Case report

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Management of hypoxic respiratory failure with the use of high flow nasal cannula (HFNC) in pregnant patients with hypokalemic periodic paralysis and suspected distal renal tubular acidosis: A case report

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Abstract

***Introduction*: Hypoxic respiratory failure occurs when the respiratory system cannot adequately provide oxygen to the body, leading to hypoxemia. High-flow nasal cannula (HFNC) improved the survival rate among patients with acute hypoxic respiratory failure. Due to physiological alterations, pregnancy can exacerbate distal renal tubular acidosis (dRTA). Pregnancy complicated by hypokalemic periodic paralysis (HPP) poses significant risks due to the potential cardiac and respiratory failure related to low potassium levels.**

***Case description*: A woman, 21 years old, pregnant with her first child at 33-34 weeks gestation came with complaints of shortness of breath one day before admission. Complaints accompanied by cramps in both legs. On the second day, the respiratory rate (RR) suddenly increased to 35x/min, and oxygen saturation (SpO2) was 95% on a non-rebreathing mask (NRM) at 15 l/min. The patient was transferred to the Intensive Care Unit (ICU) with a diagnosis of primigravida at 33-34 weeks, respiratory failure, HPP, suspected dRTA, severe metabolic acidosis, sepsis, and urinary tract infection (UTI). She was given O2 via HFNC at flow 40 l/min and a fraction of inspired oxygen (FiO2) 66%. Improvement was seen on the 4th day; the patient's shortness of breath was reduced with HFNC, and the patient's motor strength improved.**

***Conclusion*: The use of HFNC showed a positive outcome and was proven to have been successful in treating hypoxic respiratory failure in pregnant women. Respiratory muscle weakness and severe metabolic acidosis caused by dRTA and HPP cannot be cleared due to the limited settings in rural areas. Furthermore, the assessment and management of HPP and dRTA are still limited in many hospitals in remote areas of Indonesia.**

Key words: Respiratory failure, hypokalemic periodic paralysis, distal renal tubular acidosis, high flow nasal cannula, pregnancy.

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Introduction

Hypoxic respiratory failure occurs when the respiratory system cannot adequately provide oxygen to the body, leading to hypoxemia, and can be caused by alveolar hypoventilation, low atmospheric pressure/fraction of inspired oxygen, diffusion defect, ventilation/perfusion mismatch, and right-to-left shunt. (1) Patients treated with a high-flow nasal cannula (HFNC) present with an increased degree of comfort, a reduction in the severity of dyspnea, and a decreased respiratory rate. HFNC also improved the survival rate among patients with acute hypoxic respiratory failure. (2,3)

Renal tubular acidosis (RTA) affects the kidneys' ability to regulate acid levels, resulting in normal

anion gap metabolic acidosis. RTA is a rare disease, with the prevalence of distal RTA (dRTA) estimated at 0.46 per 10,000 people. RTA can be caused by autoimmune diseases (e.g., Sjögren's syndrome and rheumatoid arthritis), hypercalciuria, adverse drug effects (e.g., ifosfamide and amphotericin), and hereditary history of RTA. (4) Pregnancy can exacerbate dRTA due to the physiological alterations from pregnancy. (5)

Pregnancy complicated by hypokalemic periodic paralysis (HPP) poses significant risks due to the potential for cardiac and respiratory failure related to low potassium levels. The causes of low potassium levels can vary, ranging from congenital to acquired factors. It's important to carefully consider the patient's medical history, including the age of onset and potential triggers such as weakness episodes following exertion, high carbohydrate or salt intake, etc., which can help diagnose congenital abnormalities. Correction of serum potassium levels will improve muscle weakness. (6,7)

In our case, the patient presented with hypoxic respiratory failure due to metabolic acidosis triggered by dRTA and sepsis, which leads to the compensatory mechanism by excessive hyperventilation; over time, the respiratory muscles may fail. Respiratory failure can also be caused by respiratory paralysis due to severe hypokalemia.

Case description

A woman, 21 years old, pregnant with her first child at 33-34 weeks' gestation came with complaints of shortness of breath one day before admission. Complaints accompanied by cramps in both legs.

The patient had a history of recurrent hypokalemia, with a history of treatment with Aspar K 1 tablet twice a day orally. Vital signs showed blood pressure (BP) 118/82 mmHg, heart rate (HR) 75x/min, body temperature 36.3 ^{o}C, respiratory rate (RR) 20x/min, oxygen saturation (SpO2) 99% on four l/min nasal cannula, and Glasgow Coma Scale (GCS) 15 (E4M6V5). Head, thorax, and abdomen examinations were within normal limits. Obstetric examination revealed a gravida of 34 weeks with a cephalic presentation. On neurological examination, leg muscle strength was found to be 3/3. Laboratory examination showed hemoglobin 13.6 g/dl, hematocrit 39.8%, leukocytes 33.86x10^3/mm^3, thrombocytes 660x10^3/ul, ureum 66.60 mg/dl, creatinine 1.90 mg/dl, random blood glucose 147 mg/dl, free thyroxine (FT4) 1.10 ng/dl, thyroid-stimulating hormone (TSH) 1.250 mIU/l, and anion gap 15.37. Urinalysis: pH 6.5, leukocyte esterase (+3), protein (+2), blood (+2), erythrocytes (2-4/ul), leukocytes many cylinders (fine granules), squamous epithelium (1-2/ul), bacteria (+). Blood smear: leukocytosis (poly morpho nuclear>lymphocytes) and shift to the left without blast cells. Her chest X-ray showed no abnormalities (**Figure 1**), and so did her lung ultrasound (**Figure 2**). The patient was diagnosed with HPP due to suspected dRTA and was given KCl 50 mEq in normal saline 500 ml for 16 hours initially.

On the second day of treatment, the patient suddenly felt shortness of breath with RR of 35x/min and SpO2 95% on a 15 l/min non-rebreathing mask (NRM). The patient was transferred to the Intensive Care Unit (ICU) with a diagnosis of primigravida at 33-34 weeks, respiratory failure, HPP, suspected dRTA, severe metabolic acidosis, sepsis, and urinary tract infection (UTI).

The patient was given oxygen via HFNC with a flow of 40 l/min and FiO2 66%, a correction with sodium bicarbonate 250 mEq and KCl 225 mEq via a central venous catheter (CVC), and intravenous meropenem 1 gram three times a day. Kidney ultrasound revealed dilatation of the pelvis and calyces with narrowing of the cortex, indicating severe hydronephrosis bilaterally and multiple left nephrolithiasis, with the largest size around 0.892 cm (**Figure 3**).

On the 3rd day of treatment, oxygen via HFNC was reduced to 40 l/min and FiO2 to 50%. HFNC reduced the patient's shortness of breath, and the patient's motor strength improved, so on the 4th treatment day, the administration of oxygen was replaced with NRM 15 l/min, which was gradually reduced.

The patient showed gradual improvement in her condition, as seen from her blood gas analysis and electrolyte results (**Table 1**). On the 5th day of treatment after lung maturation has been completed, a cesarean delivery was planned. The baby was born with an Apgar score of 1/3/5 and a birth weight of 1515 grams, followed by treatment in the Neonatal ICU (NICU). The patient was discharged on the 10th treatment day with normal potassium levels (4.78 mEq/l), while the baby was discharged on the 17th. Furthermore, the patient continued to check in the urology clinic to manage her hydronephrosis and nephrolithiasis.

Discussion

The respiratory system provides oxygen to and removes carbon dioxide from the body; however, the inability to perform either or both of these tasks results in respiratory failure. Hypoxic respiratory failure occurs when the respiratory system cannot adequately provide oxygen to the body, leading to hypoxemia, and can be caused by alveolar hypoventi-

lation, low atmospheric pressure/fraction of inspired oxygen, diffusion defect, ventilation/perfusion mismatch, and right-to-left shunt. The distinguishing characteristic of hypoxic respiratory failure is a partial pressure of oxygen (PaO2) <60 mmHg with a normal or decreased partial pressure of carbon dioxide (PaCO2). Depending on the cause of hypoxemia, the alveolar-arterial (A-a) gradient may be normal or increased. (1)

Oxygen delivered by HFNC can be set up to 100% FiO2, with a maximum flow of 60 l/min and a temperature of 37 ºC. High-flow oxygen supplies heated and humidified inspiration gases, preventing thick secretions and subsequent atelectasis. High-flow oxygen also prevents low levels of positive end-expiratory pressure generated by a high gas flow rate and flushing of upper-airway dead space. Patients treated with high-flow oxygen also present with an increased degree of comfort, a reduction in the severity of dyspnea, and a decreased respiratory rate. (2)

Treatment with high-flow oxygen improved the survival rate among patients with acute hypoxic respiratory failure. Severe hypoxemic respiratory failure with PaO2/FiO2 ratio <200 mmHg treated with HFNC shows reduced intubation rate needed. In this case report, this patient was administered HFNC with a flow rate of 40 l/min and 66% FiO2. The next day, the FiO2 was lowered to 50% as the patient's dyspnea improved. Later, the patient's oxygen supply was changed to an NRM with 15 l/min of oxygen. The use of HFNC, in this case, showed a positive outcome in the patient's clinical well-being and in laboratory findings of blood PaCO2 and PaO2. (3)

In RTA, the kidneys' ability to regulate acid levels deteriorates, resulting in normal anion gap metabolic acidosis. RTA can be caused by autoimmune diseases (e.g., Sjögren's syndrome and rheumatoid arthritis), hypercalciuria, adverse drug effects (e.g., ifosfamide and amphotericin), and hereditary history of RTA. RTA is divided into four types: distal RTA (type 1), proximal RTA (type 2), mixed forms of distal and proximal RTA (type 3), and hyperkalemic RTA (type 4). RTA is a rare disease with dRTA prevalence estimated at 0.46 per 10,000 people. Profound anamnesis and physical examination of symptoms and risk factors may help in diagnosing RTA with limited facility of diagnostic imaging/tests. dRTA also shows symptoms of muscle weakness, osteopenia, osteomalacia, nephrocalcinosis, and even secondary hyperparathyroidism. A definitive diagnosis of dRTA is best made with 100 mg/kg oral ammonium chloride (NH4Cl) administration that should be measured immediately after the test and 6 hours later. If urine pH does not decrease and the urine anion gap remains positive at 6 hours, the diagnosis of dRTA can be established. In this case, we diagnosed dRTA by the evidence of normal anion gap, urine pH >5.5, hyperchloremic metabolic acidosis, and hypokalemia. The cause of dRTA in this case could not be known for sure due to the limited facilities in our hospital. However, supported by the kidney ultrasound, we suspected that the most likely cause of dRTA in this patient was bilateral severe hydronephrosis and multiple left nephrolithiasis. (4)

Pregnancy can exacerbate dRTA due to the physiological alterations from pregnancy. During pregnancy, there is mild respiratory alkalosis with some urinary bicarbonate loss as compensation. The volume of distribution for bicarbonate increases as well during pregnancy. These physiological factors and changes during pregnancy may explain worsening RTA. Patients with dRTA typically present with signs and symptoms related to severe hypokalemia, such as proximal muscle weakness, polydipsia, and polyuria. (5)

The treatment needed for dRTA includes intravenous potassium replacement along with IV bicarbonate. After the patient's potassium level is corrected, the potassium supplements should be stopped, but the hypokalemia therapy should be continued to improve the acidosis condition. In other research, a suggestion of giving baking soda as a treatment option for outpatients could be an alternative, especially for non-compliant patients. Each teaspoon of baking soda contains 4.8 g, corresponding to 59 mEq of sodium and 59 mEq of bicarbonate; by comparison, oral sodium bicarbonate tablets (650 mg) contain only 7.7 mEq of sodium and 7.7 mEq of bicarbonate. This alternative could be applied in Indonesian remote areas of hospital care for dRTA outpatient control. (5)

Muscle weakness in patients with HPP is more dominant in the lower extremities than in the upper extremities; the weakness is more predominant in proximal than distal parts. Physiological reflexes decrease or are absent, with no sensory disturbances or alterations in consciousness because the main issue lies in muscle contraction rather than nerve conduction. The normal potassium range in pregnant women is 3.3-5.1 mEq/l, whereas, in this patient, it was very low (2.27 mEq/l), resulting in muscle weakness due to membrane cell hyperpolarization. (6)

The causes of low potassium levels can vary, ranging from congenital to acquired factors. It's important to carefully consider the patient's medical history, including the age of onset and potential trig-

gers such as weakness episodes following exertion, high carbohydrate or salt intake, etc., which can help diagnose congenital abnormalities. Correction of serum potassium levels will improve muscle weakness. Therefore, the patient was given KCl therapy to restore normal serum potassium levels. The selected therapy was KCl 50 mEq in normal saline 500 ml for 16 hours, initially followed by rapid correction of KCl 225 mEq via CVC. The intravenous solution can be changed with lactated Ringer's solution, as it contains potassium and less sodium than normal saline. As hypokalemia correction progressed, the patient presented an acute dyspnea symptom, which might be caused by respiratory muscle weakness due to HPP. (6,7)

In our case, the patient presented with hypoxic respiratory failure due to metabolic acidosis triggered by dRTA and sepsis, which led to the compensatory mechanism by excessive hyperventilation; over time, the respiratory muscles failed. Respiratory failure could also be caused by respiratory paralysis due to severe hypokalemia. However, respiratory paralysis rarely develops in HPP. A previous study showed that this condition is particularly experienced by patients with severe hypokalemia with potassium levels ranging between 0.8 mEq/l to 2.09 mEq/l. (8)

Pregnancy complicated by HPP poses significant risks due to the potential for cardiac and respiratory failure related to low potassium levels, which can lead to maternal mortality. In the newborn baby delivered from an HPP mother, symptoms may include episodes of muscle weakness, difficulty breathing at birth, and challenges with feeding and breathing, which require close monitoring and expert care. (7)

Conclusion

In this case report, the use of HFNC showed a positive outcome and was proven to have been successful in treating hypoxic respiratory failure in pregnant women. Respiratory muscle weakness and severe metabolic acidosis, in our case, were caused by dRTA and HPP. The diagnosis of dRTA could not be clear due to the limited facilities in rural areas. Furthermore, the assessment and management of HPP and dRTA are still limited in many hospitals in remote areas of Indonesia.

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Conflict of interest

The authors declare that there is no competing interest regarding the manuscript.

Table 1. Blood gas analysis and electrolyte trend

Timing	pH	PaCO2	PaO2	HCO3	BE	Na	K	Cl
Day 1 (admission)	7.038	10.2	173.2	2.7	-25.9	136.7	2.27	120.9
Day 2	6.998	17.8	46.2	4.3	-25.5	137.3	2.66	120.8
Day 3	7.128	13.2	216.2	4.3	-22.7	137.5	2.93	121.6
Day 5	7.305	14.1	176.6	6.9	-17.0	137.0	2.72	122.9
Day 6	7.222	17.9	116.0	7.2	-18.3	136.3	3.19	117.8
Day 8	7.225	20.9	113.8	38.4	-17.3	138.0	2.77	117.1

Legend: PaCO2=partial pressure of carbon dioxide; PaO2=partial pressure of oxygen; HCO3=bicarbonat; BE=base excess; Na=natrium; K=kalium; Cl=chloride.

Figure 1. Chest X-ray findings on day 1 of admission

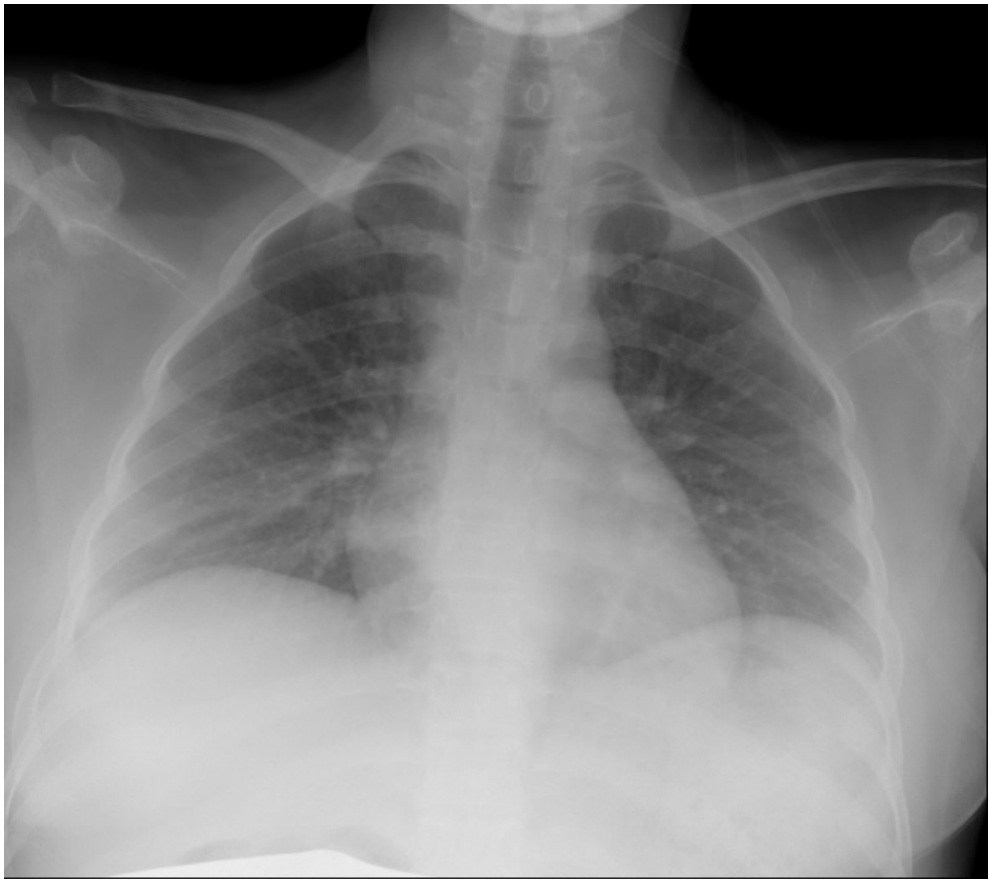


Figure 2. Lung ultrasound

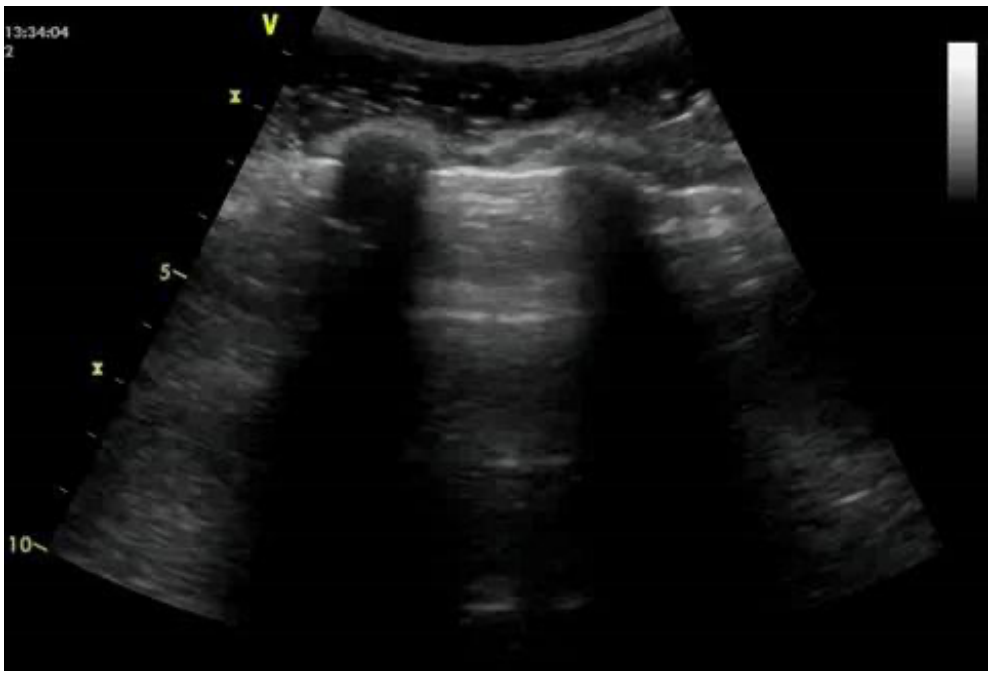
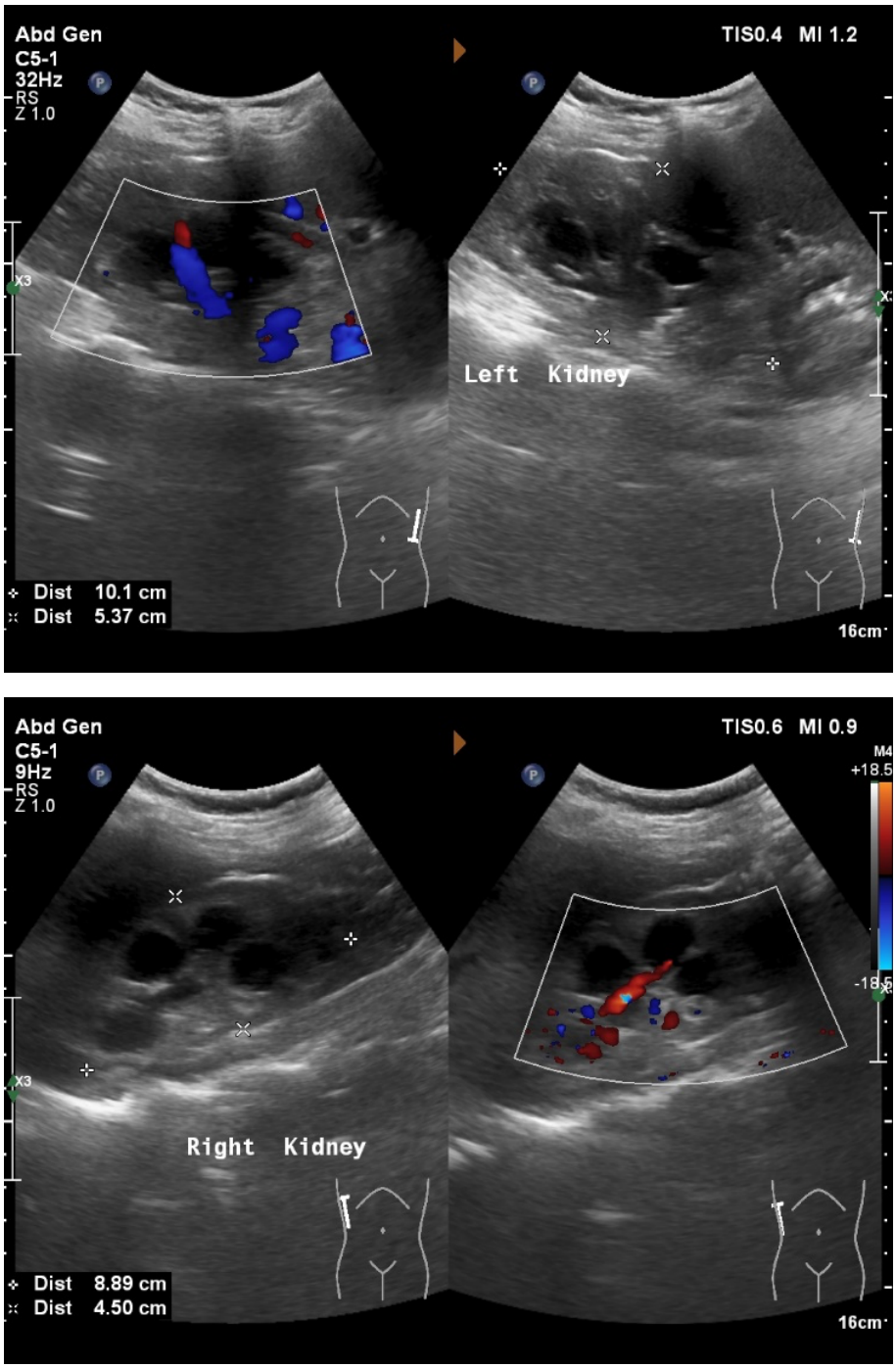


Figure 3. Kidney ultrasound



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