Undiagnosed cardiomyopathy in a neonate: significance of low oxygen saturation during anaesthesia

W. Q. Smith¹* and M. Abu-Harb²

Departments of ¹Anaesthesia and ²Neonatology, Sunderland Royal Hospital and Sunderland Eye Infirmary, Kayll Road, Sunderland SR4 7TP, UK
*Corresponding author

A case study is described of a 7-day-old full term baby with bilateral congenital cataracts who underwent surgical removal of both cataracts 2 days apart. Problems with oxygen saturation during and after the first anaesthetic prompted further investigation that revealed a non-obstructive hypertrophic cardiomyopathy. The significance and possible causes of low oxygen saturation in a previously healthy neonate during anaesthesia are discussed. The likely diagnosis of Sengers syndrome, and the evaluation of asymptomatic babies with cardiac pathology are discussed.


Keywords: anaesthesia, paediatric; complications, cardiomyopathy; complications, Sengers syndrome; children

Accepted for publication: October 30, 2000

A healthy term baby with no dysmorphic features was found to have absent red reflexes (bright light is prevented from reflecting off the vascular retina by an opacity) at an otherwise normal routine post-natal examination. Dense bilateral congenital cataracts were confirmed and urgent planned surgery arranged to remove the cataracts on separate occasions, 2 days apart. The baby weighed 2600 g on day 7 and had been fasted from milk formula for 6 h. Anaesthesia was induced through an in situ i.v. cannula with thiopental 10 mg after atropine 20 mg. Muscle relaxation was achieved using atracurium 1.5 mg before tracheal intubation with a size 3.0 uncuffed tracheal tube. Anaesthesia was maintained with sevoflurane and nitrous oxide in oxygen 50–60%, and the baby ventilated to an $\text{ET-} CO_2$ of 4.8–5 kPa.

Monitoring consisted of ECG, non-invasive arterial pressure, pulse oximetry, gas monitoring ($F_{IO2}$, $\text{ET-} CO_2$, and ET-volatile), pre-cordial stethoscope, axillary temperature, and ventilation pressure and failure alarms.

Oxygen saturation ($S_{A\text{O}_2}$) remained between 85 and 92% despite meticulous confirmation of tracheal tube placement. Manual chest inflation, re-intubation, and an $F_{IO2}$ up to 90% did not alter the $S_{A\text{O}_2}$. The chest remained clear on auscultation. An insignificant difference in $S_{A\text{O}_2}$ of only 2% was noted between pre-ductal (right arm) and post-ductal (leg) sites. End-tidal sevoflurane concentrations of 1.7–2.0% maintained a systolic arterial pressure of between 65 and 75 mm Hg. I.v. 4% dextrose/saline was infused at a rate of 4 ml kg$^{-1}$ h$^{-1}$ during the 90 min of anaesthesia in addition to 40 ml of calculated fluid deficit. Normothermia was maintained.

The only other abnormality noted was elevation of ST segments on standard lead I. Emergence and extubation after reversal of residual neuromuscular block with neostigmine 100 µg and atropine 20 µg were uncomplicated. The trachea was free of secretions. The baby was returned to the neonatal unit with a $S_{A\text{O}_2}$ of 94%, breathing oxygen 30% and in no apparent respiratory distress. As no satisfactory explanation could be offered for the oxygenation difficulties experienced perioperatively, a neonatologist was consulted about the possibility of undetected congenital cardiac or pulmonary disease.

On return to the neonatal unit, examination revealed a pink and well-perfused baby with normal pulses and heart sounds. Chest x-ray confirmed clear lung fields but showed an enlarged heart. ECG revealed ST segment elevation in AVL, I, II, V4 and V6, with T wave inversion in lead III.

Overnight the baby needed oxygen 30% to maintain a $S_{A\text{O}_2}$ of 95%, but feeding was commenced without difficulty early the next morning, and oxygen therapy was gradually weaned. An echocardiogram on the first post-operative day revealed a markedly thickened left ventricular free wall and interventricular septum, without outlet obstruction, consistent with non-obstructive hypertrophic cardiomyopathy (HCM). No other structural abnormalities were noted. The arterial duct was closed but the foramen ovale was small and
Disorders associated with neonatal hypertrophic cardiomyopathy (HCM)

<table>
<thead>
<tr>
<th>Disorder</th>
<th>Associated Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Noonan syndrome</td>
<td>Dysmorphic features (short stature, webbed neck, hypertelorism), cardiac malformations</td>
</tr>
<tr>
<td>Beckwith-Wiedemann syndrome</td>
<td>MacroGLOSSIA, exomphalos, visceromegaly, hypoglycaemia</td>
</tr>
<tr>
<td>Pompe disease</td>
<td>Glycogen storage disease type II, hepatosplenomegaly, poor muscle tone, high voltage ECG complexes</td>
</tr>
<tr>
<td>Fatty acid oxidation defects</td>
<td>Abnormalities in mitochondrial β-oxidation and transport of long chain fatty acids and carnitine</td>
</tr>
<tr>
<td>Mitochondrial abnormalities (e.g. Sengers syndrome)</td>
<td>Abnormal mitochondrial DNA resulting in cardiac or brain dysfunction</td>
</tr>
<tr>
<td>Trisomy 21</td>
<td>(Down syndrome)</td>
</tr>
<tr>
<td>Macopolysaccharidoses</td>
<td>Infiltrative disorders with dysmorphic features and visceromegaly</td>
</tr>
</tbody>
</table>

Two days later the second cataract was removed. Thiopental was omitted and anaesthesia was induced with sevoflurane in oxygen. Management and conduct of anaesthesia were otherwise as before, although an inspired oxygen concentration of 50–60% resulted in a \( \text{SaO}_2 \) between 90 and 93% on this occasion. There was no post-operative oxygen dependence after the second operation.

**Discussion**

Risk analysis in more than 22 000 paediatric anaesthetics shows that neonates have the highest incidence of intra-operative events, and respiratory causes (airway obstruction, laryngospasm, bronchospasm, apnoea) are the most frequent. The trachea of a term neonate is only 4 cm in length and the smallest movement of the head during surgery can displace the tracheal tube. The use of a precordial stethoscope positioned in the left axilla facilitates continuous intra-operative confirmation of air entry.

An \( \text{SaO}_2 \) that remains persistently low despite exclusion of respiratory causes, and especially when unresponsive to increased oxygen administration, must raise concerns about the presence of an intra-cardiac or cardiopulmonary shunt. Congenital cyanotic heart disease is usually recognizable. However, this baby was well oxygenated pre-operatively and had displayed no signs suggestive of cardiac problems.

Transition from the fetal to neonatal circulation is not a single event; it is regarded as a process consisting of several phases. It is important to recognize that there are times during this transition when the ratio of pulmonary vascular resistance (PVR) to systemic vascular resistance (SVR) may fluctuate to the extent that pulmonary blood flow will be significantly affected. The normal decline in PVR to adult values takes place within the first 2 weeks of life.

This baby was clinically well before the induction of anaesthesia despite having significant HCM. The low intra-operative \( \text{SaO}_2 \) might have occurred as a result of myocardial dysfunction, accompanied by a degree of right-to-left intra-cardiac shunting.

Thiopental is known to be a dose-dependant myocardial depressant and capable of lowering SVR. Oxygenation during and after the second anaesthetic, in which thiopental was omitted, was better. Although volatile anaesthetics generally depress the myocardium, sevoflurane has been shown to maintain contractility and cardiac index in infants. An anaesthetic technique using high dose fentanyl will produce less myocardial depression, although it may affect SVR. This technique also necessitates post-operative ventilation, and was not felt to be indicated in this baby.

Right-to-left shunting commonly occurs in neonates with persistent pulmonary hypertension (PPHN). Shunting from right to left across a patent arterial duct will result in a difference between pre-ductal and post-ductal \( \text{SaO}_2 \). This was not observed in our patient. Right-to-left shunting at the level of a patent foramen ovale (PFO) can result in a global reduction in oxygenation, however, as seen in this baby.

Right-to-left inter-atrial shunting occurs in newborns because the mitral valve opens before the tricuspid valve, resulting in the left atrial pressure (LAP) decreasing before the right atrial pressure. PPHN or right ventricular dysfunction secondary to HCM may have induced a right-to-left inter-atrial shunt through the PFO in this baby. Another factor to consider is the role of anaesthesia in lowering SVR and LAP.

Common causes of HCM have been excluded in this baby. The co-existence of congenital cataracts and HCM raises the possibility that this baby suffers from Sengers syndrome, characterized by cataract, cardiomyopathy, and mitochondrial cytopathy. Definitive diagnosis may be possible and requires a fresh muscle biopsy that can be analysed in only a few specialized units. Neonatal death secondary to severe cardiomyopathy has been reported in which clinical evidence of episodic tachypnoea and cyanosis had been noted within days of birth. HCM associated with mitochondrial cytopathy has been diagnosed in several adults in whom the only early clues to the diagnosis had been the presence of bilateral cataracts at birth and poor exercise tolerance throughout life.

Neonates with HCM present in a variety of ways ranging from asymptomatic to severely ill. Presentation by desaturation during anaesthesia is unusual. Typically, asymptomatic neonates are evaluated for heart disease after either the detection of a heart murmur during routine neonatal examination, a family history of congenital heart disease (CHD), or a history of pregnancy-related problems such as maternal diabetes mellitus and hydrops fetalis.

Although most babies in the UK undergo routine neonatal examination within the first day of life, it is unreliable for detecting CHD. Routine neonatal examination detects CHD in only 45% of patients, and severe disease is no more likely to be detected. In one study murmurs were heard on
routine examination in 0.6% of babies, 50% of whom had CHD. CHD commonly exhibits no signs or symptoms in the first few days of life, and the diagnosis in some cases is only made at post-mortem.

The significance of an unexplained, low $S_{aO_2}$ observed during anaesthesia in our patient is quite evident, and raises important considerations. Anaesthetists must be aware of the physiological implications of the transitional circulation during the first 2 weeks of life. There is no reliable clinical means of detecting cardiac pathology in apparently healthy neonates. A low threshold for suspecting cardiac malformations in asymptomatic neonates with associated abnormalities is warranted. Comprehensive assessment and baseline investigations are recommended before surgery in such cases, including chest x-ray, ECG and echocardiography.

References

1 Cohen MM, Cameron CB, Duncan PG. Pediatric anesthesia morbidity and mortality in the perioperative period. Anesth Analg 1990; 70: 160–7
3 Rowe RD, James LS. The normal pulmonary arterial pressure during the first year of life. J Pediatr 1957; 51: 1–4

© The Board of Management and Trustees of the British Journal of Anaesthesia 2001