Renal Ultrasound Correlates with Renal Nuclear Scan in Upper Tract Surveillance of Spinal Cord–Injured Patients

Angelo E. Gousse, David S. Meinbach, Robert R. Kester, Sanjay Razdan, Sandy S. Kim, Kapil Pareek, Line Leboeuf, David A. Weinstein, and Marcalee Sipski

Purpose: Renal ultrasound (RUS), renal nuclear scan (RNS), and intravenous pyelogram (IVP) are the most common studies used for surveillance of upper urinary tracts of spinal cord–injured (SCI) patients with neurogenic bladder (NGB). There is lack of consensus regarding which upper urinary tract studies should be incorporated in the routine surveillance protocol of SCI/NGB patients. We sought to determine if it is necessary to include both RUS and RNS as part of routine upper tract surveillance in SCI patients. Materials and Method: We retrospectively reviewed the medical records, including RUS and RNS reports, of 178 SCI patients treated at the Miami VA Medical Center during the years 1996–2001. The mean age was 56 years (range, 22–84 years). Of these 178 patients, 162 had a total of 478 paired and matched RUS and RNS studies (i.e., one RUS and one RNS, generally scheduled within 48 hours of each other) suitable for analysis. 16 patients were omitted from the study because they lacked paired and matched studies. The RUS and RNS studies were interpreted separately by different radiologists, and the findings were subjected to statistical analysis to find correlation between them, using Goodman and Kruskal's gamma coefficient. Results: Patients' levels of injury included cervical (74), thoracic (76), lumbar (21); in 7 patients, the level of SCI was unrecorded. Management of the patients consisted of spontaneous voiding with or without Crede (91), clean intermittent catheterization (42), sphincterotomy (30), and indwelling catheter (40), either suprapubic or Foley. In 361 paired and matched studies, both RUS and RNS were normal. In 56 paired and matched studies, both were positive for an upper tract abnormality. In 42 other paired and matched studies, the RUS was negative and the RNS was positive. In the final 19 paired and matched studies, the RUS was positive and the RNS was negative. The gamma coefficient between RUS and RNS was 0.924 ($p < .005$). Conclusion: Upper urinary tract surveillance of SCI patients can be performed solely with RUS, which is noninvasive, widely available, and less costly than RNS. Additionally, RUS provides anatomic information about the upper tracts not shown on RNS. By incorporating yearly RUS study of SCI patients, further upper tract imaging can be reserved for those cases in which the RUS reveals positive findings. Key words: *hydronephrosis, renal nuclear scan, renal parenchymal disease, renal ultrasound, spinal cord injury*

Angelo E. Gousse, MD, *is Assistant Professor, Department of Urology, and is Director of Female Urology, Voiding Dysfunction and Reconstructive Surgery, University of Miami School of Medicine, Miami, Florida.*

David S. Meinbach, MD, *is Resident in Urology, University of Miami, Florida.*

Robert R. Kester, MD, *is Urologist.*

Sanjay Razdan, MD, MCh, *is Resident in Urology, University of Miami, Florida.*

Sandy S. Kim, MA, MEd, *is Database Manager, University of Miami, Florida.*

Kapil Pareek, MD, *is Resident in Urology, University of Miami, Florida.*

Line Leboeuf, MD, *is Fellow in Female Urology and Voiding Dysfunction, University of Miami School of Medicine, Florida.*

David A. Weinstein, *is Technical Director, Urodynamics Laboratory, VAMC, University of Miami, Voluntary Assistant Professor, University of Miami School of Medicine, Florida.*

Marcalee Sipski, MD, *is Associate Professor of Neurological Surgery, University of Miami School of Medicine, and VA Rehabilitation Research and Development Center of Excellence in Functional Recovery in Chronic SCI, Miami, Florida.*

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Spinal cord injury (SCI) is a significant problem in the United States and affects over 200,000 people. It has been estimated that approximately 10,000 new cases will occur annually.[1–3] Prior to the advent of aggressive lower urinary tract management and upper urinary tract surveillance, renal failure was the most common cause of death in SCI patients and accounted for 40% of deaths in this population.[4] Advances in the management of SCI patients have led to improved survival and quality of life in this population.

To continue this positive trend, regularly scheduled evaluation of the upper urinary tracts in SCI patients is imperative. These follow-up exams are typically performed annually; more frequent follow-up has not been shown to be cost effective.[5] For many years, intravenous pyelogram (IVP) was the standard urologic imaging tool for upper tract surveillance in SCI patients. However, the advent of new diagnostic imaging techniques in the 1980s led to the initiation of renal ultrasound (RUS)[6] and renal nuclear scan (RNS)[7,8] as tools to evaluate the upper urinary tracts.

Previous studies have recommended the combined use of RUS with RNS as a substitute for the IVP in SCI patients.[9,10] Many SCI centers now utilize RNS for routine yearly testing in all patients or on an alternating basis with IVP.[1] However, no data indicate that nuclear scan is necessary in SCI patients with a normal renal ultrasound. Because both RUS and RNS have been routinely obtained annually at our institution, we sought to determine the concordance between these two studies and to ascertain what clinical information might be missed by omitting RNS as part of routine surveillance. The impetus to eliminate the RNS study was to improve clinical efficiency and to diminish cost, while simultaneously maintaining high quality urologic care.

Materials and Method

We retrospectively reviewed the medical records of 178 spinal cord–injured patients from the Spinal Cord Unit of the Miami VA Medical Center in Miami, Florida. All patients with SCI were routinely scheduled to have annual RUS and RNS for upper tract surveillance; the two tests were generally scheduled within 48 hours of each other. Patients who had undergone both RUS and RNS during the preceding 5 years (1996 to 2001) were eligible for inclusion in the data analysis. The RUS and RNS studies were interpreted by different radiologists, each one unaware of the other diagnostic modality's interpretation.

RUS was performed in the supine position, with the patient being turned either to the right or to the left side to facilitate imaging of the respective kidney. The kidneys were imaged with a 4 MHz transducer, except in thin patients when a 5 MHz transducer was used. Transverse and longitudinal views of each kidney were obtained. A bladder catheter was in place to ensure adequate drainage. A RUS study was judged to be positive if it demonstrated any degree of caliectasis or pyelocaliectasis; parenchymal disease (based on cortical thickness and echogenicity); or the presence of complex cysts, calculi, solid masses, or other renal and/or peri-renal processes. For the purpose of the study, simple renal cysts were not considered an abnormality because they did not dictate any change in patient management.

Prior to the RNS, there was no special

bowel preparation. Patients were well hydrated, and a Foley catheter was placed to avoid artifacts from bladder overdistention such as vesicoureteral reflux. MAG-3 (Technetium-99m mercaptoacetyltriglycerine, or Tc-99m) with a dosage of 4 mCi was injected intravenously. The radioactivity of both kidneys was detected by gamma scintillation camera. The background activity was subtracted to obtain the net activity on each kidney over a period of 30 minutes. The number of Tc-99m gamma emission counts was measured at the highest point of radioactivity per minute over the kidney (peak time). Half-clearance time (t½) was calculated from the peak time to the point when half of the radioisotope activity disappeared from the kidney.

Each RNS scan was categorized as 1, normal curve; 2, impaired perfusion and function (determined by peak counts); and 3, delayed excretion with a prolonged t½ > 15 minutes, suggestive of obstruction. Both the effective renal plasma flow (ERPF) and the renal index data were unreported by the radiologists.

Data were collected for paired and matched studies (defined as one RUS and one RNS performed within the same time frame), and any abnormality detected by RUS or RNS was noted regardless of its clinical severity.

Statistical analysis

Goodman and Kruskal's gamma coefficient was utilized as our symmetric measure of association to analyze RUS and RNS findings, thereby standardizing the difference between the number of concordance and discordance pairs.[11] A positive gamma indicates that there are more concordance pairs than discordance pairs. That is, there is a positive relationship between the variables.[12] The gamma coefficient is preferable to Spearman R or Kendall tau when data contain many tied observations.

Results

The mean age of the 178 patients with SCI was 56 years, with an age range of 22 to 89 years (**Table 1**). The patients' levels of injury included cervical (74), thoracic (76), and lumbar (21). In 7 patients, the level of injury was not found in the records. Bladder management of the patients consisted of spontaneous voiding with or without Crede (91), clean intermittent catheterization (42), sphincterotomy (30), and indwelling catheter (40), either suprapubic or Foley. Several patients had required more than one type of bladder management. As seen in **Table 2**, the average time elapsed since injury was more than 10 years in most patients (average, 23.9 years).

Sixteen patients had to be omitted from the study because they lacked paired and matched studies. A total of 478 paired and matched studies were analyzed from the remaining 162 patients, for an average of 2.95 paired study comparisons per patient. Three hundred sixty-one paired and matched RUS and RNS studies were determined to be normal. In another 56 paired and matched studies, both were positive for an upper tract abnormality. In 42 paired and matched studies, the RUS was negative and the RNS was positive; whereas in the final 19 paired and matched studies, the RUS was positive and the RNS was negative (**Table 3**).

RUS found abnormalities in 57 patients (35.2%). Of the 75 positive ultrasound studies, 39 were positive for hydronephrosis, 39 revealed parenchymal disease, 22 revealed

Table 1. Age distribution of patients

Age (years)	No.
21–40	22
41–60	64
61–80	59
>80	7

Table 2. Years removed from injury

Years from injury	No.
<10	40
11–20	35
21–30	25
31–40	23
41–50	14
> 50	13

Table 3. Breakdown of RUS versus RNS

RUS	RNS	No. of paired studies
–	–	361
+	+	56
–	+	42
+	–	19

Note: RUS = renal ultrasound; RNS = renal nuclear scan.

renal stones, and 8 revealed solid renal mass (renal malignancy found in 2 of these 8 patients). Many ultrasounds had more than one pathologic finding. We found 19 cases of hydronephrosis and/or parenchymal disease that were noted on renal ultrasound but not on renal scan.

RNS detected abnormalities in 51 patients (31.5%). Of the 98 positive RNS, 73 had decreased perfusion and/or function, which was often a mild finding. Renal obstruction was suspected in 25 RNS studies; 14 had RUS confirmation, while 11 occurred in the RUS(–), RNS(+) group. In six of these, a follow-up RNS was performed that proved to be normal. The remaining 5 RUS(–), RNS(+) studies came from two patients, and both were found to be obstructed on further testing.

The gamma coefficient between RUS and RNS was 0.924 ($p < .005$), indicating a highly significant correlation between these two upper tract studies.

Discussion

The primary goal of this investigation was to determine if RUS could reliably be used as a sole modality for yearly monitoring for the detection of upper tract abnormalities in SCI patients with neurogenic bladder (NGB). If its concordance with RUS was found to be high, then RNS might be safely dropped from routine use as a yearly upper tract screening test. The results indicate an excellent concordance between RUS and RNS. Out of 478 paired and matched RUS and RNS study comparisons, 417 correlated for a gamma coefficient of 0.924 ($p < .005$).

Our patients underwent both RUS and RNS yearly in their follow-up evaluations, and we evaluated an average of 2.95 paired and matched studies per patient. The average time since injury in this study was 23.9 years. We found that 35.2% of patients had an abnormality on RUS, and 35.2% had an abnormality on RNS. The number of patients with abnormal studies is not unusual. In a mean 5-year follow-up, McKinley et al.[13] found that 10.6% of patients had abnormal renal tests; this increased to 25.9% by a mean of 20 years, which shows that there is a relationship between renal deterioration and time removed from injury.

Although the majority of studies correlated, it is important to examine those studies that did not. The present report lacks an IVP as a reference, so it is not possible to comment on which study (between RUS and RNS) is correct when there is discordance between the two. We found 19 RUS studies to be positive for hydronephrosis or parenchymal disease that were not found on RNS. This may be because RUS is more sensitive at detecting hydronephrosis than RNS. A recent study performed by Tsai et al. demonstrated the reliability of ultrasound and nuclear scan in revealing the existence of hydronephrosis.[10] By comparing the results with the IVP (or clinical diagnosis in the nine patients unable to tolerate IVP), the sensitivities of RUS and RNS were calculated to be 96% and 91%, respectively. Thus, RUS was not only reliable in diagnosing hydronephrosis, but it was more sensitive than RNS.

When looking at the reverse situation, we found 42 cases in which the RNS was positive but the RUS was normal. Some of these nuclear scans may have been falsely positive. The Tsai et al. study found false-positive rates for nuclear scan to be 16% and for the renal ultrasound to be 10%. While our study does not have the benefit of IVP results to check against, one can use the Tsai et al. study to state that RNS produces more false-positives than RUS,[10] which may partially explain the higher number of RNS(+), RUS(–) results in our study.

Discordance could be due to the conditions under which the studies were performed. RNS may show retention of radioactivity if the patient is inadequately hydrated. The position of the patient may lead to a false-positive study, as it can give the appearance of retained cortical activity. A prior report determined that RUS more accurately detected the presence of hydronephrosis if the bladder was full.[14] Since renal ultrasound in our study was performed with a catheter in place, and the bladder decompressed, increased false-negative ultrasounds could occur, increasing discordance between the paired and matched studies.

Although it is possible that hydronephrosis or other upper tract pathology may be overlooked by omitting a nuclear scan, the abnormality may be so mild as to be clinically irrelevant. Bodner et al.[15] performed a small study of in-office renal ultrasounds (read by urologists) that were compared to the findings of other diagnostic modalities. The authors found one instance of nonobstructive hydronephrosis that was missed by ultrasound, but no cases of hydronephrosis related to obstruction were missed.

In our cases, when RNS noted an abnormality that RUS did not, the nuclear scan abnormality was primarily decreased perfusion and/or function rather than obstruction. While decreased perfusion and/or function may be representative of mild amounts of damage to the kidneys that, over time, could result in significant parenchymal disease, these patients generally have other symptoms that would lead the urologist to perform a more in-depth work-up.

It is known that both RUS and RNS are technician and interpreter dependent. Suboptimal technique may lead to inappropriately negative interpretation. Reader-to-reader variation may occur. For example, in three of our cases, RUS was initially reported to show calyceal dilation, but another radiologist later retrospectively determined the same findings as being secondary to simple renal cysts.

Besides the excellent correlation with RNS, other data argue in favor of a yearly renal ultrasound. RUS provided anatomical information that was not reliably noted on RNS. In addition to identifying hydronephrosis and renal parenchymal disease, in 39 and 39 studies, respectively, RUS also picked up renal stones in 22 scans and solid renal masses suspicious for malignancy in 8. These findings would have gone undetected, and ultimately may have caused increased patient morbidity and mortality, if RUS were not used for surveillance.

The highly significant gamma coefficient in our study – plus the finding that few cases of clinically important pathology were missed by renal ultrasound – support the conclusion that use of RUS for patients with SCI is an acceptable screening tool. Furthermore, the anatomical detail provided by ultrasound may give the practitioner additional clinical information that is not obtainable by RNS.

Conclusion

Functional abnormalities detected on RNS usually present with anatomically abnormal RUS, suggesting the correct diagnosis. Also, RUS can detect anatomical pathology that RNS cannot. Although there occasionally is discordance between RUS and RNS, we found, as have others, that RUS appears to be more sensitive than RNS for diagnosing upper tract pathology.

Upper urinary tract surveillance of SCI patients can be safely done by yearly renal ultrasound, which is less invasive, more available, and less costly. Yearly RNS can be safely omitted as part of the routine upper tract surveillance of SCI/NGB patients. Abnormal ultrasound findings can be further investigated by other modalities (such as RNS, IVP, CT scanning, and/or 24-hour creatinine clearance), depending on the clinical circumstances.

REFERENCES

1. Harvey C, Rothschild BB, Asmann AJ, et al. New estimates of traumatic SCI prevalence: a survey-based approach. *Paraplegia*. 1990;28:537.
2. Go BK, DeVivo MJ, Richards JS. The epidemiology of spinal cord injury. In: Stover SL, DeLisa JA, Whiteneck GG, eds. *Spinal Cord Injury: Clinical Outcomes from the Model Systems*. Gaithersburg, MD: Aspen Publishers; 1995:289–316.
3. Exner G, Meinecke F. 15 Jahre Anlaufstelle zur Vermittlung von Betten fur Querschnittgelahmte. *BG – Fachzeitschrift fur Arbeitssicherheit und Unfallversicherung*. 1992;12:778.
4. Donnelly J, Hackler RH, Bunts RC. Present urologic status of the World War II paraplegic: 25 year follow-up; comparison with status of the 20-year Korean War paraplegic and 5-year Vietnam paraplegic. *J Urol*. 1972;108:558.
5. Lloyd LK. New trends in urologic management of spinal cord patients. *Cent Nerv Syst Trauma*. 1986;3:3.
6. Brandt TD, Neiman HL, Calenoff L, et al. Ultrasound evaluation of the urinary system in spinal-cord-injury patients. *Radiology*. 1981;141:473.
7. Vera A, Merritt JL, Erickson BR. Renal function in spinal cord injury: a preliminary report. *Arch Phys Med Rehabil*. 1986;67:257.
8. Morcos SK, Thomas DG. A comparison of real-time ultrasonography with intravenous urography in the follow-up of patients with spinal cord injury. *Clin Radiol*. 1988;39:49.
9. Tempkin A, Sullivan G, Paldi J, et al. Radioisotope renography in spinal cord injury. *J Urol*. 1985;133:228.
10. Tsai S, Ting H, Ho C, et al. Use of sonography and radioisotope renography to diagnose hydronephrosis in patients with spinal cord injury. *Arch Phys Med Rehabil*. 2001;82:103.

11. Goodman LA, Kruskal WH. Measures of association for cross classifications. *J Am Stat Assoc*. 1954;49:732.
12. *SPSS 10.0 Guide to Data Analysis*. Upper Saddle River, NJ: Prentice-Hall, Inc.; 2000:362.
13. McKinley WO, Jackson AB, Cardenas DD, et al. Long-term medical complications after traumatic spinal cord injury: a regional model systems analysis. *Arch Phys Med Rehabil*. 1999;80:1402.
14. Bih LI, Tsai SJ, Dong LJ. Sonographic diagnosis of hydronephrosis in patients with spinal cord injury: influence of bladder fullness. *Arch Phys Med Rehabil*. 1998;79:1557.
15. Bodner DR, Witcher M, Resnick MI. Application of office ultrasound in the management of the spinal cord injury patient. *J Urol*. 1990;143:969.