

Dilution Acidosis and an Increase of P(A-a)O₂ during Transurethral Resection of the Prostate

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Intravascular absorption of bladder irrigating solution is a well-known complication during transurethral resection of the prostate (TURP)^{1,2}, but little is known about its influence on acid-base equilibrium and blood gases, in comparison with hyponatremia. The following case illustrates the occurrence of dilution acidosis and a defect in oxygenation during TURP. We calculated P(A-a)O₂ using the equation: $P_{A_{O_2}} = (P_B - P_{H_2O}) \times F_{I_{O_2}} - Pa_{CO_2}/R + (Pa_{CO_2} \times F_{I_{O_2}} \times (1-R)/R)$, where $P_B = 760$ (mmHg), $P_{H_2O} = 47$ (mmHg), and $R = 0.8$.

Report of a Case

A 54-year-old man weighing 50 kg was scheduled for TURP due to a benign prostatic hypertrophy. Spinal anesthesia was induced using 2.0 ml of 0.3% dibucaine, and analgesia below the tenth thoracic dermatome was obtained. A radial arterial catheter was inserted and arterial blood gas analysis revealed pH 7.39, PaO₂ 91 mmHg, PaCO₂ 43 mmHg, and HCO₃⁻ 25 mEq/L; P(A-a)O₂ was 8 mmHg and serum sodium was 136 mEq/L. The surgery was started, using an irrigating solution which contained sorbitol 2.7 w/v% and mannitol 0.54 w/v%. Twenty minutes after the start of the resection, serum sodium had fallen to 118 mEq/L and de-

creased further to 109 mEq/L within 10 min, accompanied with a decrease in HCO₃⁻ and pH. After the next 20 min, the patient complained of nausea, and the muscle of the shoulder twitching. Serum sodium had decreased to the value of 106 mEq/L and blood gas analysis demonstrated pH 7.31, HCO₃⁻ 20 mEq/L, PaCO₂ 40 mmHg, PaO₂ 79 mmHg, and P(A-a)O₂ 23 mmHg. Furosemide 10 mg was given by I.V. and Resectol-TTM (balanced solution manufactured to infuse during TURP, which contains mannitol 15 w/v%, glucose 5.0 w/v%, dextran 70 3.0 w/v%, NaCl 0.85 w/v%, and CaCl₂ 0.05 w/v%)³ was started to infuse intravenously. The resection was completed in 50 min, when serum sodium was 104 mEq/L and blood gas analysis still revealed dilution acidosis, although P(A-a)O₂ decreased to 15 mmHg; pH 7.32, HCO₃⁻ 20 mEq/L, PaCO₂ 40 mmHg, PaO₂ 86 mmHg. Resectol-TTM 300 ml had been infused in 30 min, and serum sodium gradually increased, but HCO₃⁻ remained low. Sixty minutes after the surgery, the pH had returned to 7.40 due to a decrease in PaCO₂, and PaO₂ had increased to 96 mmHg due to a decrease in P(A-a)O₂ to 11 mmHg. Blood pressure and heart rate were stable throughout the surgery, and the remainder of the postoperative course was uneventful. The changes in blood gases and serum sodium are presented in figure 1, and figure 2 shows the significant correlation between HCO₃⁻ and serum sodium.

Discussion

Dilution of the extracellular fluid results

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in metabolic acidosis only when extraordinarily large volumes of isotonic solutions are gained, because bicarbonate is gener-

ated from intracellular or bone sources⁴. Apparently, the patient undergoing TURP is under an unusual situation, and massive intravascular absorption of irrigating solution may dilute and expand the extracellular fluid compartment. In this case, sequential analyses of blood gases demonstrated the proceeding decrease of pH, and the significant relationship between HCO_3^- and serum sodium indicates that the decrease in HCO_3^- was caused by dilution. Moreover, mannitol contained in Resectol-TTM aggravated and continued the dilution, inducing water movement from the intracellular to the extracellular compartment⁵.

Dilution acidosis can be repaired simply by the renal excretion of a fluid equal in volume to that which is administered⁴. It will be corrected spontaneously, when diuresis is forced to treat hyponatremia. In our case, the decrease in pH was compensated by the decrease in PaCO_2 caused by hyperventilation, but HCO_3^- remained low even after the partial restoration in serum sodium. The infusion of hypertonic mannitol was demonstrated to cause a more substantial decrease in the extracellular bicarbonate concentration in contrast to the similar degree of expansion with isotonic saline⁶. Therefore, the infusion of Resectol-TTM, which is hyperosmotic, but contains no HCO_3^- , might aggravate and facilitate the decrease in HCO_3^- due to the isotonic irrigating solution.

The expansion of extracellular fluid volume causes interstitial pulmonary edema

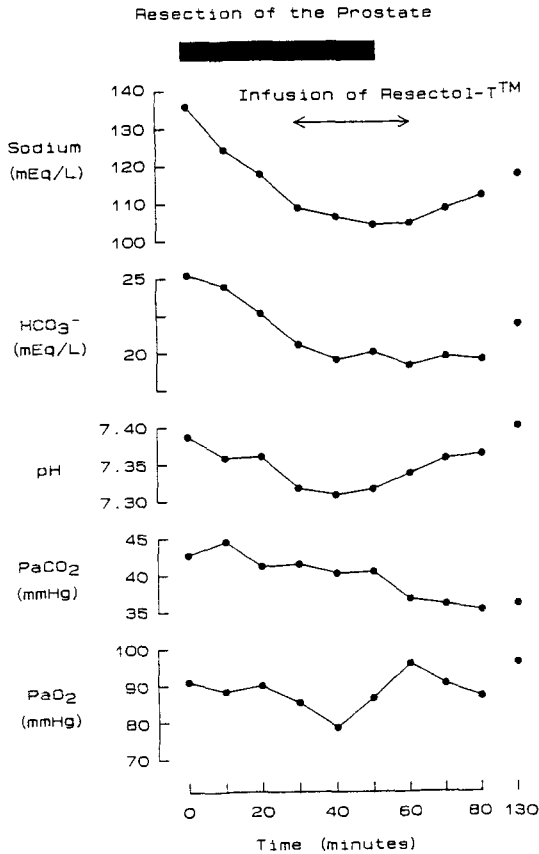


Fig. 1. Serum sodium, HCO_3^- , pH, PaO_2 , and PaCO_2 during and after the transurethral resection of the prostate.

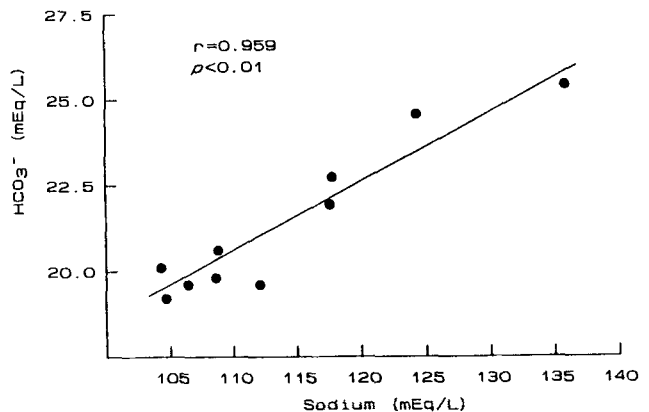


Fig. 2. Correlation between HCO_3^- and serum sodium during and after the transurethral resection of the prostate.

and impairs pulmonary oxygenation, without cardiac failure. Casthely and co-workers studied 18 patients who underwent TURP, and found that $P(A-a)O_2$ had increased in inverse proportion to a decrease in serum sodium, in spite of the minimal change in CVP⁷. They also found that the increase in $P(A-a)O_2$ was significantly larger in the patients who had needed furosemide, because of severe hyponatremia. Kawamoto et al., also reported increases of $P(A-a)O_2$ in two patients who developed moderate hyponatremia⁸. Also in our case, the simultaneous increase in $P(A-a)O_2$ with the decrease in serum sodium suggested the occurrence of interstitial pulmonary edema due to the absorption of irrigating fluid.

Pa_{O_2} increased due to the decrease in Pa_{CO_2} , but the increase in $P(A-a)O_2$ persisted. This might be due to the rapid infusion of Resectol-TTM containing mannitol, in addition to the absorption of irrigating solution. Mannitol is as effective as furosemide for inducing diuresis following TURP, but it may be dangerous in a patient who is already overloaded⁹. Infusion of mannitol has been demonstrated to cause significant increases in blood volume and in pulmonary capillary wedge pressure, and increases in $P(A-a)O_2$, and interstitial pulmonary edema^{10,11}. Severe pulmonary edema due to repeated infusion of 20% mannitol has also been reported, during the treatment of acute water intoxication¹². It took about one hour to restore the preoperative value in Pa_{O_2} and $P(A-a)O_2$, and this required time corresponds to a previous report¹⁰.

In summary, we examined a case, which developed dilution acidosis and moderate hypoxemia during TURP. We recommend the checking of blood gases as well as serum sodium during TURP, even when there are no apparent symptoms of hyponatremia or pulmonary edema, and not to infuse solutions containing mannitol without HCO_3^- , in the treatment of hyponatremia.

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