An Expert System for the Detection of Renal Obstruction

TO THE EDITOR: We read with much interest the paper published by Garcia et al. (*1*) on an expert system for the diagnosis of renal obstruction using ^{99m}Tc-mercaptoacetytriglycine (MAG3) renography. Providing that an acceptable gold standard exists, a validated expert system may help an inexperienced observer in daily clinical work. Unfortunately, the diagnosis of renal obstruction is a matter of continuous controversy, because a gold standard is lacking. The only accepted definition of obstruction is indeed a retrospective one: "any restriction to urine flow, that left untreated, will cause progressive renal deterioration" (*2*). Thus, an expert system used for the diagnosis of renal obstruction should be based and validated on 2 series of patients with hydronephrosis, 1 corresponding to a simple dilatation, without any further renal deterioration, and 1 in which the conservative attitude resulted in kidney damage. The opinion of 3 experts, whatever the quality of their expertise, based on some renographic criteria, cannot be considered an acceptable substitute for a gold standard. Moreover, it is obvious that the renographic criteria on which the expert system relies, namely the MAG3 clearance and the parameters of drainage, are highly dependent on the way these parameters have been measured. As an example, let us examine critically the clinical case provided by the authors. The QuantEM renal quantification program designed by Taylor et al. (*3*) provides a reduced MAG3 clearance of 83 mL/min/1.73 m^2, and the relative uptake is symmetric, thus suggesting that both kidneys have impaired function. This is rather difficult to accept because at least the left kidney is considered nonobstructed and because the early renographic images reveal an early high renal uptake with rapid disappearance of the heart activity. The level of overall function is not unimportant, particularly if a low clearance is accepted by the expert program as a criterion for obstruction. Concerning the drainage, one can observe that both the renal curves and the renal pelvis curves of the basic renogram look very similar. Under furosemide, the time to half-maximum counts (T1/2) for the left kidney is paradoxically longer than that for the right kidney, simply because the initial activity is lower on the left side than on the right side. It is easy to understand that, at the limit, in the case of an empty kidney at the beginning of a diuretic test, the curve would be horizontal. In the present case, the likelihood of right obstruction is probably based on the pelvic T1/2, which is much shorter on the left side. One can, however, argue about the way the T1/2 was obtained, and the uncertainties about the way to define T1/2 have often been underlined (*4*). For the left kidney, a fit has been determined on the first 5 min, whereas for the right kidney the entire curve has been considered. Using equal time intervals for both fits would probably have provided approximately the same T1/2 values. In conclusion, such an expert system is undoubtedly a valuable tool for the interpretation of a renogram, but its introduction in clinical practice should be delayed until a better agreement is reached on the definition of obstruction, on the renographic parameters to be used, and on the criteria applied for defining these parameters.

REFERENCES

1. Garcia EV, Taylor A, Halkar R, et al. RENEX: an expert system for the interpretation of ^{99m}Tc-MAG3 scans to detect renal obstruction. *J Nucl Med.* 2006;47:320–329.
2. Koff SA. Problematic ureteropelvic junction obstruction [editorial]. *J Urol.* 1987;138:390.
3. Taylor A Jr, Corrigan PL, Galt J, et al. Measuring technetium-99m-MAG3 clearance with an improved camera-based method. *J Nucl Med.* 1995;36:1689–1695.
4. Conway JJ, Maizels M. The "well tempered" diuretic renogram: a standard method to examine the asymptomatic neonate with hydronephrosis or hydroureteronephrosis. A report from combined meetings of The Society for Fetal Urology and members of The Pediatric Nuclear Medicine Council—The Society of Nuclear Medicine. *J Nucl Med.* 1992;33:2047–2051.

Amy Piepsz
CHU St. Pierre
Brussels, Belgium

Hamphrey Ham
UZ Gent
Ghent, Belgium

REPLY: We greatly appreciate the thoughtful comments made by Professors Piepsz and Ham regarding the patient example and initial validation of RENEX, our expert system for detection of renal obstruction. We agree that it would be ideal to further validate RENEX using gold standards and parameters widely accepted by the entire medical community to detect renal obstruction. Nevertheless, the role of expert systems is to properly transfer the knowledge of the experts in a specific domain (such as detection of renal obstruction) to a computer program so that others with less expertise may use it to assist them to perform at the level of the experts. As such, what we are validating is that RENEX will reach the same conclusions about renal obstruction as would be reached by a typical nuclear medicine expert—that is, how well the transfer of knowledge took place. Professors Piepsz and Ham state that "the diagnosis of renal obstruction is a matter of continuous controversy" and make the appeal that introduction of RENEX into clinical practice should be delayed until all controversies surrounding detection of renal obstruction are resolved, including agreement on a gold standard. Professional competence has been defined as the ability to manage ambiguous problems, tolerate uncertainty, and make decisions based on limited information (*1*), and nuclear medicine physicians with various levels of expertise perform and interpret thousands of diuresis renography studies every year while these issues persist. Should we then make the appeal that diuresis renography studies not be performed clinically until the controversies in interpretation raised by Professors Piepsz and Ham are resolved? We should not demand more of an expert system than we expect from our own human experts.

In regard to the interpretation of the clinical study, Professors Piepsz and Ham argue that it is difficult to accept that both kidneys have reduced function. The camera-based ^{99m}Tc-mercaptoacetytriglycine (MAG3) clearance was 83 mL/min/1.73 m^2. The

normal camera-based MAG3 clearance is 321 ± 71 mL/min/1.73 m^2, which is comparable to the normal MAG3 clearance based on plasma samples, 302 ± 73 mL/min/1.73 m^2 (*2,3*). MAG3 clearance decreases with age and is estimated to decrease by 3.77 mL/min/1.73 m^2 after age 40 (*3*); consequently, an 88-y-old person would be expected to have a reduced MAG3 clearance of approximately 121 mL/min/1.73 m^2. The reduction in parenchymal function is supported by the fact that the cortical 20-min/maximum-count ratios were elevated for both kidneys, 0.47 for the right and 0.74 for the left (normal values are 0.19 ± 0.07 and 0.19 ± 0.04 for the right and left kidneys, respectively (*2*)). The cortical 20-min/maximum-count ratios are displayed in an expanded review of quantitative data; this display was available to the experts but was not reproduced in the RENEX paper for reasons of space (*4*).

Uptake was asymmetric between the left (54%) and right (46%) kidneys but was within normal limits. After furosemide, obstruction was excluded in the left kidney primarily by the rapid washout of the tracer from the left collecting system, as can be appreciated by inspection of the images. Calculation of the pelvic time to half-maximum counts in the left kidney was based on the first 5 min because no pelvic activity was detected after 5 min. The right kidney was determined to be obstructed because it markedly retained tracer after furosemide; moreover, the function of the 2 kidneys was similar, indicating that the right kidney could have responded to furosemide just as the left kidney responded if the right kidney had not been obstructed.

Neither the experts nor RENEX was aware of clinical data other than the sex, age, height, weight, and the fact that the patient was referred for suspected obstruction. (In the future, we plan to enhance the design of RENEX to incorporate clinical data.) We reviewed the clinical history and course of the patient. The patient presented with a 13.6-kg (30-lb) weight loss, an abdominal wall abscess, and a right upper quadrant mass. Her serum creatinine level was 1.1 mg/dL. Although this is a normal value, she had reduced muscle mass secondary to her weight loss, and serum creatinine may remain normal even when the glomerular filtration rate is reduced by as much as 60% (*5*). A CT scan showed a large pelvic mass suggestive of uterine leiomyosarcoma, a large necrotic right upper quadrant mass, and an abdominal wall abscess. Biopsy of the right upper quadrant mass revealed adenocarcinoma. A MAG3 scan was obtained because of concern regarding the patient's renal status. The MAG3 scan was interpreted as showing obstruction of the right kidney; a urology consult was obtained and a stent placed in the right ureter. At the completion of her hospital stay, the patient was discharged to hospice care.

Finally, Professors Piepsz and Hamm argue that an expert system used for the diagnosis of renal obstruction "should be based and validated on 2 series of patients with hydronephrosis, 1 corresponding to a simple dilatation, without any further renal deterioration, and 1 in which the conservative attitude resulted in kidney damage." If Professors Piepsz and Hamm (or other investigators) have such a series, we would be glad to collaborate with them on transferring the data and processing it using our system.

REFERENCES

1. Schon DA. *The Reflective Practitioner: How Professionals Think in Action*. New York, NY: Basic Books; 1983.
2. Esteves FP, Taylor A, Manatunga A, Folks R, Krishnan M, Garcia EV. Normal values for camera-based MAG3 clearance, MAG3 curve parameters, excretory parameters and residual urine volume. *AJR*. In press.
3. Russell CD, Taylor AT, Dubovsky EV. Measurement of renal function with technetium-99m-MAG3 in children and adults. *J Nucl Med.* 1996;37:588–593.
4. Garcia EV, Taylor A, Halkar R, et al. RENEX: an expert system for the interpretation of ^{99m}Tc-MAG3 scans to detect renal obstruction. *J Nucl Med.* 2006;47:320–329.
5. Levey AS, Madaio MP, Perrone RD. Laboratory assessment of renal disease: clearance, urinalysis and renal biopsy. In: Bremner BM, Rector FC Jr, eds. *The Kidney.* Philadelphia, PA: Saunders; 1991:919–937.

Ernest V. Garcia
Andrew Taylor
Emory University School of Medicine
Atlanta, Georgia