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Complete recovery after profound acidosis (pH 6.49)

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SUMMARY We describe an infant with profound acidosis caused by chronic therapeutic salicylate poisoning. The confirmed arterial blood pH of 6.49 must be close to the limit of tolerable acidity and is the lowest such value in our experience. Full recovery was made.

Case report

A 2½ month old infant weighing 3.6 kg presented to the paediatric emergency ward with a three day history of a dry non-productive cough, diarrhoea, and vomiting. During the preceding three days she had reportedly received approximately 125 mg aspirin three times daily (administered by the mother) in an attempt to alleviate symptoms. The mother also reported that the infant had had generalised convulsions lasting 10 minutes on the day of admission.

Clinical examination showed an infant who was somnolent, dehydrated, hypothermic (temperature 35°C), hyperpnoeic (respiratory rate 72/minute), shocked (systolic blood pressure 50 mmHg), and anuric. There was clinical evidence of extensive, right sided, middle and lower lobe pneumonia. The infant's weight, head circumference, and length were well below normal. Arterial blood gas analysis and serum urea, creatinine, and electrolyte determinations confirmed a profound metabolic acidosis with respiratory compensation and hypertonic dehydration.

Initial baseline laboratory values were as follows: pH 6.82; P_{aCO_2} , 13.1 mmHg; P_{aO_2} , 40.8 mmHg; bicarbonate 3.4 mmol/l; base deficit 32.0 mmol/l; oxygen saturation 36.7%; serum sodium 163 mmol/l; serum potassium 7.3 mmol/l; serum urea 38.7 mmol/l; serum creatinine 230 µmol/l; serum osmolality 397; and whole blood glucose 18.2 mmol/l. A

serum salicylate concentration of 1.36 mmol/l (reference value less than 0.36 mmol/l) and a high anion gap acidosis confirmed chronic, salicylate overdosage. A blood specimen for prothrombin index failed to clot and a bleeding time (Ivy method) of 20 minutes confirmed a bleeding diathesis. A lumbar puncture on admission was normal.

Sodium bicarbonate 8.5% (2 mmol/kg) was given intermittently in addition to a continuous infusion at a rate of 0.03 mmol/kg/minute. While measures were taken to correct the severe metabolic acidosis and dehydration the patient developed generalised convulsions which were controlled with diazepam (1.5 mg, stat) and phenobarbitone (20 mg, IV stat) in single doses. Fifteen minutes later the patient developed a cardiorespiratory arrest but was successfully resuscitated and transferred to the intensive care unit. Prophylactic dexamethazone (2 mg IV, 6 hourly) was given for possible cerebral oedema. Fresh frozen plasma and vitamin K (2 mg IV, single dose) were given because of the deranged haemostatic values. Arterial blood gas determination immediately after cardiopulmonary resuscitation showed the following: pH 6.49; P_{aCO_2} 43.1 mmHg; P_{aO_2} , 30.1 mmHg; bicarbonate 3.4 mmol/l; and oxygen saturation 24%.

The above values were checked in triplicate. The patient was then rehydrated slowly, rewarmed, mechanically ventilated, and given inotropic support with isoprenaline (0.04 µg/kg/minute) and intravenous antibiotics (cefotaxime 100 mg IV, 6 hourly). Peritoneal dialysis (using 1.5% Dianeal solution) was begun 6 hours after admission to the intensive care unit. Arterial blood gas analysis four hours later showed: pH 7.06; P_{aCO_2} , 33.9 mmHg; P_{aO_2} , 108.4 mmHg, bicarbonate 7.3 mmol/l; and oxygen saturation 93.7%. At this point the ventilator settings were as follows: F_{iO_2} 0.8, respiratory rate 35/minute, expired minute volume 4.0 l/minute. Twelve hours later the patient was still acidotic (pH

7.15) but hypothermia and poor perfusion had improved considerably—her temperature was 37.4°C and systolic blood pressure 80 mmHg. The Fio_2 was gradually decreased to 0.4 during this time to prevent pulmonary oxygen toxicity. Peritoneal dialysis was continued for the next 48 hours at which point the infant's serum urea and creatinine concentrations were 9.1 mmol/l and 111 $\mu\text{mol/l}$ respectively. The patient was no longer hypernatraemic (serum sodium 143 mmol/l) or acidotic (pH 7.40; Paco_2 , 28.4 mmHg; Pao_2 , 129 mmHg; base deficit 6.2; and oxygen saturation 98.2%). Mechanical ventilation was continued for five days with gradual weaning to paediatric continuous positive airway pressure. Extubation was achieved on the 6th day without complications.

Vital signs at the time of discharge from the intensive care unit were as follows: blood pressure 100/70 mmHg, respirations 35/minute, temperature 37.2°C, and pulse 120/minute, (sinus rhythm). At the time of transfer to the paediatric ward two weeks after admission renal function, haematologic, and blood gas values were all within normal limits. Further recovery during the next two weeks was uneventful and the patient was eventually discharged home to be followed up at the paediatric outpatient clinic. One month later clinical examination showed no abnormalities apart from suboptimal growth indices. More importantly, there was no evidence of neurologic impairment and renal function remains normal.

Discussion

Survival after acidosis of the severity noted in this patient is uncommon and has not hitherto been reported even after cardiac arrest,¹ diabetic ketoacidosis, and advanced renal insufficiency. The arterial blood pH of 6.49 observed in this infant is the lowest value in our experience and must surely be close to the limit of tolerable acidity. The hydrogen ion concentration at this pH represents an 8 fold increase of the normal value of 40 nmol/l. Chronic salicylism not only produces a greater frequency of signs and symptoms but also increases the risk of developing severe clinical manifestations such as profound acidosis, dehydration, and either coma or seizures, or both. The diagnosis is often delayed because there is an accompanying illness the symptoms of which (fever, nausea and vomiting, tachypnoea, irritability, and disorientation) are similar to those of salicylate poisoning. At Baragwanath Hospital gastroenteritis, pneumonia, and dehydration are the most common associations with salicylism in paediatric patients.³

It is unfortunate that the pH of the cerebrospinal fluid and cerebrospinal fluid salicylate concentrations were not measured when the patient was most acidotic. Several factors contribute to the degree of passage of salicylate into the cerebrospinal fluid.⁴ The important factor in the context of this discussion is that of acid base balance. It is known that the distribution of salicylate between the extra—and intracellular compartments is influenced by the pH of both compartments. Hill² has shown that in experimental salicylate poisoning rapid alkalinisation causes a decrease in brain, muscle, and liver salicylate concentrations. Since salicylate probably has a direct toxic effect on the central nervous system as well as on the kidney, and one might assume that the more rapid removal of salicylate from tissue is advantageous, the temptation to use sodium bicarbonate treatment is strong. In children, however, even high doses of bicarbonate may not produce a sufficiently alkaline urine because (a) the high degree of inorganic acid production with its accompanying aciduria cannot be compensated for by giving bicarbonate and (b) the alkalinisation cannot be accomplished adequately until potassium depletion has been corrected.⁴ Moreover, the large amounts of sodium bicarbonate needed to alkalinise the urine may increase the serum sodium concentration rapidly and significantly, thereby incurring the risk of central nervous system damage. Despite these shortcomings it is our opinion that the benefits of giving sodium bicarbonate judiciously outweigh the admitted hazards and therefore sodium bicarbonate is recommended for this purpose.

The central nervous system and the heart are especially susceptible to deranged function when the blood pH is less than 7.1 (hydrogen ion concentration 80 nmol/l). This case clearly shows that the human body is capable of tolerating profound acidosis at pH values well below 7.1. What the long term effects of such a profound acidosis will be in this patient are difficult, if not impossible to predict.

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