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Reduced Tc-99m DMSA uptake in a patient with renal tubular acidosis: Effect of acid-base imbalance

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Tc-99m dimercaptosuccinic acid (DMSA) is used as a renal cortical imaging agent to detect parenchymal abnormalities especially in children. Kidney uptake of DMSA provides an index for evaluation of a functional tubular mass, which depends on the renal blood flow and proximal tubular cell membrane transport function. We here report a boy with renal tubular acidosis, which has noticeably reduced uptake on his Tc-99m DMSA scintigraphy, despite a totally normal Tc-99m MAG-3 study. The case reported here clearly demonstrates a situation in which renal uptake of DMSA may be dissociated from a functional renal mass and the importance of acid-base balance which alters Tc-99m DMSA uptake.

Key words: renal tubular acidosis, Tc-99m DMSA, Tc-99m MAG-3

INTRODUCTION

RENAL TUBULAR ACIDOSIS (RTA) is described as kidneys with impaired ability to secrete hydrogen ions in the distal nephron or to reabsorb bicarbonate (HCO_3) ions proximally, leading to chronic metabolic acidosis.[1] The primary defect in proximal RTA (pRTA) is reduced renal HCO_3 resulting in significant bicarbonaturia. pRTA is usually accompanied by hyperchloremic metabolic acidosis with a normal or slightly reduced serum potassium concentration, and the ability to lower urinary pH to below 5.5 in the face of spontaneous acidemia or after acid loading. It may appear as an isolated defect; primary or secondary, or integrated in a generalized proximal tubule defect, coupled with urinary wasting of many solutes known as Fanconi syndrome. Experimental pathophysiologic studies suggest a defect in the proximal tubule Na,K-ATPase pump, leading to excessive urinary loss of HCO_3, Na, K, glucose, phosphate and amino acids.[1,2]

We here report an infant with proximal renal tubular acidosis accompanied by glucosuria and proteinuria. This patient had a Tc-99m DMSA study performed due to a history of upper urinary tract infection, which showed diffuse decreased uptake in the kidneys bilaterally and increased liver activity. MAG-3 study performed 1 week later was normal. This case clearly demonstrates the difference in renal handling of Tc-99m DMSA and MAG-3 in metabolic acidosis.

CASE REPORT

A 51-day-old boy was admitted to the hospital for intractable vomiting and diarrhea. At adnission, he was dehydrated and had acidosis. Urinalysis revealed a specific gravity of 1,015, urinary pH of 6.5, mild proteinuria and 2–3 leucocytes per high power field microscopic examination. Serum electrolytes measured at the time were as follows: BUN 5 mg/d*l* (normal: 4–20), creatinine 0.53 mg/d*l* (normal: 0.5–1.2), uric acid 4.2 mg/d*l* (normal: 2.7–8.5), Na 129 mEq/L (normal: 135–145), K 2.5 mEq/L (normal: 3.5–5.5), Cl 104 mEq/L (normal: 95–110), venous pH 7.22 (normal: 7.35–7.45), HCO_3 content 13.8 mEq/L (normal: 24–26), pCO_2 36.2 mmHg (normal: 27–40). Laboratory findings demonstrated that the urine pH was inappropriately high despite spontaneous hyperchloremic metabolic acidosis, suggestive of renal tubular acidosis. Furthermore, tubular phosphorus reabsorption was low at 90% with glycosuria and proteinuria but the

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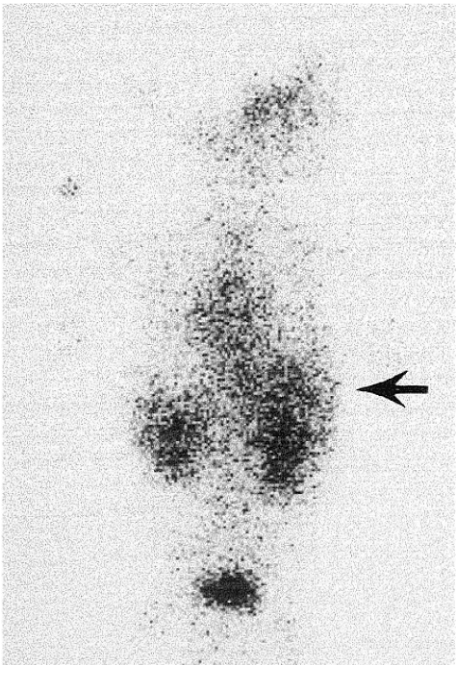

Post

Fig. 1 Posterior Tc-99m DMSA scan shows decreased concentration in kidneys bilaterally and elevated liver uptake (*arrow*).

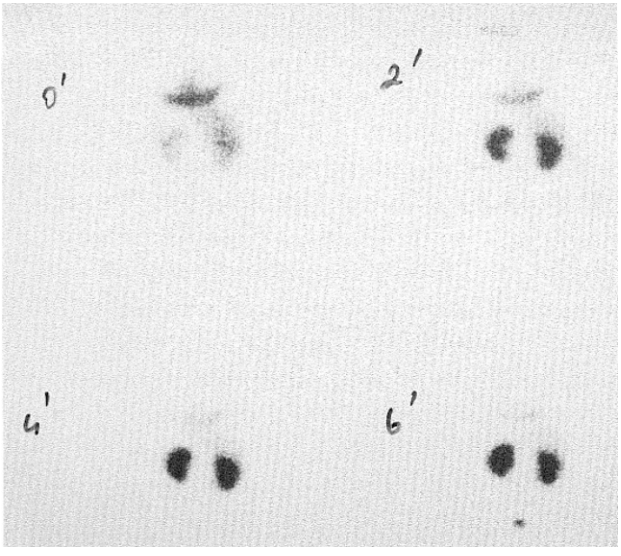

Fig. 2 Two-minute interval posterior images of Tc-99m MAG-3 images show normal concentration.

urinary Ca/Cr ratio was normal. With all these findings, the patient was diagnosed with proximal renal tubular acidosis.

He was investigated for the presence of upper urinary tract infection. His renal ultrasound did not show any abnormalities. This was followed by a Tc-99m DMSA scintigraphy. Images were acquired 4 hours after injecting 18 MBq of a radiopharmaceutical, by means of a gamma camera (Toshiba 601, Japan) with a parallel hole, low energy, high-resolution collimator. Posterior and posterior oblique images for 300,000 counts were collected with the patient in the supine position. The images showed increased liver activity with diminished renal uptake (Fig. 1). The absolute renal uptake was 12% in the right and 10% in the left kidney.

A diuretic renogram was performed with 37 MBq Tc-99m MAG-3 within one week. Images were acquired with a parallel-hole, low energy, general purpose collimator in the posterior view with the patient in the supine position. Perfusion, concentration and excretion functions of both kidneys were normal (Fig. 2). The renogram curve did not display any abnormality.

DISCUSSION

Our patient with renal tubular acidosis showed poor Tc-99m DMSA uptake, but a normal concentration and excretion of Tc-99m MAG-3. This boy appears to be very similar to patients with nephronophthisis reported by Hecht et al. who had poor renal uptake of Tc-99m DMSA, but normal MAG-3 studies.[3] These authors suggested that the lack of DMSA uptake was due to failure of uptake by the tubule or defective binding of the isotope within the cell.

Renal handling of Tc-99m DMSA has been studied by Müller Suur et al. in rats.[4] They found that low fractions of protein free Tc-99m DMSA enter the tubular lumen by glomerular filtration and are not reabsorbed by the tubular epithelium. The majority of Tc-99m DMSA is removed from peritubular capillaries, which depends on aerobic metabolism and is then bound to the cell plasma proteins, presumably at a high binding constant.[5] Autoradiography has shown that most of the Tc-99m DMSA concentrates in the cytoplasm of the proximal tubular cells.[6]

Many studies have documented the clinical utility of Tc-99m DMSA scanning in the pediatric population,[7–9] yet few data exist regarding its ability to quantitate total renal function in children.[10,11] There is a close relationship between the functioning renal mass and the absolute number of sites available for DMSA binding in the tubular cells of the kidneys.[12] Bajc et al. studied a total of 282 renal scintigrams with Tc-99m DMSA in age ranging from 10 days to 10 years.[13] They found that average background activity was 14% of the average kidney activity at birth and decreased to approximately 6% during the first year of life. Groshar et al. did not find a significant correlation between age and renal uptake although a significant inverse correlation was found between the percent injected dose per cubic centimeter of renal tissue (%ID/cm^3) with increasing age.[14]

Organ distribution of DMSA can be altered by the method of preparation and peritubular uptake may be influenced by acid base disturbances.[15–17] Yee et al. have shown that acid-base imbalance significantly alters DMSA

kinetics.[15] In their experimental study which was performed on rats, acidosis noticeably increased the background activity and caused a significant rise in liver accumulation. In the case reported here, the renal uptake was well below the normal limits with poor renal definition. Based on the observation of Goodgold et al.,[12] who found a close correlation ($r = 0.75$) between creatinine clearance and absolute DMSA uptake, a marked reduction was not expected in face of normal creatinine clearance due to immaturity of the renal cells in our patient.

In contrast to DMSA uptake, Tc-99m MAG-3 scintigraphy was normal in our patient, probably owing to the differences in renal handling. 20% of MAG-3, which is not protein-bound is filtered through the glomerular capillaries. MAG-3-protein complexes pass into the peritubular capillary network, where dissociation occurs. Free MAG-3 is then actively transported into the proximal tubular cells.[18] Administration of probenecid decreases the transport of Tc-99m MAG-3[19] whereas it does not block the renal enzyme system that concentrates DMSA[5] confirming the presence of a different uptake mechanisms.

The case reported here clearly demonstrates a situation in which renal uptake of DMSA may be dissociated from the functional renal mass. Our findings indicate that poor uptake of Tc-99m DMSA in combination with a normal MAG-3 study would alert the nuclear medicine physician to the possibility of various pathologic states other than tubular cell loss which may affect renal uptake. The consideration of acid-base imbalance is particularly important, especially in the evaluation of serial changes in renal function.

REFERENCES

1. Penney MD, Oleesky DA. Renal Tubular acidosis. *Ann Clin Biochem* 1999; 36: 408–422.
2. Herrin JT. Renal tubular acidosis. In: Barrat TM, Avner ED, Harmon WE (eds). *Pediatric Nephrology*. Baltimore, MD; Williams & Wilkins, 1999: 565–581.
3. Hecht H, Ohlsson J, Starck SA. Poor renal uptake of Technetium-99m dimercaptosuccinic acid and near normal technetium-mercaptoacetyltriglycine renogram in nephronophthisis. *Pediatr Nephrol* 1996; 10: 167–170.
4. Müller-Suur R, Gutsche HU. Tubular Reabsorption of Technetium-99m DMSA. *J Nucl Med* 1995; 36: 1654–1658.
5. Goldraich NP, Alvarenga AR, Goldraich IH, Ramos OL, Sigulem D. Renal accumulation of Tc-99m DMSA in the artifically perfused rat kidney. *J Urol* 1985; 134: 1282–1286.
6. Müller-Suur R. Radiopharmaceuticals, their intrarenal handling and localisation. In: Murray IPC, Ell PJ (eds). *Nuclear medicine in clinical diagnosis and treatment*, vol. I. New York; Churchill Livingstone, 1995: 195.
7. Sty JR, Weels RG, Starshak RJ. Imaging in acute renal infection in children. *Am J Roentgenol* 1987; 148: 471–477.
8. Bjorgvinsson E, Majd M, Eggli ED. Diagnosis of acute pyelonephritis in children: comparison of sonography and Tc-99m DMSA scintigraphy. *Am J Roentgenol* 1991; 157: 539–543.
9. Majd M, Rushton HG. Renal cortical scintigraphy in the diagnosis of acute pyelonephritis. *Semin Nucl Med* 1992; 22: 98–111.
10. Moris S, Chittenden SJ, Rivens I, Heary TA, Vanstone C, Meller ST. Absolute Tc-99m DMSA renal uptake in children: a study of 321 kidneys. *Nucl Med Commun* 1995; 16: 566–571.
11. Flower MA, Meller ST, Chittenden SJ, Fielding SL, Evans K, Gordon I. Absolute Tc-99m DMSA renal uptake in children: optimum time to scan. *Nucl Med Commun* 1995; 16: 572–574.
12. Goodgold HM, Fletcher JM, Steinhardt GF. Quantitative Technetium 99m dimercaptosuccinic acid renal scanning in children. *Urology* 1996; 47: 405–408.
13. Bajc M, Wallin L. Tc-99m DMSA renal scintigraphy during kidney maturation. *Clin Nucl Med* 1995; 20: 211–214.
14. Groshar D, Gorenberg M. Quantitative SPECT uptake of Tc-99m dimercaptosuccinic acid by the kidneys in children. *J Nucl Med* 1999; 40: 56–59.
15. Yee CA, Lee HB, Blaufox MD. Technetium-99m DMSA renal uptake: influence of biochemical and physiologic factors. *J Nucl Med* 1981; 22: 1054–1058.
16. Ikeda I, Inoue O, Kurata K. Chemical and biological studies on Tc-99m DMS-I: Formation of complexes by four different methods. *Int J Nucl Med Bio* 1977; 4: 56–65.
17. Vanlic-Razumenic NM, Gorkic DA. Studies of chemical and biological properties of Tc-99m DMS (dimercapto succinic acid)-renal imaging agent. *Eur J Nucl Med* 1976; 1: 235–242.
18. Eshima D, Taylor A Jr. Technetium-99m mercaptoacetyltriglycine: update on new Tc-99m renal tubular function agent. *Semin Nucl Med* 1992; 22: 61–73.
19. Frizberg AR, Kasina S, Eshima D, Johnson DL. Synthesis and biological evaluation of technetium-99m MAG-3 as hippuran replacement 1986; 27: 111–116.