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Evaluation of exercise-induced acute renal failure in renal hypouricemia using Tc-99m DTPA renography

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We present a case of a thirty-eight-year-old man who had exercise-induced acute renal failure (exercise-induced ARF). He experienced oliguria, general fatigue, and vague discomfort in the lower abdomen after he exercised. As he had suffered from hypouricemia before, he was diagnosed as having exercise-induced ARF associated with hypouricemia. Enhanced computed tomography (CT) images showed patchy wedge-shaped contrast enhancement on his bilateral kidneys, consistent with characteristic observations for exercise-induced ARF. Tc-99m diethylene triamine pentaacetic acid (DPTA) renography revealed decreases in both the renal blood flow (RBF) and glomerular filtration rate (GFR), and revealed parenchymal dysfunction of the bilateral kidneys. Renogram revealed a hypofunctional pattern on the bilateral kidneys. CT images and Tc-99m DTPA renography also had improved when the symptoms of exercised-induced ARF indicated improvement. It has been hypothesized that one cause of exercise-induced ARF may be renal vasocontraction. Although CT images are useful in evaluating exercise-induced ARF, Tc-99m DTPA renography can more easily and safely evaluate renal function. We also show that Tc-99m DTPA renography is useful in precisely evaluating the degree of improvement of exercise-induced ARF.

Key words: Tc-99m diethylene triamine pentaacetic acid (Tc-99m DTPA), hypouricemia, exercised induced acute renal failure, patchy wedged contrast enhancement, vasocontraction

INTRODUCTION

PRAETORIUS and Hirk first reported idiopathic renal hypouricemia,[1] and in 1989, acute renal failure associated with hypouricemia was reported by Erley et al.[2] After these cases were reported one after another, and as a result, a consensus has developed in which the causes of hypouricemia may include both renal tubular obstruction and increased excretion of urinary uric acid.[1] Hypouricemia is a rare syndrome, found in approximately 0.4% of outpatients in Japan.[3] Computed tomography (CT) images performed until the third day from onset generally show patchy wedge-shaped contrast enhancement on the bilateral kidneys. Tc-99m diethylene triamine pentaacetic acid (DTPA) renography is useful in evaluating the function of each kidney separately. This technique can provide information regarding blood flow, location, and the shape of the kidney. Furthermore, it can evaluate renal parenchymal function precisely. We describe a case of exercise-induced acute renal failure (exercise-induced ARF) that was successfully evaluated using Tc-99m DTPA renography.

CASE REPORT

A thirty-eight-year-old man who had experienced chest pain, general fatigue, nausea, vomiting, oliguria, and vague discomfort in the lower abdomen was admitted to a local hospital. Negative T waves were discovered in the electrocardiograms (ECG). Suspecting ischemic heart disease, the physicians performed cardiac functional

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Table 1 The laboratory data from the second day after the onset

			normal
BUN	mg/d*l*	82.7	8.0–21.0
Cr	mg/d*l*	13.4	0.4–1.1
24 hr Ccr	m*l*/min	1.7	97–137
UA	mg/d*l*	10.8	2.3–5.5
Myoglobin	ng/m*l*	180	< 60
Na	mEq/*l*	139	138–146
K	mEq/*l*	4.7	3.6–4.9
Cl	mEq/*l*	101	99–109
Ca	mg/d*l*	9.4	8.5–10.5
P	mg/d*l*	8.5	2.5–4.5
PH		7.36	7.38–7.42
PO_2	mmHg	85.3	80–100
HCO_3	mmol	20.3	22–26
β_2-microglobulin	μ/day	337	< 40

Note; BUN = Blood Urea Nitrogen, Cr = creatinine, 24 hr Ccr = 24-hour creatinine clearance, UA = uric acid, Na = sodium, K = potassium, Cl = chloride, Ca = calcium, P = phosphorus, β_2-microglobulin = Urinary β_2-microglobulin

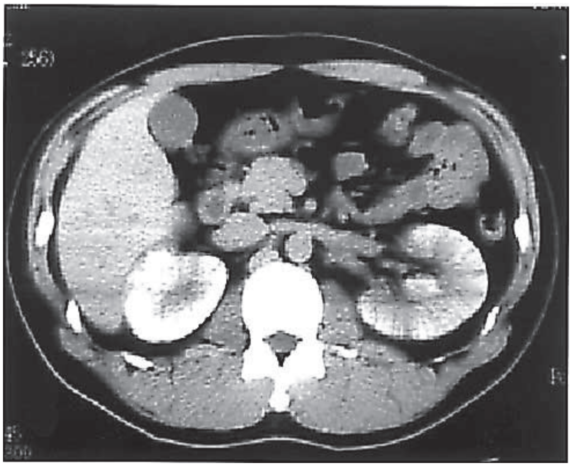
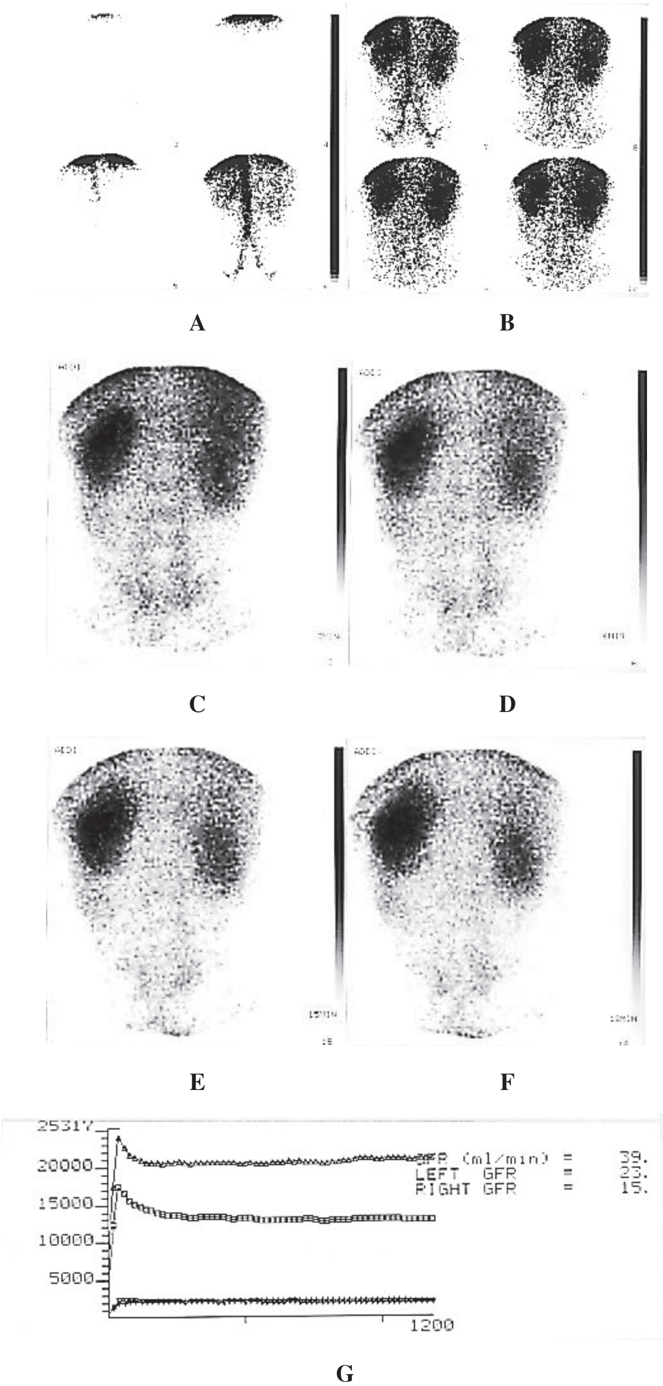


Fig. 1 The non contrast-enhanced CT images at 24 hours after bolus injection of contrast medium show the residue of contrast medium on the bilateral kidneys, and show patchy wedge-shaped contrast enhancement.

examinations such as ultrasound (UCG); however, no abnormalities appeared. The patient's laboratory data showed blood urea nitrogen (BUN) at 33.3 mg/d*l*, and creatinine at 4.42 mg/d*l*. He had acute renal failure. The patient was a police officer. He had just performed a 50-meter sprint in pursuit of a criminal. He had experienced general fatigue and vague discomfort in the lower abdomen ever since receiving a job-related fitness test; however, these symptoms had been improving for about ten days. In the past, when he had exercised hard, the same severe symptoms had appeared, and he had been admitted to another hospital. A renal biopsy had been performed, though no histological abnormal findings had been recognized on the renal biopsy. He had been diagnosed with hypouricemia based on both the medical examination and the laboratory data of the other hospital. His eldest son had also been diagnosed with hypouricemia (2.8 mg/d*l*), and among his blood relatives was another with hypouricemia; hence, exercise-induced ARF was suspected. The patient's laboratory data on the second day from onset were as follows (Table 1). Dynamic enhanced CT images were performed for the purpose of making a diagnosis. CT scanning was performed up to the third phase, and at both five hours and twenty-four hours after a bolus injection of contrast medium. CT images revealed patchy wedge-shaped contrast enhancement (Fig. 1), and he was diagnosed with exercise-induced ARF. In addition, Tc-99m DTPA renography was performed to evaluate renal failure with glomerular filtration rate (GFR). He was hydrated with 300 m*l* of water at 30 min before the examination. Tc-99m DTPA was labeled in our institute with a commercially available freeze-dried kit (Daiichi Radioisotope Co., Tokyo, Japan), which had a labeling yield of over 95%. The administered dose was 185 MBq. Tc-99m DTPA was administered through an indwelling butterfly needle during infusion of 20 m*l* normal saline solution. The renography was carried out in the supine position. A gamma camera was attached to a low-energy parallel collimator (ZLC 7500 Shimadzu, Kyoto). The renography was obtained for twenty minutes. Dynamic images revealed a decrease of renal blood flow (RBF) to the bilateral kidneys (Fig. 2A, B). Functional images showed an increase of background, renal parenchymal dysfunction (left GFR 23 m*l*/min, right GFR 15 m*l*/min) and did not reveal the excretion of Tc-99m DTPA from kidney to bladder (Fig. 2C–F). The renogram showed a hypofunctional pattern on his bilateral kidneys (Fig. 2G). His urinary output was from 200 m*l* to 300 m*l*/day, and his oliguria had continued for five days from onset. However, from the sixth day, he had spontaneous voiding of more than 2000 m*l*/day. After that, his renal function gradually improved. While his renal function was improving, his serum uric acid levels decreased, and he became hypouricemic once again. His uric acid clearance was 65.8 m*l*/min (9.4 + 1.6 m*l*/min), and the clearance ratio of uric acid against creatinine (CUA/Ccr) was 69.6% (5.5%–11.1%), which reflected increased excretion of uric acid into the urine. After the patient's renal function had improved, Tc-99m DTPA renography and CT were performed to reevaluate his renal function. Dynamic images revealed increased RBF (Fig. 3A, B), and functional images revealed that the parenchymal function of the bilateral kidneys was normalized (left GFR 53 m*l*/min, right GFR 40 m*l*/min) (Fig. 3C–F). The renogram showed the delayed pattern in the bilateral kidney (Fig. 3G). No abnormal findings were recognized on the enhanced CT images (Fig. 4). On the 27th day after his admission, he was discharged from our hospital, because his BUN and creatinine levels were within the normal ranges.



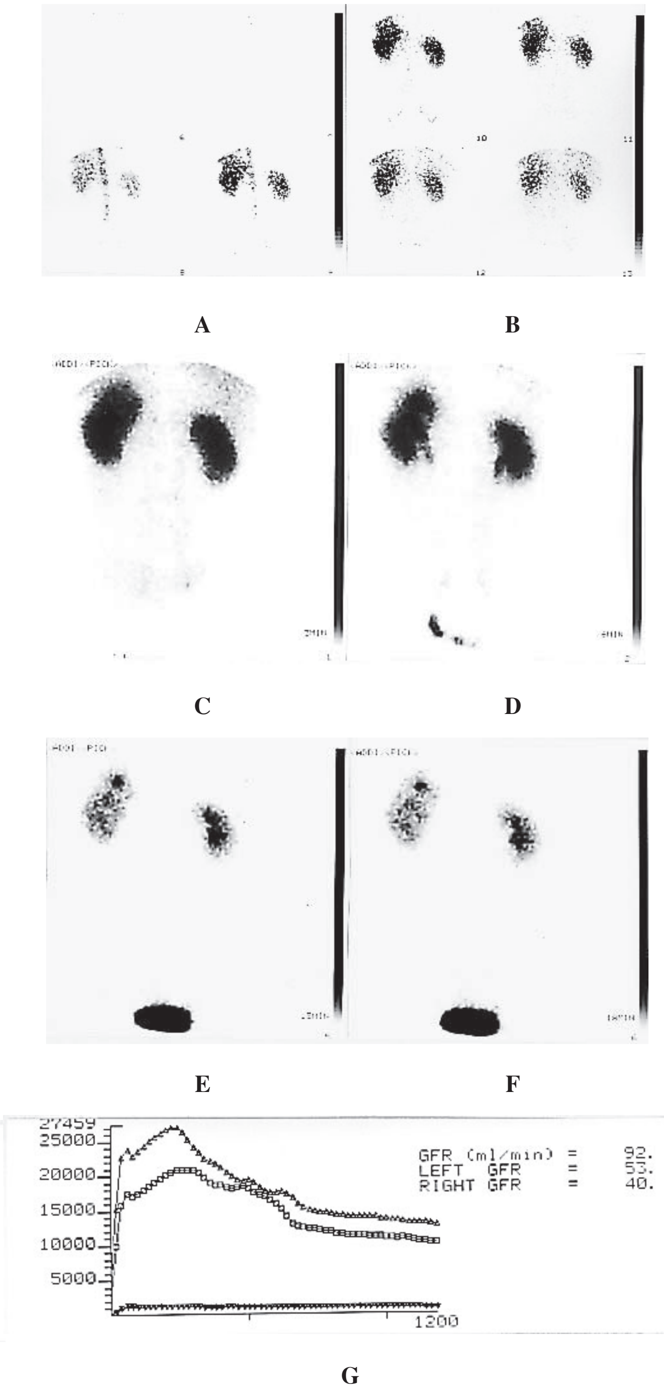


Fig. 2 Tc-99m DTPA renography at onset. Dynamic data were obtained at 2 seconds per frame for 1 minute after injection. Dynamic images show decreased renal blood flow on the bilateral kidneys (A, B). Data of functional image were obtained for 1 minute at 3 (C), 6 (D), 15 (E), and 18 minutes (F) after injection. Functional images show increased background, decreased GFR, and parenchymal dysfunction of the bilateral kidneys (C–F). Data of renogram were obtained for 20 minutes after injection. The renogram shows a hypofunctional pattern on the bilateral kidneys (G).

Fig. 3 Tc-99m DTPA renography after symptoms improved. Dynamic data were obtained at 2 seconds per frame for 1 minute after injection. Dynamic images show the improvement of renal blood flow (A, B). Data of functional image were obtained for 1 minute at 3 (C), 6 (D), 15 (E), and 18 minutes (F) after injection. Functional images show that the renal parenchymal function of the bilateral kidney is normal (C–F). Data of renogram were obtained for 20 minutes after injection. The renogram shows a delayed pattern on the bilateral kidney (G).

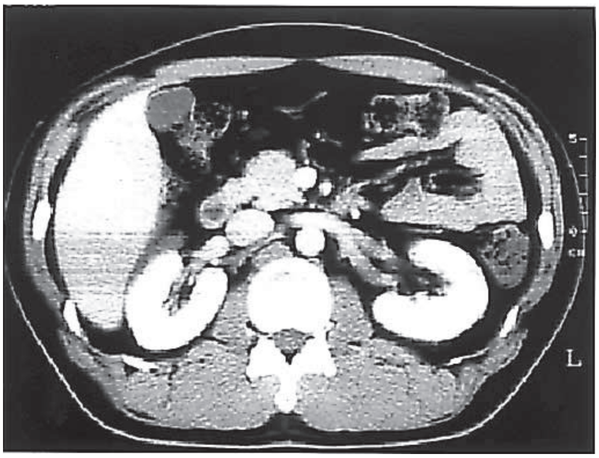


Fig. 4 Enhanced CT images after symptoms improved. Patchy wedge-shaped contrast enhancement is not seen on the enhanced CT images.

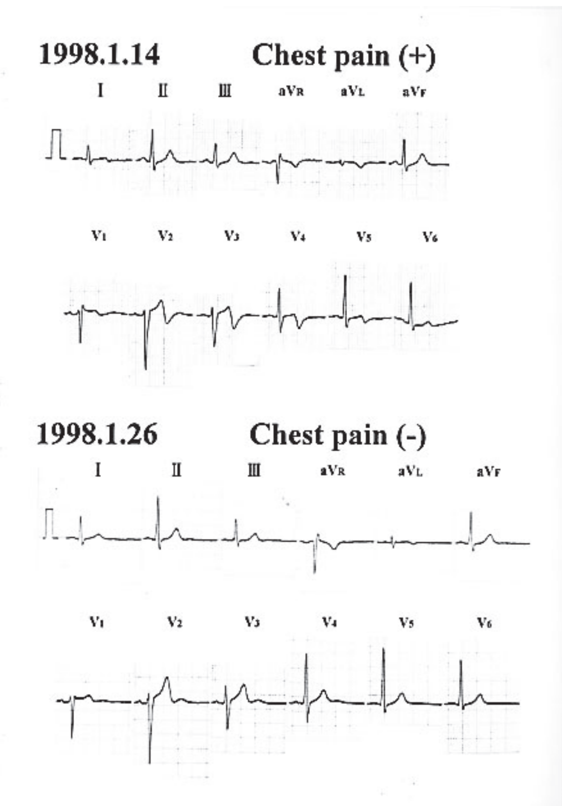


Fig. 5 The patient's ECG on admission to our hospital (*upper*). The ECG shows negative T wave. The ECG after symptoms is improved (*lower*). Negative T waves are not seen.

DISCUSSION

Renal hypouricemia is a rare syndrome that is believed to be caused by increased excretion of uric acid because of proximal tubular obstruction.[1,4] It often occurs in blood relatives and has been reported to be associated with heredity. While there are some reports that the cause of exercise-induced ARF may be hypouricemia, there are some reports of other apparent causes.[5,6] Recently in Japan, many cases of young people with hypouricemia contracting exercise-induced ARF have been reported.[5,6] Premonitory symptoms are loin pain, abdominal pain, vomiting, and a slight fever. When renal failure occurs, the serum uric acid level rises; however, when renal function improves, the urinary uric acid level rises. There are characteristic observations on CT images of patchy wedge-shaped contrast enhancement. It has been reported that exercise-induced ARF may be related to renal vasocontraction.[6,7] In 2002, Ishikawa reported acute renal failure syndrome with severe loin pain after anaerobic exercise (ALPE), which was combined with severe loin pain induced by anaerobic metabolism during a short distance race.[6] The mechanism of exercise-induced ARF is unclear. It is believed that one of its mechanisms may be uric acid nephropathy induced by a rise of uric acid in the proximal tubules, and that this rise of uric acid may be caused by increased synthesis of uric acid associated with exercise, urinary acidification, and a decrease of GFR.[4–10] Dehydration induced by exercise and drastic excess of uric acid are supposed. However, another mechanism has also been proposed. It is of interest that exercise-induced ARF may be caused by decreased RBF because of vasocontraction. Renal vasocontraction may be caused by free-radical oxygen induced by exercise. Uric acid is a powerful antioxidant; given low uric acid levels, free-radical oxygen cannot be managed, and vasocontraction may occur.[5–9] In the present case, CT images revealed patchy wedge-shaped contrast enhancement on the bilateral kidneys, and the Tc-99m DTPA renography showed decreases in both RBF and GFR, and did not reveal the excretion to the bladder at the onset. CT images and the Tc-99m DTPA renography after symptoms had ameliorated showed an improvement of renal function. The reason why Tc-99m DTPA renography did not show the excretion to bladder may suggest that the decrease of RBF due to vasocontraction causes the delay of excretion. This finding may suggest a relation to the residue of contrast medium in the kidney on the CT image. We concluded that vasocontraction might cause exercise-induced ARF. Importantly, a case of exercise-induced ARF combined with cerebral infarction has been reported. Single photon emission computed tomography (SPECT) showed that the cerebral blood flow of the occipital region was low at the onset, but then recovered. It is supposed that vasocontraction might affect the brain as well as the kidneys.[8,10] Abnormal ECG findings were discovered at our patient's onset, but ECG showed improvement in parallel with improvement of renal function (Fig. 5). As well, no cardiac abnormalities were discovered with either UCG or cardiac loading test. Vasocontraction might occur in the coronary artery, though this sort of case has never been reported. We can suppose that vasocontraction may occur in the circulatory system of the whole body.

In this case, as vasocontraction may cause the decrease of RBF, Tc-99m DTPA was used to evaluate the RBF because RBF has a correlation with GFR. CT images are useful in evaluating renal failure morphologically, but there is the possibility that renal function will be negatively affected by contrast medium. We think that it is more judicious to make a diagnosis using other techniques, including magnetic resonance imaging (MRI). Unfortunately, it is difficult to evaluate the RBF using CT, MRI and laboratory data, but renography enables us to evaluate RBF and renal function. We can grasp this condition of this disease by renography. To our knowledge, a case of exercise-induced ARF evaluated with Tc-99m DTPA renography has never been reported. It is a non-invasive diagnostic modality, and calculates GFR in a precise and timely fashion without the necessity of urine or blood sampling.[11] As no contrast medium is required, and Tc-99m DTPA is well known not to be nephrotoxic at all,[11] we think that this method should become more widely used in evaluating both the severity of renal dysfunction and its improvement. We emphasize that Tc-99m DTPA renography is also useful in evaluating the improvement of exercise-induced ARF.

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