maximum number of cases were of PUJ Obstruction and CT urography was done to rule out vascular crossings as a cause of PUJO. Four out of the 9 cases were associated with vascular crossing causing PUJ obstruction.

Quantitative Image Analysis:

Adequate contrast enhancement of the renal and splenic parenchyma was obtained in all the cases in which split bolus CT protocol was done. Renal parenchymal enhancement was more than splenic enhancement in all the cases. Mean renal cortex enhancement was 186.62 ± 28.41 HU with a SNR of 12.48 ± 4.7 and mean renal medulla enhancement was 145.51 ± 25.36 with a SNR of 10.83 ± 4.62 **(Table 1).**

Table – 1 Mean CT Attenuation And Signal To Noise Ratio For Different Anatomic Regions

Region	Mean CT attenuation +SD (Range)	SNR(Signal to noise ratio)
Renal cortex	186.62 ± 28.41 (131-274)	12.48 ± 4.7 (2.6-26.6)
Renal Medulla	145.51 ± 25.36 (45-200)	10.83 ± 4.62 (2.4-21.7)
Pelvicalyceal system	615.06 ± 512.81 (39-2567)	12.96 ± 6.27 (2.9-40)
Spleen	126.43 ± 20 (95-210)	10.15 ± 4.71(2.9-21)
Renal artery	142.69 ± 10.28 (121-161)	10.56 ± 5.54 ((1.9-27.2)
Renal Vein	145.1 ± 15.59 (119-167)	12.03 ± 3.7 (2.8-18.9)

Qualitative Image Analysis:

Renal parenchymal enhancement was rated as excellent in 86% of the cases. Diagnostic quality enhancement was seen in 14% of cases. None of cases were rated as poor for renal parenchymal enhancement.

The total opacification score out of 8 was calculated for each patient by addition of score given to all segments. Also, as described earlier a corrected opacification score was also calculated for all by dividing the total no of segments opacified by the number of segments expected to be opacified and multiplying by 8.

Corrected opacification score= No of segments opacified*8/No of segments expected to be opacified.

The mean opacification score for all cases was 7.158 + 1.292 , the corrected opacification score for all cases was 7.696 + 0.678.

Radiation Dose:
Age group subdivision for various age groups was done according to the k factor as specified in AAPM report 96. The overall mean effective dose was 4.072 ± 2.004 mSv. All the age groups received an almost similar effective dose with the maximum mean effective dose in age group 1-18 years (5.58 ± 2.27 mSv).

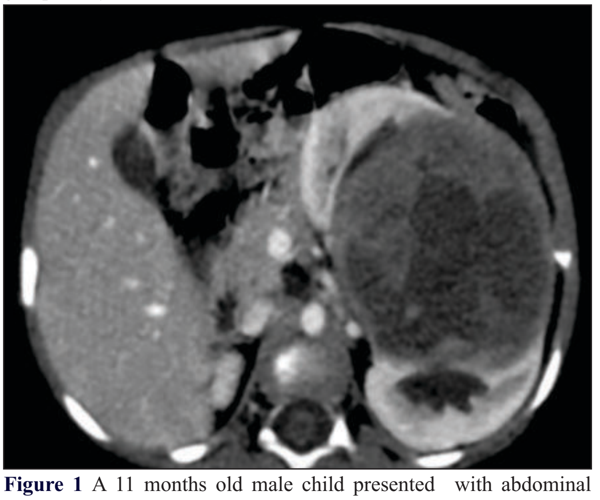

Figure 1 A 11 months old male child presented with abdominal distension for 2 months. FIGURE 1- Axial split bolus CTU image shows a well defined , heterogeneous mass lesion arising from mid pole of left kidney making claw sign.This is the case of left renal Wilms tumor.

Figure 2 A 18 year old boy with right sided flank pain with PUJ Obstruction. FIGURE 2- Coronal MIP image shows segmental branch of renal artery (red arrow) and renal vein (blue arrow) crossing the pelvis at the level of PUJ obstruction.

DISCUSSION
Our split bolus protocol was in line with most of the studies in terms of contrast allocation ratio, so as to achieve better enhancement of vessels and parenchyma.We acquired the scan after 80 seconds of second contrast bolus (compared to 60-120 seconds in other studies) for two main reasons: for better visualization of renal masses which may help in preoperative planning, and better characterisation of cysts.

The mean renal cortex and medulla enhancement obtained in our study (186.62 + 28.41 and 145.51 + 25.36 respectively) was slightly lower than that mentioned by Chen et al (1) (202.5 + 30.75 and 151.9 + 25.48) who used less scan delay times compared to our study. Lee et al(2),who compared image quality differences with contrast allocation ratio also have reported mean attenuation of renal cortex and medulla as 142.9 + 18.8 and 186.8 + 22.5 HU respectively. This is probably due to the longer scan delay time used in their study (70 seconds).

One of the problems we addressed while qualitatively analysing the images was that in many cases of obstruction such as PUJO the ureteral segment distal to obstruction did not opacify, which is indeed anticipated. The mean opacification scores for such patients reduced drastically. Thus we calculated the corrected opacification score based on the number of segments that were expected to be opacified as described earlier in the text. To our knowledge none of the previous studies done in adults with urinary tract obstruction have addressed this problem. The mean opacification score and corrected mean opacification score for our study were 7.158+1.292 and 7.696+ 0.678 respectively. This correction method can also be used for evaluating split bolus CTU in Adults and children in further studies.

The effective radiation dose exposure for the typical three phase CT Urography acquisition ranges from 15-40 mSv as described in previous studies (1,2,3). With omission of an unenhanced as well as delayed scan, the radiation exposure with our protocol can be as low as 0.064 mSv. The overall mean radiation dose calculated in our study was 4.072+ 2.004 mSv (Range 0.064-8.08). Bombinski et al reported mean effective doses in the range of 1.14 to 2.32 mSv in various weight groups in their low dose CT Urography protocol (3). The higher mean effective dose in our study may also be attributed to the additional delayed scans acquired.

CONCLUSION
Single phase split bolus CTU protocol used in our study provides excellent renal parenchymal enhancement and adequate opacification of the collecting system for evaluation of kidney and urinary tract in children and adults in most of the cases with good diagnostic accuracy and minimal radiation exposure. It is also helpful in accurately diagnosing complications such as infections and renal strictures in these patients. It can be used as an alternate diagnostic tool in resource limited settings where MRI is not available.

Corrected opacification score' may be considered a new visual tool for adequate and optimal imaging of pediatric and adult urinary system.

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