MULTISLICE COMPUTED TOMOGRAPHY UROGRAPHY (MSCTU): A DESCRIPTIVE STUDY USING THE “SPLIT- BOLUS” TECHNIQUE

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Abstract

Multislice computed tomography (MSCT) provides high spatial and temporal resolution images in addition to high quality multiplanar and threedimensional reconstructions. As a result of its diagnostic efficacy the Computed Tomography Urography (CTU) has become the technique of choice for evaluating the urinary tract, virtually replacing the traditional urography examination. At Padre Hurtado Hospital, Santiago, Chile, we conducted a retrospective analysis to review our experience with CTU scanning and split-bolus technique, which has the potential to yield a synchronous nephrographic and excretory phase of the urinary system, thus reducing radiation dose for patients, number of images, and costs generated by conventional MSCT urography. A series of 31 cases is presented, along with description of techniques applied as well as study main findings.

Keywords: Genitourinary system, Radiation dosage, CT Urography, Split-bolus technique.


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Introduction

Currently, multislice computed tomography (MSCT) technique produces not only images of high spatial and temporal resolutions but also high quality multiplanar and three-dimensional reconstructions. Due to this capability, Computed Tomography Urography (CTU) has become the technique of choice for evaluating the urinary tract (1), practically replacing conventional urography (2), mainly in patients with hematuria and risk factors for urothelial cancer (3).

CTU allows a comprehensive evaluation of the urinary tract (collecting system, ureters, and bladder) and its main purpose is the detection and characterization of urothelial malignancies (4). It is also useful in the visualization of urinary lithiasis, kidney tumors, evaluation of traumatic or infectious lesions, and congenital malformations (3); additionally, it allows assessment of the complete abdominal and pelvic area, which is useful for both the staging of patients with urinary tract malignancies and the diagnosis of extraurinary tract pathology (2).

Traditionally, CTU has been performed according to the following procedures:
• Acquisition of images prior to intravenous contrast administration for detecting urolithiasis.
• A second image acquisition in corticomedullary phase is carried out after administration of IV contrast agent; a third acquisition is performed during nephrographic phase, whereas a fourth image acquisition is obtained during the excretory phase (3, 4).
• If a proper opacification of structures needing evaluation has not been achieved, additional image acquisition at a later stage is carried out.

Different protocols have been developed in order to optimize this technique aimed at diminishing the effective radiation dose received by patients (4, 5). Within these protocols, the application at different times of a split-bolus IV contrast medium technique and a subsequent single image acquisition—by synchronizing nephrographic and urographic phases—has proved to be a feasible alternative (5, 6).
The main goal of this retrospective descriptive review is to identify and present the most important findings in our series of patients, which were studied due to diverse pathologies, i.e., tumors of the urinary tract, congenital malformations, and other acquired diseases. Protocol used in our institution will be described in detail and results obtained by applying this technique will be shown.

**Materials and methods**

We conducted a retrospective assessment of CTU images with split-bolus technique, which was performed at the Imaging Service of Hospital Padre Hurtado, Santiago, Chile, between July 2007 and July 2008, involving 31 patients referred for evaluation of hematuria or other urinary tract diseases. We excluded patients with serum creatinine greater than 1.5 mg / dl. All tests were performed on a 16-row multislice computed scanner (Toshiba Aquilion), using standardized technical parameters (Table 1).

**Table 1. Technical parameters used**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>mA</td>
<td>400 mA</td>
</tr>
<tr>
<td>kV</td>
<td>120 kV</td>
</tr>
<tr>
<td>Pitch</td>
<td>1.5 1b</td>
</tr>
<tr>
<td>Collimation</td>
<td>1 x 16 mm</td>
</tr>
<tr>
<td>Rotation time</td>
<td>0.5 sec</td>
</tr>
<tr>
<td>Reconstruction filter</td>
<td>2 (soft tissue)</td>
</tr>
<tr>
<td>Average time</td>
<td>18.21 sec.</td>
</tr>
<tr>
<td>Estimated radiation dose</td>
<td>560 mGy cm</td>
</tr>
<tr>
<td>Reconstruction</td>
<td>1 c / 0.8 mm</td>
</tr>
</tbody>
</table>

Thin sections of each study were stored on two CD-ROMs (1mm c / 0.8 mm) to subsequently being reevaluated on a Vitrea ®2 workstation (Vital Images Inc., Minnetonka, USA) by two experienced radiologists in abdominal and pelvic MSCT image interpretation. Depending on the findings, multiplanar reformatting, MIP, and VR images, were performed.
The following protocol was used:

1. Technical parameters
   • Described in Table 1.

2. Details involved in the course of the MSCTU examination
   • The patient should drink 500 to 700 ml of water, while staying in the waiting room.
   • Once in the scanner table, with the patient in the supine position, both a scout image and an acquisition without contrast, from the T12 vertebral level to 2 cm below the pubic symphysis, are performed.
   • Then, with the digital timer to 0 (t = 0) 100 ml of non-ionic contrast medium, Ioversol, 320 mg / ml (Optiray®, Tyco Healthcare, Hazelwood, USA) (2-3 ml / sec) are intravenously injected.
   • The patient stands up and walks in the scanner room.
   • At 6 minutes (t = 6 min), the patient is placed on the table in the supine position and a new scout image is obtained.
   • At 9 minutes (t = 9 min) the patient is injected 50 ml more of the same intravenous contrast and a new acquisition is achieved, this time from the diaphragm to the symphysis pubis. Thus, both pyelographic and nephrographic phases of the urinary system are obtained in just a single acquisition (Figure 1).
   • If ureters are not fully opacified or a proper delimitation of the bladder wall is not obtained, the patient should be placed in the prone position to perform a third and final image acquisition, with no additional wait time.

Figure 1(a), (b), and (c). (a) Coronal MPR image, normal kidney in the nephrographic phase and simultaneous contrast of the excretory system. (b) Coronal MIP showing complete opacification of the excretory system and bladder. (c) Volume Rendering (VR) image in postero-anterior view, depicting the anatomy of the renal and excretory systems as well as bladder anatomy

Results

Thirty-three (33) CTUs with split-bolus technique were performed in 31 patients,
including 16 males and 15 females, with an average age of 54.4 years (range from 17 to 87 years).

Forty-eight percent (48%) of patients were referred with the diagnosis of hematuria; 12% for evaluation of congenital malformations, and 9% for hydronephrosis of unexplained etiology. Other diagnoses included recurrent urinary tract infections, urinary tract tuberculosis, and actinic cystitis.

Eighty-four percent (84%) of the tests were positive for urinary system pathology, most of which corresponded to benign disorders (63%), such as renal cysts, infectious lesions, congenital malformations, or anatomic variants (Figures 2-6) and urolithiasis.

Figure 3 (a)-(d). (a) Axial image showing annular thickening of the right middle ureter. (b) Coronal MPR view of the same patient where thickening of inflammatory aspect of the proximal ureter is depicted. (c) and (d) 3-D MIP and VR images of the same patient showing infundibuliform stenosis of the distal left ureter.

Figure 2 (a) and (b). (a) Coronal MPR showing left hydronephrosis associated with severe cortical thinning. There is a diffuse wall thickening of the ureter with no lumen and with inflammatory changes of periureteral fat. Tuberculosis was confirmed by urine bacilloscopy. (b) Coronal MPR images of the same patient showing indemnity of the right excretory system.

Figure 4 (a) and (b). (a) Coronal oblique MPR depicting horseshoe kidneys, with complete parenchymal bridge joining the lower poles. (b) Axial image in nephro-urographic phase of the same patient, where a corticomedullary area of decreased attenuation in the right kidney is shown, consistent with focal pyelonephritis.

Figure 6 (a) and (b). (a) VR images showing bilateral double excretory system, with atrophy of the right inferior system. (b) Coronal oblique MPR of the same
patient, depicting right renal atrophy with marked cortical thinning of the inferior system.

**Figure 5 (a) and (b).** 3D-MIP and VR images showing renal ectopia with left pelvic kidney.

**Figure 7 (a) and (b).** Axial and coronal MPR images, where a intravesical polypoid tumor compromising both the ureterovesical junction and the distal right ureter is observed.

**Figure 8 (a) and (b).** Axial and coronal MPR images showing a large bladder tumor with endophytic growth and extraserous involvement, along with infiltration of the trigone and left ureterovesical junction. Some ipsilateral iliac lymph nodes are also seen.

**Figure 9.** Coronal MPR image showing a solid exophytic tumor in the upper pole of right kidney with small calcifications in its thickness, compatible with renal cell carcinoma.

Malignancy was detected in 12% of the studies conducted: 3 urothelial neoplasms (Figures 7, 8) and a hypernephroma (Fig. 9), all of them verified by a pathologic study.

A 15% of the studies were normal. Extra-urinary pathology was detected in 27% of examinations performed, including cholelithiasis, inguinal hernia containing part of the bladder, thrombosis of the vena cava, and diverticular disease.

**Discussion**

CT urography with split-bolus technique is a highly reliable and efficient method for assessing urinary tract pathology, since it allows characterization of urothelium, from the renal collecting system to the bladder, in a short period of time (4).
This technique reduces the effective radiation dose received by the patient, through elimination of one or more of the phases performed during conventional CT urography. This is a relevant fact if we consider that most of our patients presented benign pathology of the urinary system, which is consistent with outcomes published in medical literature (5). Additionally, this technique generates fewer images, thus facilitating interpretation (6).

The protocol used in this study incorporates a digital scout image obtained at 6 minutes to increase the probability of visualizing the opacified ureter with a minimal rise of radiation dose, thus ensuring a high quality examination (7). One of the drawbacks of this technique deals with the evaluation of neoplasms that produce minimal bladder wall thickening, where a sensitivity of 74% has been reported (5). However, it should be considered that in patients with hematuria and risk factors for urothelial malignancy a conventional cystoscopy—the diagnostic procedure that remains the gold standard method for evaluating the bladder mucosa—have to be performed (4). In our series there were three cases of bladder cancer, all of them with transmural involvement, so the presence of contrast in the lumen was not a limiting factor in its evaluation. This technique, though it does not considered an arterial or corticomedullary phase, still exhibits an adequate performance for detection of renal cell carcinoma (5); the four neoplasms detected in our series had an adequate anatomo pathological correlation.

Summarizing, we can say that according to our experience this technique—which reduces radiation exposure to patients—is useful in studying diseases of the urinary tract, showing results similar to those reported in the literature.
References
