Journal of PeriAnesthesia Nursing 000 (2022) 1−3

Contents lists available at ScienceDirect

Journal of PeriAnesthesia Nursing

journal homepage: www.jopan.org

Clinical

Initiating Continuous Renal Replacement Therapy in Patients With Transurethral Resection of Prostate Syndrome: A Case Report

Dongqin Deng, BS[a], Qi Zhang, MM[b], Weifeng Tu, PhD[c], Xinquan Yang, MM[b], Yinghui Qi, MM[b], Junlong Zhang, PhD[b,*]

[a] *Hemodialysis center, Affiliated Hospital of Jiangnan University, Wuxi, China*
[b] *Department of Anesthesiology, Lianyungang Hospital Affiliated of Jiangsu University, Lianyungang, China*
[c] *Faculty of Anesthesiology, Suzhou Science & Technology Town Hostpital, Suzhou school, Nanjing Medical Universty, Suzhou, China*

Keywords:
continuous renal replacement therapy
transurethral resection of prostate syndrome
volume overload
hyponatremia

A B S T R A C T

With advances and developments in hysteroscopy, cystoscopy, transurethral resection of bladder tumor, and arthroscopy, transurethral resection of prostate (TURP) syndrome has been increasingly reported. TURP syndrome is often accompanied by severe hyponatremia, fluid overload, and a plasma hypotonic state, resulting in heart failure and pulmonary and cerebral edema. Conventional treatment methods, such as intravenous infusion of hyperosmotic saline, can rapidly reverse the downward trend of serum sodium levels in efforts to prevent and treat cerebral edema. However, this may not be suitable for patients with cardiac and renal insufficiency and may induce central pontine myelinolysis due to the possibility of worsening volume load and difficulty in controlling the correction rate of serum sodium. The patient described in this report presented with severe hyponatremia (sodium<100 mmol/L) combined with intraoperative pulmonary edema; his cardiac function and oxygenation status deteriorated after an intravenous infusion of 3% hypertonic saline. He underwent continuous renal replacement therapy (CRRT) to prevent the progression of multiple −organ edema and cardiac insufficiency. CRRT has demonstrated efficacy in the treatment of chronic hyponatremia in patients with renal failure, and can slowly and continuously correct water-electrolyte imbalance, acid-base imbalance, and volume overload. TURP syndrome with severe hyponatremia and pulmonary edema was diagnosed; accordingly, the patient was treated with 3% hypertonic saline, furosemide, and CRRT, without the development of overt neurological sequelae.

With advances and developments in hysteroscopy, cystoscopy, transurethral resection of bladder tumor, and arthroscopy, there has been an increasing trend in literature reports describing transurethral resection of prostate (TURP) syndrome, which is caused by massive fluid absorption during surgery, resulting in fluid overload, hyponatremia, and a plasma hypotonic state, which in turn leads to acute cardiac insufficiency and multiple organ edema.[1] Guideline recommended conventional treatment (2014 European Hyponatremia Guideline Development Group) has been controversial because of the additional volume burden and difficulty in controlling the correction rate of serum sodium, which may increase the severity of heart failure and pulmonary edema, thus placing patients at risk for severe neurological sequelae.[2] Continuous renal replacement therapy (CRRT) has demonstrated efficacy in the treatment of chronic hyponatremia in patients with renal failure, and can slowly and continuously correct water-electrolyte imbalance, acid-base imbalance, and volume overload by adjusting the composition of the replacement fluid and dialysate or adjusting the treatment parameters.[3,4] The role of renal replacement therapy in the treatment of TURP syndrome has not yet attracted significant clinical attention. In the present case, TURP syndrome with severe hyponatremia and pulmonary edema was diagnosed, and the patient was treated with CRRT without the development of overt neurological sequelae. Case reports were published with informed consent from patients.

Case Report

A 66-year-old man with prostate hyperplasia was admitted to the authors' hospital. Laboratory investigations and preoperative physical examination yielded no abnormal findings. The patient's serum

Conflict of Interest: None to report.
Funding: None to report.
* Address correspondence to Junlong Zhang, Department of Anesthesiology, Lianyungang Hospital Affiliated of Jiangsu University, 41 Hailian East Road, Lianyungang city, Jiangsu Province, 222000, China.
E-mail address: zjlddqzyw@126.com (J. Zhang).

https://doi.org/10.1016/j.jopan.2022.09.001
1089-9472/

Table 1
Changes in pH, Electrolyte Levels, and Hemoglobin During TURP Syndrome

	pH	Sodium (mmol/L)	Potassium(mmol/L)	Chloride(mmol/L)	Calcium(mmol/L)	Hemoglobin(g/dL)
Pre-operation	7.38	138.90	4.06	106.70	2.37	14.00
Intraoperative 1h	7.36	130.90	3.51	104.80	0.99	11.30
Intraoperative 1.5h	7.26	<100.00	4.55	71.60	0.59	7.70
Intraoperative 1.8h	7.21	<100.00	3.96	71.40	0.59	7.40
Postoperation 6h	/	102.80	3.51	72.30	1.57	7.50
Postoperation 18h	/	125.20	3.86	86.40	2.56	8.60
Postoperation 22h	7.34	132.20	3.68	95.50	2.83	11.20
Postoperation 3d 72h	7.41	139.70	3.55	106.10	2.27	11.60

sodium, potassium, chloride, calcium, and hemoglobin (Hb) levels were 138.9 mmol/L, 4.06 mmol/L, 106.7 mmol/L, 2.37 mmol/L, and 14.00 g/dL, respectively. The patient underwent transurethral resection of the prostate under general anesthesia. Noninvasive blood pressure (BP), electrocardiogram, and pulse oximetry were routinely measured after the patient arrived to the operating room. Anesthesia was induced using midazolam 0.05 mg/kg, fentanyl 5 μg/kg, propofol 1 mg/kg, and cisatracurium 0.2 mg/kg. Anesthesia was maintained using 100% oxygen, 2% to 3% sevoflurane and cisatracurium. Ventilation was controlled to maintain end-tidal carbon dioxide tension in the range of 35 to 45 mm Hg. An intravenous sodium chloride solution was infused as maintenance fluid.

At the start of the procedure, irrigation fluid containing 5% mannitol was connected to the lateral port of the unipolar resectoscope and infused by gravity with the irrigation fluid raised to 70 cm above the patient. BP was maintained within 100/60 to 130/80 mm Hg.

A 3% sodium chloride solution 100 mL was injected intravenously as a precautionary measure 30 min after the operation started. During the operation, the visual field was light red. One hour after the operation started, blood chemistry values were notable for the following: pH 7.36; sodium 130.90 mmol/L; potassium 3.51 mmol/L; chloride 104.80 mmol/L; calcium 0.99 mmol/L; partial pressure of oxygen (PaO_2) 406.00 mm Hg; and total Hb (tHb) 11.30g/dL. The surgeon was informed that the patient's arterial blood gas (ABG) profile was consistent with mild hyponatremia, with a recommendation that the duration of the operation should be shortened as much as possible. Furosemide 20 mg was injected intravenously, and normal saline was changed to 3% sodium chloride solution.

Ninety minutes after surgery started, a total of 15 L of 5% mannitol solution was irrigated. ABG analysis revealed the following values: pH 7.26; sodium<100.00 mmol/L; potassium 4.55 mmol/L; chloride 71.60 mmol/L; calcium 0.59 mmol/L; PaO_2 168.30 mm Hg; and tHb 7.70 g/dL. Physical examination revealed pulmonary rales and TURP syndrome complicated by severe hyponatremia (<100.00 mmol/L), acidosis, and pulmonary edema. Infusion of 5% hypertonic saline was initiated immediately, and intravenous furosemide 20 mg and dexamethasone 10 mg were infused simultaneously.[5] After approximately 15 min of treatment, his vital signs were notable for reduced BP and an oxygen saturation of 90% on pure oxygen; ABG analysis revealed the following values: pH 7.21; sodium <100.00 mmol/L; potassium 3.96 mmol/L; chloride 71.40 mmol/L; calcium 0.59 mmol/L; PaO_2 56.80 mm Hg; and tHb 7.40 g/dL. The operation lasted for 2 h. A total of 200 mL of 3% hypertonic saline, 100 mL of 5% hypertonic saline, 400 mL of 0.9% normal saline, and 300 mL of sodium bicarbonate were infused. The patient was transferred to the intensive care unit (ICU) for further treatment.

After transfer to the ICU, CRRT was initiated to correct water-electrolyte imbalance, acid-base imbalance, and water poisoning to avoid hypertonic sodium chloride infusion worsening of his volume status.[6] Continuous venovenous hemofiltration (CVVH) was used, with a blood flow rate of 200 to 230 mL/min, a replacement flow rate of 2000 mL/h; the ultrafiltration rate of CVVH was 20-25 mL/kg/h. The components of the replacement fluid included saline solution 3000 mL, sterile water 820 mL, 5% dextrose 170 mL, 10% potassium chloride 10 mL, 25% magnesium sulfate solution 3.2 mL, and 10% calciumchloride 6.4 mL. Sodium bicarbonate solution (5%) was pumped through the peripheral vein at a rate of 100 mL/h. The patient's real-time ABG analysis results were used to adjust the infusion rate of the 5% sodium bicarbonate solution, and the concentration of sodium and other ions in the replacement solution.

CVVH was stopped after 22 hours, while ABG analysis revealed the following: pH 7.34 mmol/L; sodium 132.20 mmol/L; potassium 3.68 mmol/L; chloride 95.5 mmol/L; and calcium 2.83 mmol/L. In addition, transfusions of blood cells, plasma, cryoprecipitate, and albumin are used to correct anemia, increase colloid osmotic pressure, and improve coagulation. On postoperative day 2, the patient gradually recovered from anesthesia and the endotracheal tube was removed. On postoperative day 3, the patient's ABG analysis yielded the following values: pH 7.41; sodium 139.70 mmol/L; potassium 3.55 mmol/L; chloride 106.10 mmol/L; and calcium 2.27 mmol/L (Table 1). No overt neurological sequelae were observed on postoperative day 7, and the patient was discharged.

Discussion

Surgical treatment of benign prostatic hyperplasia includes three types: transurethral surgery; open simple prostatectomy; and minimally invasive techniques. Monopolar TURP (M-TURP) is the "gold standard" for the transurethral treatment of benign prostatic hyperplasia. On the basis, bipolar TURP (B-TURP), transurethral incision of the prostate, transurethral vaporization of the prostate, and laser prostatectomy have been developed. Minimally invasive surgery, including transurethral microwave therapy, transurethral needle ablation, prostatic stents, and prostatic artery embolization, can improve symptoms and avoid the occurrence of TURP syndrome, with a certain rate of retreatment and limited availability of equipment.[7] In order to ensure a clear surgical field of vision and smoothly resection the prostate tissue on the surgical side, transurethral surgery needs to maintain the irrigation fluid circulation unobstructed. Non-ionic flushing solution is used in M-TURP procedures, such as 5% mannitol, 1.5% glycine, 2.2% glycine, 3% sorbitol, sterile water, 2.7% sorbitol−0.54% mannitol, and 5% glucose, and its absorption in large amounts can trigger TURP syndrome. B-TURP and laser prostatectomy using isotonic saline as irrigation fluid can effectively avoid hyponatremia and hemolysis caused by electrolyte-free irrigation fluid.

Hyponatremia is a common electrolyte disorder that is further distinguished into acute and chronic hyponatremia based on duration. It can be treated according to symptom severity, volume status, etiology, serum osmolality, and disease course. The guideline, published by the 2014 European Hyponatremia Guideline Development Group, indicated that the severity of neurological symptoms is an important factor in the treatment of hyponatremia. For severe hyponatremia caused by fluid absorption, which is characterized by short duration, atypical symptoms, volume overload, and is prone to severe neurological complications, the guidelines recommend the bolus administration of 3% hypertonic saline and strict control of serum sodium correction rate within 24 hour at 8 to 10 mmol. Although this treatment can rapidly reverse serum sodium, thus hindering the development of cerebral edema and cerebral hernia, for severe hyponatremia with volume overload, it is difficult to control the correction rate of serum sodium and cause additional capacity, which further increases the severity of heart failure and pulmonary edema and increases the risk for osmotic demyelination syndrome.

The ideal treatment for TURP syndrome is to progressively correct water-electrolyte and acid-base imbalance, eliminate volume overload, and reduce the risk for neurological complications. As the preferred extracorporeal kidney support therapy, CRRT has been widely used in critically ill patients with kidney injury and multiple organ failure in the ICU, and has demonstrated good efficacy in the correction of severe hyponatremia and volume expansion in patients with kidney failure. CRRT has the following advantages over conventional therapy for TURP syndrome: effectively controlling increases in rate of serum sodium concentration; isotonically eliminating internal and external water accumulation in cells; maintaining hemodynamics in a relatively stable state; avoiding treatment-related capacity overload and electrolyte disorder; correcting water-electrolyte imbalance and acid-base imbalance simultaneously; promoting parenteral nutrition; and as an adjuvant treatment for other concurrent diseases.[8-10]

Compared with the treatment of complications, it is more important to identify the influencing factors of irrigation fluid absorption (IFA) and take appropriate measures to prevent TURP syndrome. Previous studies have found that the maximum and mean IFA values of B-TURP are significantly lower than that of M-TURP. It is suggested that the promotion of new transurethral surgery may be beneficial to reduce the incidence of TURP syndrome. Several intraoperative factors influence IFA by altering perfusion pressure, amount of irrigation, and systemic resistance to irrigation, such as irrigation height, irrigation flow, perforation of the prostatic capsule, size and number of transected venous sinus, irrigation system, operation time, volume of prostate, resection depth, operation duration, and surgeon experience. Irrigation height and irrigation system are the factors influencing intravesical pressure (IVPs). Although traditional high-pressure irrigation is used to reduce the amount of bleeding and to obtain a clearer surgical view, lowering the irrigation height to 40 cm or less than 60 cm reduces the maximum and mean IVPs, thereby reducing the incidence of IFA.[11] In recent studies, several monitoring techniques have been used to assess the volumes of IFA, which is helpful for early detection of IFA and prevention of disease progression, including measuring the concentration of ethanol in exhaled air, weighing the patients before and after surgery, adding radioactive isotopes to the irrigation solution, monitoring serum sodium levels, and comparing the volume of the irrigation solution.

This case report describes a patient with TURP syndrome treated with hyperosmotic saline and CRRT to gradually correct electrolyte disturbances and multiple organ edema for effective prophylaxis and treatment of neurological complications. In patients with severe hyponatremia in TURP syndrome, CRRT may be beneficial. It should be noted, however, that further clinical studies are needed to confirm the efficacy of this treatment.

Acknowledgment

Elsevier Webshop reviewed this manuscript for grammar.

References

1. Ortner G, Nagele U, Herrmann TRW, et al. Irrigation fluid absorption during transurethral bipolar and laser prostate surgery: a systematic review. *World J Urol*. 2022;40:697–708.
2. Hoorn EJ, Zietse R. Diagnosis and treatment of hyponatremia: compilation of the guidelines. *J Am Soc Nephrol*. 2017;28:1340–1349.
3. Yessayan LT, Szamosfalvi B, Rosner MH. Management of dysnatremias with continuous renal replacement therapy. *Semin Dial*. 2021;34:472–479.
4. Rosner MH, Connor MJ. Management of severe hyponatremia with continuous renal replacement therapies. *Clin J Am Soc Nephrol*. 2018;13:787–789.
5. Garrahy A, Cuesta M, Murphy B, et al. Active management of severe hyponatraemia is associated with improved mortality. *Eur J Endocrinol*. 2021;184:9–17.
6. Sterns RH, Hix JK, Silver SM. Management of hyponatremia in the ICU. *Chest*. 2013;144:672–679.
7. Lerner LB, McVary KT, Barry MJ, et al. Management of lower urinary tract symptoms attributed to benign prostatic hyperplasia: AUA guideline part II-surgical evaluation and treatment. *J Urol*. 2021;206:818–826.
8. Ostermann M, Dickie H, Tovey L, et al. Management of sodium disorders during continuous haemofiltration. *Crit Care*. 2010;14:418.
9. Neyra JA, Ortiz-Soriano VM, Ali D, et al. A multidisciplinary approach for the management of severe hyponatremia in patients requiring continuous renal replacement therapy. *Kidney Int Rep*. 2018;4:59–66.
10. Dodd SE, Jankowski CJ, Krambeck AE, et al. Metabolic acidosis with hemodilution due to massive absorption of normal saline as bladder irrigation fluid following holmium laser enucleation of prostate. *J Anesth*. 2016;30:1060–1062.
11. Tokas T, Ortner G, Herrmann TRW, et al. Relevance of intravesical pressures during transurethral procedures. *World J Urol*. 2021;39:1747–1756.