CASE REPORT

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Hypothermia-induced acute kidney injury in an elderly patient

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Hypothermia, defined as an unintentional decline in the core body temperature to below 35°C, is a life-threatening condition. Patients with malnutrition and diabetes mellitus as well as those of advanced age are at high risk for accidental hypothermia. Due to the high mortality rates of accidental hypothermia, proper management is critical for the wellbeing of patients. Accidental hypothermia was reported to be associated with acute kidney injury (AKI) in over 40% of cases. Although the pathogenesis remains to be elucidated, vasoconstriction and ischemia in the kidney were considered to be the main mechanisms involved. Cases of AKI associated with hypothermia have been reported worldwide, but there have been few reports of hypothermia-induced AKI in Korea. Here, we present a case of hypothermia-induced AKI that was treated successfully with rewarming and supportive care.

Keywords: Hypothermia; Acute kidney injury; Rewarming; Vasoconstriction; Ischemia

INTRODUCTION

Hypothermia, defined as an unintentional decline in core body temperature to below 35°C, is a life-threatening condition. The clinical settings associated with hypothermia include environment exposure, cold water immersion, and myxedema [1]. Patients with malnutrition and diabetes mellitus as well as those of advanced age are at high risk of accidental hypothermia due to impaired mechanisms for control of body temperature [2]. Hypothermia affects basal metabolism and cardiovascular, neural, hematological, respiratory, and hormonal systems [1,3]. It was reported to be associated with acute kidney injury (AKI) in over 40% of cases [4]. Although the pathogenesis remains to be elucidated, vasoconstriction and ischemia in the kidney, which can occur during the hypothermic phase or after rewarming, were reported to induce AKI in patients with hypothermia [5]. While the mortality rate of accidental hypothermia is comparatively elevated, better intensive care management and rewarming techniques have improved prognosis. Although AKI associated with severe hypothermia has been reported worldwide, few cases have been documented in Korea. Here, we present a case of hypothermia-induced AKI treated successfully with rewarming and supportive care.

CASE REPORT

A 78-year-old Korean male was admitted to our hospital in November for severe hypothermia. He had been

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diagnosed with hypertension at the age of 65 years, and had been treated with medications. He was found comatose on a mountaineering path 4 hours prior to admission. The temperature on the mountain, where he was lying, was reported to be 14°C. Upon admission, the patient was in deep stupor. His blood pressure, as measured in the supine position, was 80/50 mmHg, heart rate was 85 beats per minute, and respiratory rate was 19 per minute. The body temperature was below 34.0°C (exceeding the measurement range of 34.0°C to 44.0°C of the thermometer, which had an error of measurement of ± 0.2°C). Electrocardiography showed J waves, prolonged QT, and occasional premature ventricular complexes (Fig. 1A). Therefore, we estimated that his body temperature was indicative of moderate to severe hypothermia.

Chest radiography appeared normal, and ultrasonography of the kidneys showed normal echogenicity and intact corticomedullary differentiation without hydronephrosis. The patient's kidneys were within the normal range in size (the right kidney measured 9.3 × 5.4 cm, and the left kidney measured 9.9 × 4.6 cm). Renal scan (technetium-99m MAG3) indicated normal excretion and secretion functions. Urinalysis showed no proteinuria, and urine microscopic exam showed 10 to 19 red blood cells per high-power field with no casts. Blood urea nitrogen and serum creatinine concentrations were 25 mg/dL (normal range, 8 to 20) and 2.7 mg/dL (normal range, 0.6 to 1.2), respectively. In addition, fractional excretion of sodium was 4.5% and renal failure index was 2.25. The results of hormonal assays were as follow: plasma cortisol 14.6 μg/dL (normal range, 4.0 to 18.3), thyroid simulating hormone 1.43 μIU/mL (normal range, 0.17 to 4.05), free triiodothyronine 0.49 ng/dL (normal range, 0.78 to 1.82), and free thyroxine 1.25 ng/dL (normal range, 0.93 to 1.20). Anterior pituitary hormone levels were normal.

The results of arterial blood gas analysis were as follows: pH 7.260, pCO_2 28.0 mmHg, pO_2 151.0 mmHg, and HCO_3^- 12.6 mmol/L. Other laboratory studies produced the following results: serum calcium 8.8 mg/dL, serum phosphate 8.0 mg/dL, serum sodium 141 mEq/L, serum potassium 3.7 mEq/L, serum magnesium 3.1 mg/dL, hemoglobin A1c 5.4%, lactic acid 11.4 mmol/L, serum myoglobin 1,685.0 ng/mL, serum lactate dehydrogenase 159 IU/L, serum creatine phosphokinase 68 U/L, and serum amylase 582 U/L. Urinary concentrations of sodium, potassium, chloride were 95, 44.1, and 114 mEq/L, respectively. Urine osmolality was 537 mOsm/kg.

Upon hospitalization, the patient was wrapped in a warm blanket. We provided him with a forced-air warming system (Warm Touch, Mallinckrodt Medical Inc., Dublin, Ireland) infused with warmed saline (42°C) by pressure infusion (Ranger, Alrizant Healthcare Inc., Eden Prairie, MN, USA). Five hours of warming resulted in an increase in body temperature to 37.3°C, and the patient regained consciousness. Subsequently, electrocardiography showed a normal sinus rhythm (Fig. 1B). After supportive care, the serum creatinine levels decreased gradually from 2.7 to 1.1 mg/dL on the fourth day of the hospital stay. The patient was discharged after 12 days of hospitalization, and the serum creatinine and body temperature were 1.2 mg/dL and 36.5°C at discharge (Fig. 2).

DISCUSSION

Here, we reported a 78-year-old male with a history of hypertension who had developed AKI after cold exposure. To our knowledge, this is the first report of a surviving hypothermic AKI patient in Korea; the patient was treated with supportive care and rewarming therapy.

Hypothermia is a life-threatening condition that is defined as an unintentional decline in core body temperature to below 35°C, and can be divided into mild (33°C to 35°C), moderate (30°C to 33°C), and severe (< 30°C) categories according to body temperature [6]. In our case, the body temperature of the patient was below the range of measurement as indicated by the ear thermometer (measurement range, 34.0°C to 44.0°C). Thus, we assumed that the subject had moderate or severe hypothermia after considering his electrocardiography results. Hypothermia affects basal metabolism, cardiovascular, neural, hematological, respiratory, and hormonal systems [1,3]. Malnutrition, diabetes mellitus, and old age are considered as risk factors for accidental hypothermia [2].

In our case, the patient, who was at elevated risk because of his advanced age, developed AKI after cold ex-

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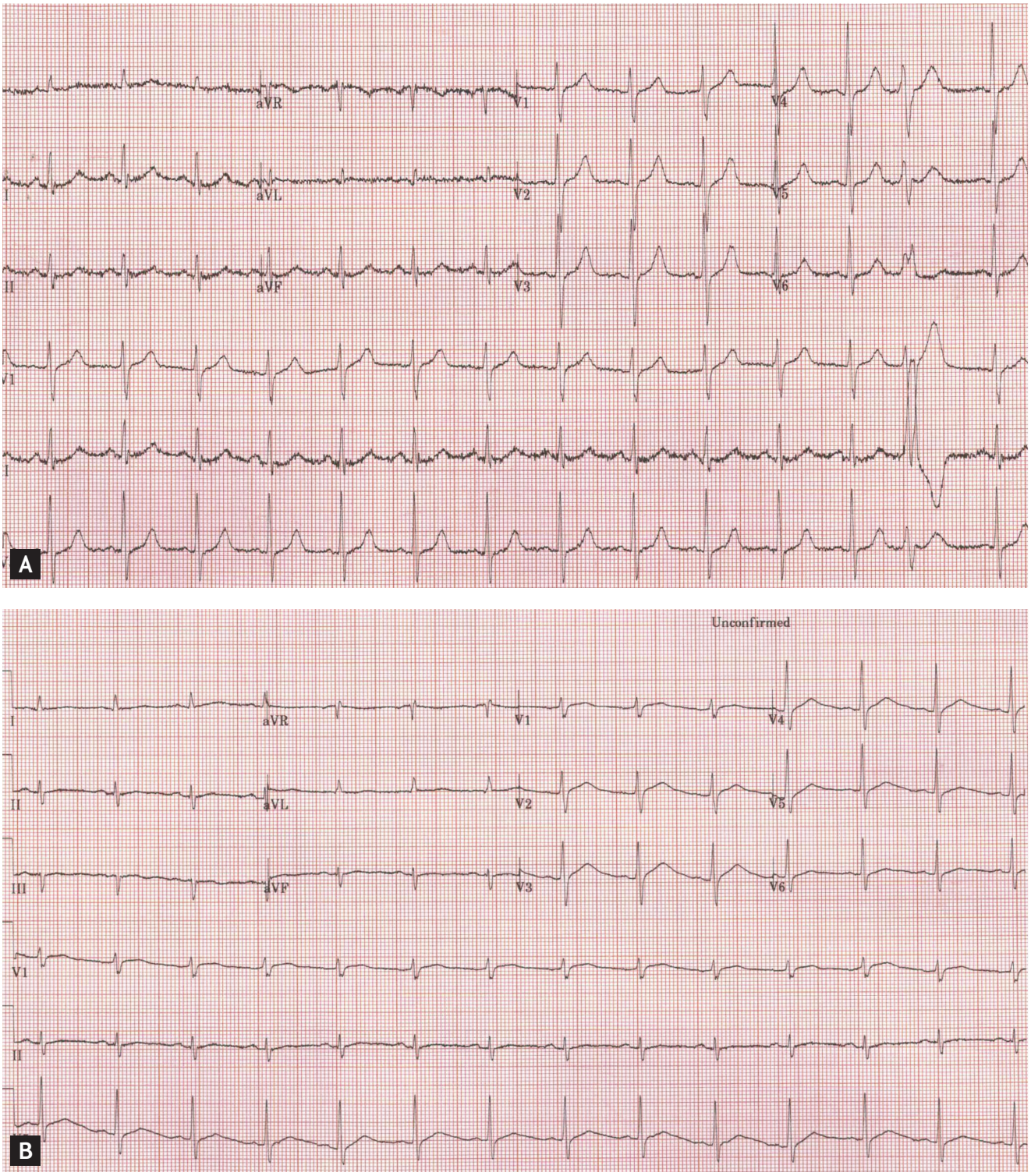

Figure 1. (A) Initial electrocardiography showed J (Osborn) waves, prolonged QT interval, and premature ventricular complex. (B) After 20 hours, electrocardiography showed a normal sinus rhythm.

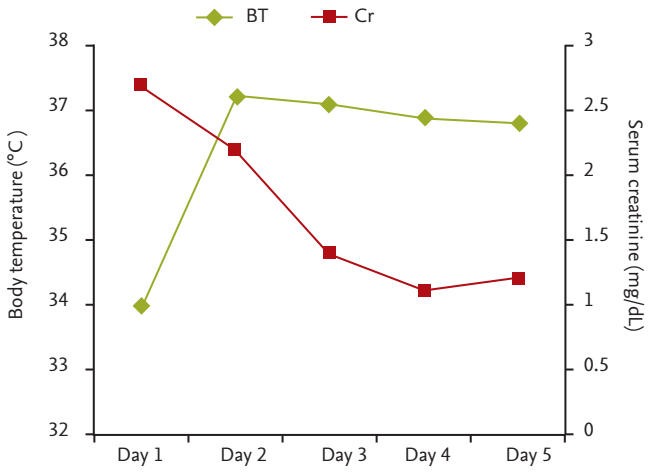

Figure 2. Serial changes in serum creatinine and body temperature during hospitalization. Serum creatinine levels increased to 2.25-fold the normal levels and returned to the normal level within a short duration. Tympanic temperature could not be determined due to the low body temperature, so a value of 34.0°C was used.
BT, body temperature; Cr, creatinine.

posure for 4 hours. The elderly are susceptible to cold-induced injuries due to reduced awareness of cold, failure of physiological mechanisms of heat conservation, and less effective circulatory adjustments [7]. The incidence of hypothermia-induced AKI has not been reported, but it was noted in over 40% of patients with accidental hypothermia who required admission to an intensive care unit [4]. Prerenal failure, occurring as a consequence of reduced renal blood flow, is considered the main cause of hypothermia-induced AKI, although the pathogenesis remains undetermined [5]. Although rewarming therapy improved the prognosis of hypothermia, it can cause AKI due to reduction of peripheral vasoconstriction [5]. For treatment, our subject was enveloped with a warm blanket and provided with an infusion of warmed saline (42°C); these are considered as active rewarming methods [6]. After rewarming for 5 hours and accompanying supportive care, the patient regained consciousness with a recorded body temperature of 37.3°C. During this rewarming therapy, we administered intravenous fluids to prevent hypovolemic shock. Rewarming shock did not occur in this case, and the serum creatinine level decreased gradually from 2.7 to 1.1 mg/dL on the fourth hospital day.

In this case, we chose a warm blanket and warmed saline as active rewarming therapy. Active rewarming therapy may be classified as surface heating and central rewarming methods [6]. In general, surface rewarming therapy includes warm blankets, mattresses, bottles, piped suits, or submersion of the patient in water at 40°C to 45°C. There are various methods for central rewarming therapy, including airway rewarming, peritoneal dialysis, and warm enema, extracorporeal warming, and infusion of warmed intravenous fluids [7]. However, there is no consensus regarding which method is preferable. Airway rewarming can cause respiratory burn injury; it requires ventilator adjustments and is readily available for intubated patients [6]. However, intravenous infusion of warmed saline is a more accessible and rapid method without severe complications compared to other procedures in clinical practice. Recently developed portable techniques have allowed the administration of warm humidified air or oxygen (heated to 42°C to 46°C) and heated intravenous solutions.

The mortality rate among elderly patients with hypothermia has been reported to be over 35%, with various causes of death including heart problems, such as ventricular fibrillation and ventricular asystole [8]. Durakovic et al. [8] reported that 12 of 14 elderly hypothermia patients died within 1 to 216 hours from admission. Fortunately, our patient recovered, which was considered to be due to improved intensive management and rewarming methods [6]. There were two previous case reports of hypothermia in Korea, and both of the patients died despite intensive supportive care [9]. The patients had serious underlying diseases; i.e., liver cirrhosis and stuporous quadriplegia with posttraumatic palsy, respectively. However, our patient had no such serious underlying conditions, which is important for the prognosis of accidental hypothermia [10]. The recovery in this case may have been due to rapid and appropriate intensive care, including rewarming therapy, and lack of serious underlying disease.

In conclusion, we reported an elderly patient who developed AKI following cold exposure. Fortunately, our patient recovered following prompt supportive care and rewarming therapy. Therefore, appropriate supportive care and rewarming therapy are crucial in the management of accidental hypothermia.

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Conflict of interest

No potential conflict of interest relevant to this article is reported.

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