Respiratory depression caused by infantile hypertrophic pyloric stenosis

Abstract

Infantile hypertrophic pyloric stenosis (IHPS) results in electrolyte disturbances due to persistent vomiting. Though the significance of hyperventilation in metabolic acidosis is established, debate continues regarding hypoventilation in metabolic alkalosis. We present six cases of respiratory depression requiring ICU admission in infants with hypochloremic, hypokalemic metabolic alkalosis due to IHPS.

Keywords: infantile hypertrophic pyloric stenosis, hypochloremic, bronchiolitis, hypoventilation, alkalosis, chemoreceptor, hypochloremic

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Abbreviations: IHPS, infantile hypertrophic pyloric stenosis; PICU, pediatric intensive care unit; ICUs, intensive care unit

Introduction and aim

Infantile hypertrophic pyloric stenosis (IHPS) can result in electrolyte disturbances due to persistent non-bilious vomiting. The typical acid-base disturbance in IHPS is hypochloremic, hypokalemic metabolic alkalosis.[1] While the significance of hyperventilation in metabolic acidosis has long been established, debate continues regarding hypoventilation (i.e. compensatory respiratory acidosis) in metabolic alkalosis.

A few case reports exist in the literature regarding hypoventilation in patients with pyloric stenosis.[2–7] We report our experiences of patients with IHPS who had respiratory depression and required pediatric intensive care unit (PICU) admission. We assessed the indications for PICU admissions for patients with IHPS over a 15year period (2000-2014) at the state's only tertiary pediatric hospital. In particular, we were interested in the detrimental respiratory effects of severe metabolic alkalosis associated with prolonged vomiting in IHPS.

Materials and methods

A retrospective chart review was performed on patients with IHPS admitted into PICU at Princess Margaret Hospital for Children, between 2000 and 2014 inclusive. Charts were reviewed with special attention to presentation, oxygen requirements, apneas and bradypneas, blood results, operative reports, past medical history, investigation of alternative diagnoses, and management. Data entry was completed using Microsoft Excel. The hospital ethics committee approved this study.

Findings

The process for identification of cases for this series is detailed in Figure 1. This discussion will focus on the six cases admitted preoperatively with severe metabolic alkalosis and apneas and/or desaturations. Regarding the two other cases, one was admitted to PICU on day 2 for an acute pre-operative deterioration with massive hematemesis, and the second was admitted to PICU post-operatively for respiratory distress due to concurrent RSV bronchiolitis. This patient had a mixed picture of blood gases, with predominant respiratory acidosis. These cases will not be discussed further.

Patient demographics are detailed in Table 1. All infants presented with persistent non-bilious vomiting after feeds, 5 of which had become projectile by presentation. At presentation, median chronological age 7.9weeks (range: 4-12weeks), corrected age 4.5weeks (range: -0.5–12weeks), and median weight 3.9kg (range: 2.7–4.2). Median duration of symptoms was 2.2weeks (range: 0.5-6weeks). Other symptoms included weight loss, reduced urine output (estimated by number of wet nappies), diarrhea, and constipation. On clinical assessment by emergency department physicians, all cases were documented as 'severely dehydrated' on admission.

Two of the patients had positive examination findings for pyloric stenosis (palpable 'olive' and visible peristalsis). Pyloric stenosis was diagnosed by ultrasound in all six of these cases. All of these cases had hypochloremic, hypokalemic metabolic alkalosis on admission and were admitted to PICU due to severe metabolic derangement with desaturations and/or apneas. Five had acute renal failure on admission (creatinine range: 63 – 307umol/L) attributed to dehydration.

These patients experienced a combination of apneas (noted in nursing observations), bradypnea (RR < 30), and desaturations (range: SpO2 61 – 86% on pulse oximetry). All infants required supplemental oxygen at median rate 2.5L/min (range: 1 – 10) for between 8 – 72 hours. One required intubation and mechanical ventilation. All cases were managed with NGT decompression and IV hydration. All underwent uncomplicated pyloromyotomy after normalization of fluid, pH, and electrolyte balance at mean 3 days after presentation (range: day 2-5). None experienced desaturations or apneas once acid-base balance was restored and there were no post-

operative metabolic derangement. The five non-incubated patients were transferred directly to the ward post-operatively. Case 6 returned to PICU and was extubated without complications 12hours post-op and subsequently transferred to the ward.

Table 1 History, clinical course, clinical and laboratory findings, and respiratory findings for cases

Patient	1	2	3	4	5	6
Gestational age (weeks)	8	4	12	7.5	8.3	7.7
Gender	Male	Male	Female	Male	Female	Female
	Term.	Term.	Term.	Premature - 33/40	Term.	Premature - 31/40
PMHx	Intubation and supplemental oxygen at delivery.	Nil issues	Nil issues	Nil issues.	Supplemental oxygen at delivery	Supplemental oxygen and CPAP at delivery.
Symptom duration (weeks)	6	1.5	4	3	1	0.5
Projectile vomiting?	Yes. Occasional fresh blood.	Yes	Yes	Yes	Yes. + coffee-ground	Yes
Clinical dehydration	Severe	Severe	Severe	Severe	Severe	Severe
Positive examination?	Yes	No	Yes	No	No	No
Day of PICU admission	0	0	0	0	0	1 (day 0 of tertiary hospital admission)
Stated reason for PICU admission	"Desaturations/apneas and alkalosis"	"severe metabolic derangement and abnormal renal function"	"metabolic derangement"	"significant dehydration, apneas and severe metabolic alkalosis"	"metabolic alkalosis, apneas, and fluid resuscitation requirements"	"recurrent apneic episodes requiring intubation"
Time to surgery (days)	3	2	2	3	5	2
Time to discharge (days)	5	4	5	5	6	5
Operation	Open (Ramstedt) pyloromyotomy	Open (Ramstedt) pyloromyotomy	Laparoscopic pyloromyotomy	Open (Ramstedt) pyloromyotomy	Laparoscopic pyloromyotomy	Open (Ramstedt) pyloromyotomy
pH (7.35-7.45)	7.59	7.63	7.68	7.62	7.58	7.7
K (3.5-5.6 mmol/L)	2.7	2.9	2	3	2.2	2
Cl (96-110 mmol/L)	73	81	59	72	49	59 ??
HCO3 (18-29 mmol/L)	62	49	70	58	66	32
Creatinine (<35 umol/L)	81	65	136	63	307	33
Apnoea?	Yes	Yes	No	Yes	Yes	Yes
Bradypnea?	"Shallow breaths"	"erratic breaths"	"shallow breaths"	RR 24	"reduced respiratory effort"	RR 18
	RR 9	RR 10	RR 25		RR 13	
Desaturations	To 61% on room air (RA)	To 70% on RA	To 86% on RA	To 77% on RA	To 78% on RA	To 85% on 40% O2 mask

Discussion

Vomiting of gastric contents in infantile hypertrophic pyloric stenosis (IHPS) results in a typical hypochloremic, hypokalemic metabolic alkalosis [1]. For many years this has not been a recognized cause of apneic events.[8] hypoventilation due to the severe alkalosis of IHPS.[2–7] Reports in the adult literature have also come to similar conclusions in cases of gastric outlet obstruction and other causes of severe metabolic alkalosis.[7,9–14] Grantham and Schloerb presented similar results almost 50years ago in dogs over who developed severe hypercapnia after induction of a subtraction metabolic alkalosis by draining of their gastric juices, an analogous physiological condition to IHPS.[15]

Under normal circumstances, the body compensates in metabolic alkalosis by reducing renal bicarbonate reabsorption with production of alkaline urine and hypoventilation resulting in increased PaCO2.[16] The resultant hypercapnia and hypoxia should limit progression to significant hypoventilation by stimulation of the central respiratory centre and peripheral chemo receptors respectively.[11,17] As such, the

hypoventilatory response to alkalosis is generally not as marked as the well-recognized hyperventilatory response to metabolic acidosis.
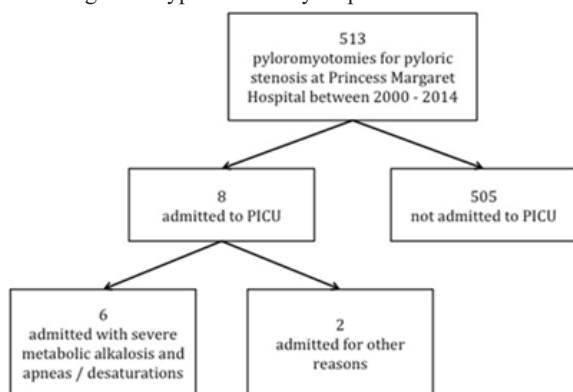

Figure 1 Flowchart of case selection.

Both the renal and respiratory processes must be impaired to permit the excessive respiratory compromise seen in this series of patients, and other similar case studies. Since the kidneys are extremely efficient at excreting excess bicarbonate in the urine, this must be impaired to maintain steady-state alkalosis.[16,18] In this case, the substantial volume depletion that occurs in IHPS is important as it reduces the glomerular filtration rate. This occurs both due to direct fluid loss from vomiting and also due to the hypochloremia typical to this state, with contraction of extracellular fluid volume.[11] Our cases fit this model; they were clinically severely dehydrated on admission and five had acute renal failure, which corrected after fluid resuscitation. Also, in hypochloremic alkalosis, the kidneys inappropriately conserve sodium at the expense of hydrogen ions, resulting in acidic urine.[18] Urinary pH was not routinely documented in our cases, but we would expect them to have this paradoxical aciduria.

The profound compensatory hypoventilation seen in our cases rarely occurs to a clinically significant extent without underlying respiratory compromise, typically severe obstructive respiratory disease in the adult population.[7] However, there is a growing consensus that this mechanism is more significant than previously thought. In adult ICUs, alkalosis not infrequently precludes successful weaning off mechanical ventilation.[11] This is supported by the findings of Abreu e Silva who showed that infants with IHPS-associated metabolic alkalosis had significantly increased frequency of central sleep apnea events compared to recovery or control cases.[19]

Both peripheral and central chemoreceptors are less sensitive to hypoxia and hypercapnia during metabolic alkalosis.[20–22] In addition, alkalosis is known to impair hypoxic pulmonary vasoconstriction thereby producing a ventilation-perfusion mismatch .[11] These factors together help to explain the mechanism by which a pathological hypoventilation and hypoxia can occur during metabolic alkalosis. None of these cases had findings that indicated other causes for these apneas and desaturations including sepsis, meningitis, non-accidental injury, respiratory infection, or cardiac abnormalities. In each case there were no neurological deficits other than generalized lethargy, no history of seizures, no fever, and a normal cardiac examination.

Conclusion

The relationship between IHPS-induced metabolic alkalosis and respiratory depression has been described in a few small case series.[2–7] Our case series again highlights the possibility of profound hypoventilation with desaturations occurring as a result of the metabolic alkalosis of infantile hypertrophic pyloric stenosis.

Several factors play a role in development of this phenomenon, yet the literature here is scarce and outdated compared to the data on hyperventilation in acidosis. While a rare occurrence, it is important for clinicians to be aware of the risk of respiratory suppression in patients with infantile hypertrophic pyloric stenosis, and the multi-factorial pathophysiological mechanisms that lead to this phenomenon.

Conflicts of interest

Author declares there are no conflicts of interest.

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