

## Clinical reports

# Critical alkalosis following intraperitoneal irrigation with sodium bicarbonate in a patient with pseudomyxoma peritonei

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### Abstract

Pseudomyxoma peritonei (PMP) is a rare disease, presenting with large amounts of mucinous ascites, and treatment with intraperitoneal irrigation with mucolytic agents has been tried. We report a patient with PMP who underwent intraperitoneal irrigation with sodium bicarbonate and exhibited marked alkalosis. The patient was a 78-year-old woman who had mucinous ascites, and an appendiceal and an ovarian tumor. Bilateral salpingo-oophorectomy and appendectomy were performed, and she then underwent intraperitoneal irrigation with sodium bicarbonate (7%, 1000 ml). Shortly after the irrigation, blood gas analysis showed critical alkalosis (pH, 7.66; base excess [BE], 24 mEq·l<sup>-1</sup>; HCO<sub>3</sub><sup>-</sup>, 50 mEq·l<sup>-1</sup>) with electrolyte imbalance (Na<sup>+</sup>, 153 mEq·l<sup>-1</sup>; K<sup>+</sup>, 2.8 mEq·l<sup>-1</sup>; Ca<sup>2+</sup>, 0.98 mEq·l<sup>-1</sup>; Cl<sup>-</sup>, 99 mEq·l<sup>-1</sup>). The alkalosis and electrolyte imbalance were ameliorated with the administration of potassium chloride and calcium chloride intravenously, and the patient was extubated after the 2-h surgical procedure. The patient was discharged home after 15 days without problems. Sodium bicarbonate may be an effective mucolytic agent for PMP. However, during irrigation with sodium bicarbonate, careful evaluation of the acid-base balance and serum electrolytes, and prompt treatment of alkalosis or electrolyte imbalance, should this occur, are of great importance.

**Key words** Pseudomyxoma peritonei · Intraperitoneal irrigation · Sodium bicarbonate · Alkalosis

### Introduction

Pseudomyxoma peritonei (PMP) is a rare disease which presents with large amounts of mucinous materials in the peritoneal cavity. The primary tumor is often a mucinous cystadenoma or cystadenocarcinoma of the appendix. Although the clinical course is usually slow, many patients die of intestinal obstruction, with the

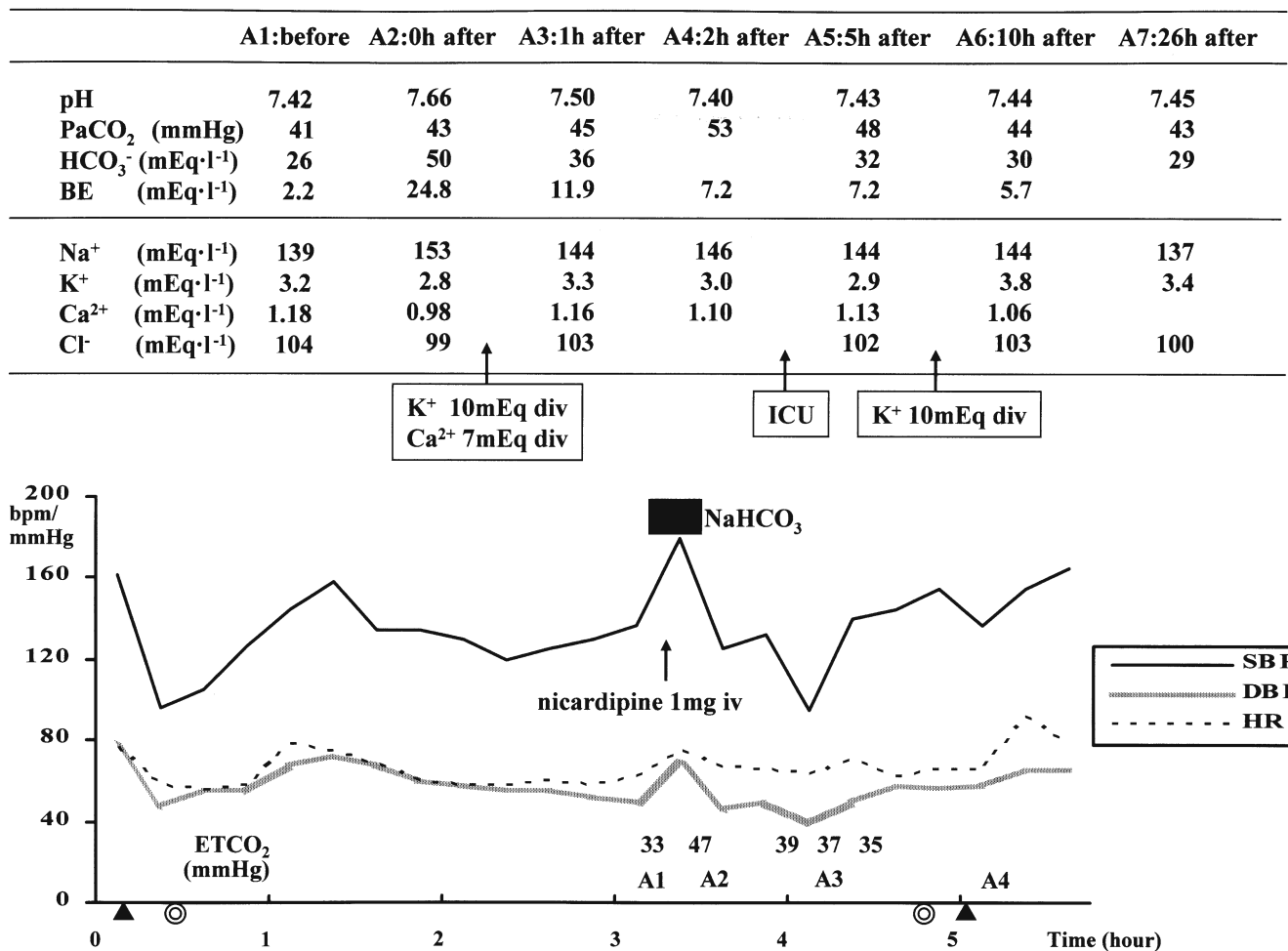
recurrent accumulation of mucus, even after attempts at mucus removal. Surgical resection of the tumor and the removal of mucus is the mainstay of treatment, but complete removal is often impossible [1–3].

Several approaches have been used to irrigate the peritoneal cavity with such mucolytic agents as 5% dextrose [4] and dextran sulfate [5]. Watanabe et al. [6] suggested first that intraperitoneal irrigation with 7% sodium bicarbonate was effective. Matsubara et al. [7] reported three patients in whom intraperitoneal irrigation was performed by instilling 1000 to 2000 ml 7% sodium bicarbonate solution, with satisfactory results. They did not observe any disturbance in the blood acid-base balance. We recently experienced a patient with PMP who underwent intraperitoneal irrigation with 7% sodium bicarbonate solution and in whom critical alkalemia occurred.

### Case report

A 78-year-old woman (154 cm, 58 kg), complaining of right lower abdominal pain and abdominal distension that had lasted for 2 years, was referred to the department of gynecology at our hospital with a diagnosis of ovarian tumor. Computed tomography (CT) revealed a large volume of homogeneous ascites, a multiseptated right ovarian tumor 10 cm in diameter, and an appendiceal tumor 2.4 cm in diameter. Laboratory examinations showed increases in total cholesterol (240 mg·dl<sup>-1</sup>), uric acid (5.7 mg·dl<sup>-1</sup>), and carcinoembryonic antigen (134 ng·ml<sup>-1</sup>).

An exploratory laparotomy was planned. When the abdomen was opened, with the patient under general anesthesia, a large volume of tenacious yellowish mucinous ascites was recognized. The mucinous ascites could not be suctioned, and was manually removed (amount, 736 g). Then, bilateral salpingo-oophorectomy and appendectomy were performed. The right ovarian



**Fig. 1.** Changes in circulatory dynamics and blood gas analysis. Sodium bicarbonate ( $\text{NaHCO}_3$ ; 7%) was administered as an intraperitoneal irrigation at a total volume of 1000 ml and an overall irrigation time of approximately 5 to 6 min.  $\text{PaO}_2$  was 135–160 mmHg during the operation (fractional inspired oxygen  $[\text{F}_{\text{I}\text{O}_2}]$ , 0.6). Filled triangles indicate intubation and

extubation. Double circles indicate the beginning and end of surgery. SBP/DBP, Systolic/diastolic blood pressure; HR, heart rate;  $\text{ETCO}_2$ , end-tidal carbon dioxide; ICU, intensive care unit; A1–7, times of blood gas analysis; before, before surgery; after, after surgery; div, intravenous drip infusion; iv, intravenous infusion

tumor was filled with mucinous material which appeared to be similar to the mucinous ascites. The appendiceal tumor had partially ruptured. Pathology examination done during the surgical procedure revealed PMP.

To facilitate the removal of the remaining mucus, intraperitoneal irrigation was done by instilling 500 ml of 7% sodium bicarbonate solution, followed by gentle agitation for 2 to 3 min prior to removal by suction. This procedure was repeated twice, with a total volume of 1000 ml and an overall irrigation time of approximately 5 to 6 min. Figure 1 presents the changes in circulatory dynamics and the results of blood gas analysis (BGA). Blood pressure was elevated during irrigation, and nicardipine (1 mg) was administered. End-tidal carbon dioxide ( $\text{ETCO}_2$ ) increased. BGA showed critical alkalosis (pH, 7.66; base excess [BE], 24 mEq·l<sup>-1</sup>;

$\text{HCO}_3^-$ , 50 mEq·l<sup>-1</sup>). In addition, hypernatremia ( $\text{Na}^+$ , 153 mEq·l<sup>-1</sup>), hypokalemia ( $\text{K}^+$ , 2.8 mEq·l<sup>-1</sup>), hypocalcemia ( $\text{Ca}^{2+}$ , 0.98 mEq·l<sup>-1</sup>), and hypochloremia ( $\text{Cl}^-$ , 99 mEq·l<sup>-1</sup>) were observed. We administered 10 mEq potassium chloride and 7 mEq calcium chloride intravenously. The alkalosis gradually resolved. After the 2-h surgical procedure, the patient woke up and was extubated. BGA after extubation showed pH, 7.40; BE, 7.2 mEq·l<sup>-1</sup>;  $\text{Na}^+$ , 146 mEq·l<sup>-1</sup>;  $\text{K}^+$ , 3.0 mEq·l<sup>-1</sup>;  $\text{Ca}^{2+}$ , 1.10 mEq·l<sup>-1</sup>;  $\text{PaCO}_2$ , 53 mmHg. The patient was monitored closely for the following 20 h in the intensive care unit (ICU). Infusion of potassium chloride (10 mEq) was repeated in the ICU. Review of the histology confirmed an appendiceal mucinous cystadenocarcinoma with metastases in the bilateral ovaries. The patient was discharged home 15 days after the surgery, and she

received systemic chemotherapy (tegafur, uracil) as an outpatient. She is doing well with no apparent recurrence at the time of this reporting.

## Discussion

PMP is a rare disease characterized by a large amount of mucinous ascites with peritoneal and omental implants; it rarely shows extraperitoneal growth. Most investigators agree that radical surgical debulking and appendectomy are adequate initial therapeutic measures, but the role of intraperitoneal chemotherapy and the application of mucolytic therapy remain uncertain [1–3]. Histologically, three main categories have been described: disseminated peritoneal adenomucinosis, peritoneal mucinous carcinomatosis, and peritoneal mucinous carcinomatosis with intermediate or discordant features [8]. The clinical outcomes vary widely between the benign and the malignant forms. Focal proliferation appears to be a prognostic factor [8,9]. Survival rates are 14% to 75% at 5 years and 3% to 68% at 10 years [8].

Several authors have found that intraperitoneal irrigation with dextrose or dextran expedites the removal of mucus and prevents its reaccumulation [4,5]; therefore, these solutions have been used often. But Shyr et al. [10], in an *in vitro* and *in vivo* study, suggested that 5% and 10% dextrose were ineffective, and Roy et al. [11] reported a patient with acute hyperglycemia following intraperitoneal irrigation with 10% dextrose.

Mucins are a family of large, heavily glycosylated proteins. Mucins are soluble in alkali; therefore, otolaryngologists have used sodium bicarbonate solutions for cleaning the airway. Since the report of Watanabe et al. [6] was published, intraperitoneal irrigation with sodium bicarbonate has been used in Japan for patients with PMP. We believe that the present case is the first documentation of critical alkalosis following intraperitoneal irrigation with sodium bicarbonate in a patient with PMP.

The peritoneal capillary vessels easily absorb sodium bicarbonate in the abdominal cavity by diffusion, such as in peritoneal dialysis, and the peritoneal surface area is equal to the body surface area. In our patient, the predicted amount of absorbed sodium bicarbonate was estimated to be approximately 30% of the entire irrigation volume, using the formula: {absorbed 7% sodium bicarbonate (ml) = body weight (kg)  $\times$  0.2  $\times$  BE (mEq·l<sup>-1</sup>)  $\times$  1.2}. Critical alkalosis happened in our patient who was irrigated with 1000 ml of 7% sodium bicarbonate solution (estimated absorbed volume of 325 ml). In our experience, we had not observed alkalosis in a patient who was irrigated with 200 ml for 2 min, twice (total volume of 400 ml; estimated absorbed

volume of 85 ml). It is uncertain why the patients reported by Matsubara et al. [7] did not develop alkalosis, despite the large volume of sodium bicarbonate that was used, although the lack of alkalosis may have been due to the administration of repeated irrigations with a small volume. We consider that BGA should be carried out when the volume of sodium bicarbonate solution exceeds 500 ml.

Alkalosis induces somnolence, disorientation, hypokalemia, hypocalcemia, and a leftward shift of the oxygen dissociation curve. Excess sodium bicarbonate induces hypernatremia, hypercapnia, and paradoxical acidosis [12], and has a negative inotropic action on myocardial contractility [13]. Although sodium retention after the administration of sodium bicarbonate is mild in comparison with that after the administration of sodium chloride [14], careful management is necessary, especially if patients have dysfunction of heart, lungs, kidney, or other organs.

If pH and bicarbonate are greater than 7.55 and 35 mEq·l<sup>-1</sup>, respectively, prompt appropriate therapy is necessary. In our patient, when BGA showed pH 7.66 and HCO<sub>3</sub><sup>-</sup> 50 mEq·l<sup>-1</sup>, we stopped intraperitoneal irrigation with sodium bicarbonate, and administered potassium chloride and calcium chloride intravenously. The patient had no complications postoperatively. In patients with severe alkalosis and electrolyte imbalance, the administration of amino acid and acidifying agents, and blood dialysis, should be considered.

In summary, we performed intraperitoneal irrigation with a large volume of 7% sodium bicarbonate solution in a patient with PMP, and observed critical alkalosis and electrolyte imbalance. During intraperitoneal irrigation with sodium bicarbonate, careful evaluation of the acid-base balance and serum electrolytes is recommended.

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