Evaluation of Upper Urinary Tract Dysfunction in Patients with Spinal Cord Injuries

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INTRODUCTION

Upper urinary tract deterioration and renal dysfunction have been reported as the leading causes of long-term morbidity and contributing causes of mortality among patients with spinal cord injuries (SCIs) [1]. A suprasacral neurologic lesion usually produces hyperreflexic contractility of the detrusor muscle with sphincter dyssynergia. An overactive bladder with high outlet resistance may induce a prolonged elevation of intravesical pressure that can functionally obstruct the upper tracts and increase the risk of hydronephrosis [2]. In patients with a sacral lesion, the urodynamic patterns are characterized by detrusor areflexia and subsequent low bladder compliance, which also predisposes them to hydronephrosis. The essence of prevention of upper tract complications lies in monitoring programs.

The upper tracts can be followed morphologically, or functionally. The morphological follow-up includes excretory urography (EXU), and ultrasonography. Direct measurement of individual renal function can be made by radionuclide studies with gamma camera renography. Biochemical analysis of blood urea nitrogen and creatinine level, or measurement of the creatinine clearance rate all reveal global renal function, and therefore have very limited roles. The relative merits of EXU, ultrasonography and radionuclide renography will be discussed.

EXCRETORY UROGRAPHY

The mainstay of urological follow-up in spinal injury departments had been the EXU, because it can provide the most detailed look at the entire urinary system, localize the site of obstruction, and often lead to a specific diagnosis. However, the cumulative radiation dose and the expense in time, both for the patient and spinal injury department militate against this type of follow-up regimen. In addition, overnight fasting and bowel preparation are required for an EXU, which can prove particularly burdensome for patients with neurogenic bladder and bowel disturbances. Furthermore, severe reactions from contrast material occur occasionally, and limited information is yielded in the presence of compromised renal function [3].

In the Marcos et al study, 75 SCI patients with neurogenic bladder dysfunction who were having routine assessment of the upper urinary tract had both EXU and renal ultrasonography. It was concluded that a combination of plain radiography of the abdomen and ultrasound scanning of the kidneys was a cheap, safe and reliable alternative to intravenous urography for regular follow-up of these patients. EXU should be performed if new abnormalities are demonstrated or if ultrasonography is unsatisfactory [4].

In a study of me and my colleagues, a total of 235 kidneys were analyzed by EXU, sonography and radioisotope renography. The sensitivity of sonography in detecting upper tract dilatation was 0.96 with a specificity of 0.90. Radioisotope renography reached a sensitivity of 0.91 with a specificity of 0.84. It was suggested that sonography and radioisotope renography are safe, sensitive, and specific for detecting hydronephrosis. Combined use of both methods appears to be a reliable alternative to EXU in the long-term follow-up of patients with SCI with neurogenic bladder dysfunction [5].

RENAL ULTRASONOGRAPHY

Ultrasonography is a noninvasive, reproducible screening test for the bladder and kidneys which involves no radiation, has no adverse effects, requires no preparation, and is independent of renal function. It is effective in the evaluation of urinary calculi, renal and bladder masses, bladder volume, bladder wall changes, renal size, and thickness of the renal cortex, as well as dilatation of the upper urinary tract (proximal hydroureter and pyelocaliectasis).

Diagnosis of hydronephrosis is the single most important determination in the periodic urologic evaluation of SCI patients. Hydronephrosis on the sonogram is graded from 0 to IV according to criteria developed by the Society for Fetal Urology. In grade 0, there is no separation over the central echo complex. Grade I hydronephrosis shows dilatation of the renal pelvis only. With grade II hydronephrosis, the renal pelvis and a few calices are dilated. A diagnosis of grade III hydronephrosis requires that all calices be dilated. Grade IV hydronephrosis may have an appearance similar to grade III, but the renal cortex over the calices is thinned. An atrophied or contracted kidney is a small kidney (less than 8 cm in an adult) with a thinned cortex [6] (Fig. 1).

Diuresis and bladder filling increase pelvic pressure and ureterovesical outflow resistance, consequently enhancing pelvic and ureteric dilatation. In a study of renal sonography of 140 kidneys, sonography was done after patients drank 300-500 mL of fluid to induce a physiologically full bladder. The results showed that performing sonography with a full bladder increases the sensitivity of detection of hydronephrosis from 83.3% to 95.8%. If the hydronephrosis disappears after voiding, the condition is mild, and conservative management such as medication, and timed complete emptying of urine, may be helpful. If hydronephrosis persists after voiding, more aggressive intervention should be given to prevent deterioration of renal function [7].

A pulsed Doppler study of the kidney is a useful adjunct examination in renal sonography. When a simple central sinus echo separation

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is noted, Dopper study can differentiate vascular origin from grade I hydronephrosis. In 1989, Platt et al studied the value of the resistive index (RI) calculated from the duplex Doppler waveform in distinguishing obstructive hydronephrosis from non-obstructive hydronehrosis, and 0.70 was suggested as the upper limit for a normal RI [8]. Conventional sonography and Doppler study were performed in 51 SCI patients, and average RIs were 0.58±0.07 in the normal group (71 kidneys), and 0.65±0.08 in the obstructive uropathy group (28 kidneys). The RI values of the kidneys in patients with obstructive uropathy were obviously higher than those in the normal group. However, the sensitivity of using RI ≥ 0.7 to identify patients with obstructive uropathy was not high (39%) [9]. In SCI patients, changes in lower urinary tract function cause "chronic" "partial" obstruction of the upper urinary tract. This may explain the difference in the results of this study from the "acute" "complete" obstruction of previous studies [8,10]. However, an abnormally high RI value is still a relatively high risk parameter indicating the necessity for aggressive intervention.

RADIOISOTOPE RENOGRAPHY

Radioisotope renography is a procedure to measure the glomerular filtration rate (GFR) or effective renal plasma flow (ERPF) of each kidney separately after injection of radionuclides. Tc-99m diethylenetriamine pentaacetic acid (DTPA) is excreted solely by glomerular filtration and is used for studies of renal perfusion and split GFR measurements. Tc-99m mercaptoacetyltriglycine (MAG3) is mostly cleared by tubular secretion and is used to evaluate tubular function and measure split ERPF. Alteration in renal tubular function probably happens earlier than in glomerular function as a result of urinary tract obstruc-tion. Hence, measurement of the ERPF could provide earlier information in regard to the adverse effects of neurogenic bladder dysfunction on upper urinary tracts [3].

In renography study, excretion delay precedes the decrease of ERPF. The time-activity curves can be classified into 6 groups corresponding to the progression of urinary tract obstruction and renal damage (see Table 1 and Fig 2). Curve A indicates normal kidneys. Kidneys with curves B or C retain a normal ERPF value, and appropriate urological management could effectively preserve renal function. In kidneys with curves D or E, excretion delay could be improved after effective urological management, but the renal damage is irreversible [11]. Kidneys with curve F are already severely contracted and have a grave prognosis.

Radioisotope renography has been used routinely as a urological survey tool for 15 years in our center, and we have found that Tc-99m MAG3 renography is an acceptable, safe, noninvasive and sensitive screening test for long-term urological surveillance in patients with SCI. For patients with normal renograms, cumbersome and unpleasant examinations such as EXU and video-urodynamic studies are not recommended. The advantages of radioisotope renography may improve its acceptability, encourage better compliance by patients with SCI in undergoing routine urological follow-up studies. It may minimize medical expenses as well.

CONCLUSION

Long-term follow-up of the urinary tract, even in asymptomatic patients, plays a key role in preservation of renal function in SCI patients. Renal sonography and radioisotope renography are safe and effective as first line screening tests. Other invasive tests, such as VUDS, EXU, and cystoscopy, are needed for decisions on further urological intervention only when a new abnormality is detected.

Table 1. Definition of Various Time-Activity Curves in Radioisotope Renography

Curve A:	Normal ERPF, Tmax < 7.5 min, T 1/2 < 9 min, RI > 40%
Curve B:	Normal ERPF, Tmax > 7.5 min or T 1/2 > 9 min, Tmax + T 1/2 < 30 min
Curve C:	Normal ERPF, Tmax < 7.5 min, T 1/2 < 9 min, Tmax + T 1/2 > 30 min
Curve D:	Decreased ERPF or RI < 40%, Tmax + T 1/2 < 30 min
Curve E:	Decreased ERPF or RI < 40%, Tmax + T 1/2 > 30 min
Curve F:	ERPF < 40 mL/min

ERPF: effective renal plasma flow; Tmax: peak time; T 1/2: half clearance time; RI: renal index (split ERPF/total ERPF)

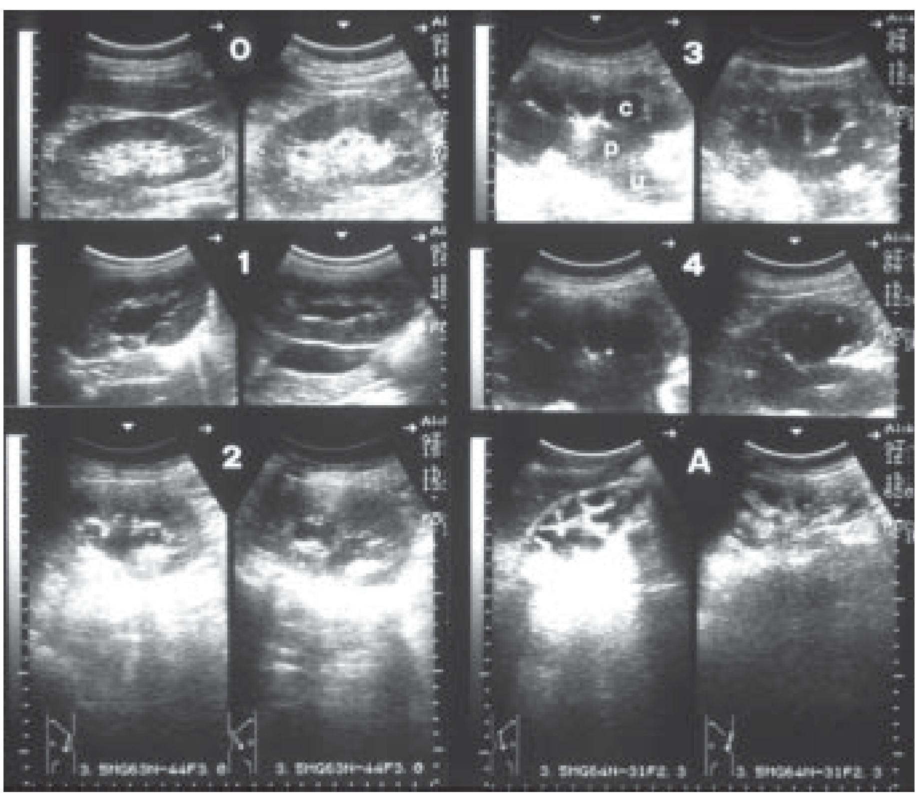

Fig. 1. Renal sonograms showing normal (0) to grade I-IV hydronehprosis, and atrophied kidneys (A).

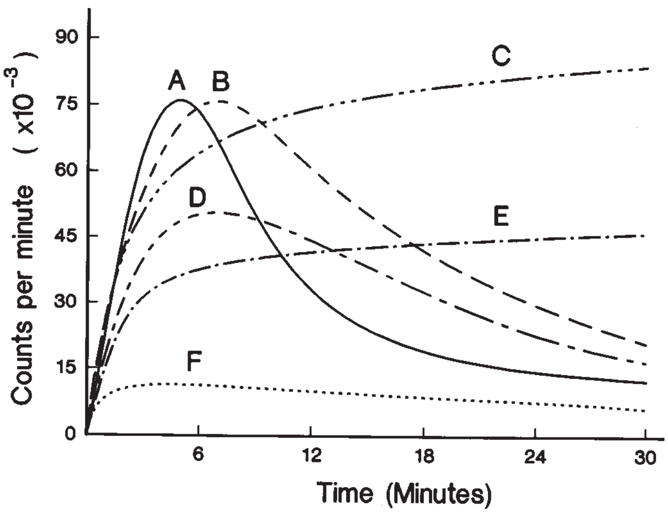

Fig. 2. Time-activity curve patterns (A to F) of radioisotope renography with Tc-99m MAG3.

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