Case Report

# Perioperative Concerns for Profound Metabolic Alkalosis During Kidney Transplantation: A Case Report

Jung Ju Choi,[1] Yong Beom Kim,[1] Hong Soon Kim,[1] Kyung Cheon Lee,[1] and Youn Yi Jo[1,*]

[1]Department of Anesthesiology and Pain Medicine, Gachon University, Gil Medical Center, Incheon, South Korea

[*]*Corresponding author*: Youn Yi Jo, Department of Anesthesiology and Pain Medicine, Gachon University, Gil Medical Center, Incheon, South Korea. Tel: +82-324603636, Fax: +82-324696319, E-mail: endless37@gilhospital.com

## Abstract

**Introduction:** Profound metabolic alkalosis is an uncommon consideration for the anesthetic management of kidney transplantation. Serum total carbon dioxide content and complex electrolyte abnormalities might be important diagnostic clues for the presence of metabolic alkalosis in the absence of arterial blood gas analysis.

**Case Presentation:** A 34-year-old female visited Gachon University Gil Medical Center, Incheon, South Korea during year 2015. She experienced aggravated renal function due to chronic hypokalemia and severe hypochloremic metabolic alkalosis, induced by laxative abuse, and underwent ABO incompatible kidney transplantation. Serum total carbon dioxide content remained high (about 60 mEq/L) over eight months of monthly follow-up prior to kidney transplantation.

**Conclusions:** The authors described their anesthetic experience of profound metabolic alkalosis with complex electrolyte abnormalities and provided a review of relevant literature.

*Keywords:* Alkalosis, Hypoventilation, Kidney Transplantation

## 1. Introduction

Although metabolic alkalosis is not an uncommon condition in hospital care with symptoms of frequent vomiting, use of diuretics and nasogastric suction, profound metabolic alkalosis is an uncommon consideration for the anesthetic management of kidney transplantation. Metabolic acidosis is a common complication associated with progressive loss of kidney function, and metabolic acidosis itself exacerbates the kidney function. The destruction of glomerular filtration function leads to confusion of filtering bicarbonate, ammonium and titratable acid, which leads to acidosis (1). Despite the scarcity of profound metabolic alkalosis in patients with renal insufficiency, it might closely be related with mortality and morbidity. A previous analysis of 10811 general medical or surgical patients reported mortality of 45% in the patients with a pH of 7.55, and mortality of 80% with pH over 7.65 (2).

Serum total carbon dioxide ($tCO_2$) is an excellent estimator of serum bicarbonate with a normal range of 23~30 mEq/L (3). However, clinicians sometimes fail to note acid-base status as suggested by $tCO_2$ when arterial blood gas analysis (ABGA) findings are unavailable.

No report has been issued to date on perioperative concerns of kidney transplantation accompanied by profound metabolic alkalosis. Here, we describe our anesthetic experience and perioperative concerns in a patient with profound metabolic alkalosis, which was suspected based on $tCO_2$ values and complex electrolyte abnormalities.

## 2. Case Presentation

A 34-year-old female (162 cm, 42 kg) underwent kidney transplantation due to end-stage renal disease at the Gachon university Gil medical center (1600-bed tertiary referral hospital), Incheon, South Korea during year 2015. She had a history of long-term laxative ingestion due to chronic constipation. Eight months pre-transplantation, she was diagnosed with renal insufficiency with hypokalemia, but did not experience any subjective symptom. Profound hypochloremic metabolic alkalosis persisted, as determined by monthly laboratory follow-up visits, despite regular oral potassium supplementation (Table 1). Peritoneal dialysis was started six months before transplantation. The patient was determined to undergo kidney transplantation from her sister and started plasma exchange/plasma pheresis using 12 units of AB$^+$ fresh frozen plasma due to ABO incompatibility (Donor, AB$^+$; Recipient O$^+$). Anti-A and -B were reduced from 1:16 and 1:4 to 1:1 and 1:1, respectively, after four plasma exchanges. She was taking mycophenolate sodium, tacrolimus, intra-

venous immunoglobulin and corticosteroid after applying rituximab. Prior to transplantation, her mental status was alert. Preoperative electrocardiography and chest x-ray were normal, and blood pressure, heart rate, and body temperature were 105/65 mmHg, 84 beats/minute, and 36.4oC, respectively. Preoperative laboratory data were as follows: hematocrit 26.6%, platelet count $267 \times 103$/mL, Blood Urea Nitrogen (BUN) 46.2 mg/dL, Creatinine (Cr) 6.1 mg/dL, $tCO_2$ 53.8 mEq/L, potassium ($K^+$) 3.8 mEq/L, chloride ($Cl^-$) 74 mEq/L, Prothrombin Time (PT) 9.2 seconds and activated Partial Thromboplastin Time (aPTT) 27.8 seconds. Parathyroid hormone was 298.6 pg/mL (normal range 10 - 65 pg/mL). Arterial blood gas analysis in the preanesthetic room revealed pH 7.56, $PaO_2$ 88 mmHg, $PaCO_2$ 71 mmHg, bicarbonate ($HCO_3$.) 60 mEq/L, and base excess 30 mEq/L. All analyzers for serum variables (TBA-200FR NEO, Toshiba, Tokyo, Japan) and arterial blood gas analysis (GEM Premier 3000, Instrumentation Laboratory, MA, USA) were calibrated periodically and the measuring variables were selected as preoperative evaluation protocol of our institute. The samples were analyzed for pH, $PaCO_2$ (standard electrodes), and the base excess and $HCO_3$. were taken from the arterial blood gas analyzer, which uses the Henderson–Hasselbalch equation and the van Slyke equation. Additionally, the concentrations of serum values, including $K^+$, $Cl^-$ (ion-selective electrode) and $tCO_2$, were measured using the same blood samples. Remifentanil 40 $\mu$g, lidocaine 40 mg, propofol 80 mg, and cis-atracurium 5 mg were administered for anesthetic induction. To maintain a Bispectral Index (BIS) score between 40 and 60, anesthesia was maintained with desflurane at 4 - 7 vol% and remifentanil at 0.05 - 0.1 $\mu$g/kg/minute. A 20-G right radial arterial catheter and a 16-Fr right internal jugular venous catheter were inserted. During transplantation, vital signs were maintained at blood pressure 97/55 - 130/78 mmHg, heart rate 72 - 91 beats/minute, and central venous pressure 2 - 9 mmHg without transfusion of blood components. The total amount of infused fluid was 3800 mL, estimated blood loss was 350 mL and urine output was 1110 mL, during the six-hour operation. The ABGA values during the operation are provided in Table 2. During the 70-minute postanesthetic care unit stay, urine output was 850 mL, and vital signs were stable with alert mentality despite a $PaCO_2$ value of 64 mmHg (Table 2).

The patient was discharged on postoperative day 15 without complication and remained asymptomatic at her 12-month follow-up without an electrolyte abnormality or sign of rejection.

## 3. Discussion

Our patient underwent ABO incompatible kidney transplantation, because she developed end stage renal disease resulting from chronic hypokalemia and severe hypochloremic metabolic alkalosis induced by laxative abuse. High $tCO_2$ and serum $Cl^-$ values at monthly follow up visits prior to transplantation suggested chronic uncompensated metabolic alkalosis.

To the best of our knowledge, this is the first clinical report of perioperative considerations in patients with end stage renal disease accompanied by profound metabolic alkalosis and evaluated the utility of serum $tCO_2$ and electrolyte values for predicting severity of acid base alterations.

Long-term laxative or diuretic abuse can lead to hypokalemia, prolonged potassium depletion, and cause vacuolization in proximal convoluted tubules, interstitial nephritis and a diminished glomerular filtration rate ([4], [5]). Volume depletion accompanied by loss of $K^+$, $H^+$ and $Cl^-$ stimulates $HCO_3$. reabsorption and produces metabolic alkalosis ([6]). Although serum $HCO_3$. values may be calculated from pH and $PaCO_2$ using the Henderson-Hasselbalch equation, serum $HCO_3$. accounts for 95% of $tCO_2$, and thus, $tCO_2$ can be regarded an excellent surrogate of serum $HCO_3$. ([3]). In our case, a persistent high $tCO_2$ level was probably due to a high serum HCO3- level. Preoperative abbreviated strong ion differences (aSID ; $Na^+ + K^+ - Cl^-$) ranged from 63 to 74 mEq/L in our patient, and the presence of such a large ion difference, enabled clinicians to predict the presence of severe metabolic alkalosis without ABGA results ([7]). Furthermore, because of the low $K^+$ level in our patient, despite oral potassium supplementation, and an inordinately low $Cl^-$ level, considerable efforts were made to correct electrolyte abnormalities and volume depletion over several months prior to transplantation.

Standing upon profound metabolic alkalosis, clinicians have to pay attention to the presence of chronic hypoventilation, which originate from compensation mechanism. An increase in arterial blood pH depresses respiratory centers and leads to alveolar hypoventilation and $PaCO_2$ elevation. Furthermore, hypoventilation activates oxygen-sensitive chemo-receptors and stimulates ventilatory drive, which limit respiratory compensation to metabolic alkalosis. Usually, $PaCO_2$ does not increase to more than 55 mm Hg in response to metabolic alkalosis ([8]), but in our patient, $PaCO_2$ increased to 70 mmHg, which could have been because chronic metabolic alkalosis persistently triggered hypoventilation, yet well-preserved oxygenation might prevent the activation of the chemoreceptor trigger zone in the respiratory center. In this case, we overlooked ventilatory adjustment and aimed at normal-

**Table 1.** Serum Total Carbon Dioxide Contents and Electrolyte Levels

| | Months Before Kidney Transplantation | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **8** | **7** | **6** | **5** | **4** | **3** | **2** | **1** |
| **tCO$_2$ (mEq/L)** | 58.8 | 57.8 | 54.8 | 58.4 | 58.6 | 59.4 | 60.6 | 60 |
| **BUN (mg/dL)** | 30.6 | 32.8 | 47.9 | 41.6 | 42.1 | 46.9 | 35.5 | 47.2 |
| **Cr (mg/dL)** | 4.3 | 5.1 | 5.8 | 6.2 | 6.2 | 5.5 | 5.4 | 6.4 |
| **Na (mEq/L)** | 144 | 139 | 139 | 138 | 139 | 136 | 138 | 139 |
| **K (mEq/L)** | 2.2 | 3.1 | 4 | 3 | 2.7 | 3.1 | 3 | 2.7 |
| **Cl (mEq/L)** | 72 | 74 | 78 | 79 | 67 | 66 | 71 | 69 |
| **Ca (mg/dL)** | 9.2 | 9.7 | 11.4 | 9.8 | 9.2 | 10.7 | 10.2 | 9.3 |
| **P (mg/dL)** | 4.1 | 5.7 | 5.4 | 4.4 | 5.2 | 6.7 | 4.7 | 6.6 |

Abbreviations: tCO$_2$, serum total carbon dioxide (normal range, 21-31 mEq/L); BUN, blood urea nitrogen (8-22 mg/dL); Cr, creatinine (0.5-1.2 mg/dL); Na, sodium (135-145 mEq/L); K, potassium (3.5-5.5 mEq/L); Cl, Chloride (95-110 mEq/L); Ca, calcium (8.2-10.8 mg/dL); P, phosphate (2.5-4.7 mg/dL).

**Table 2.** Arterial Blood Gas Analysis Results During the Perioperative Period

| | Pre-IND | Time After Anesthesia Induction | | | | PACU |
|---|---|---|---|---|---|---|
| | | **30 min** | **1 h** | **3 h** | **5 h** | |
| **pH** | 7.56 | 7.64 | 7.66 | 7.55 | 7.49 | 7.41 |
| **PaCO$_2$(mmHg)** | 71 | 54 | 51 | 41.5 | 56 | 64 |
| **PaO$_2$(mmHg)** | 88 | 225 | 206 | 233 | 207 | 263 |
| **HCO$_3$.(mEq/L)** | 60 | 58 | 58 | 37 | 43 | 41 |
| **BE(mEq/L)** | 30 | 30 | 30 | 14 | 18 | 14 |

Abbreviations: HCO$_3$., bicarbonate; BE, base excess, Pre-IND, pre-anesthetic room; PACU, post-anesthetic care unit.

izing PaCO$_2$ values, which might have aggravated alkalosis in our patient. In addition, despite correction of acid-base disturbance during anesthesia, chronic hypoventilation might have persisted after emergence from anesthesia because there could be a significant time discrepancy between the velocity of correction for metabolic and respiratory component.

Hyperphosphatemia has been reported in more that 70% of patients that undergo hemodialysis (9), and induces secondary hyperparathyroidism, high serum phosphorus and a high calcium–phosphorus ion product, the latter of which contributes to the development of coronary-artery calcification and increases mortality in young adults that undergo hemodialysis (9, 10). In our case, parathyroid hormone and serum phosphate levels were elevated. Increased daily intake of calcium-containing phosphate-binding agents or vitamin D-derivatives might help reduce secondary hyperparathyroidism and its complications (10, 11).

Our patient underwent ABO incompatible kidney transplantation. Blood group antibody removal by plasma pheresis, immunosuppression induction with rituximab, a B-cell depleting agent, and maintenance using tacrolimus, mycophenolate and corticosteroid prevent isoagglutinin titer rebound and probably improve graft survival (12).

In conclusion, in the presence of electrolyte abnormalities, tCO$_2$ is a valuable diagnostic parameter for determining the presence of acid-base alterations. In cases of profound metabolic alkalosis, clinicians must pay attention to accompanying chronic hypoventilation and determining a tolerable PaCO$_2$ level, based on the severity of metabolic alkalosis and the existence of hypoxia.

## Footnotes

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