

## Flip-flop circulation: An unusual cause and case of neonatal desaturation

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### Abstract

Neonates are given anaesthesia for multiple surgeries, however coupling neonatal physiology with child physiology is a common error made. Circulation changes at birth from the foetal to adult type, but neonates are prone to revert to foetal circulation with disastrous effects. This phenomenon is known as flip flop or YoYo circulation. We report a case of a premature neonate, being operated for intestinal perforation, with Yo Yo circulation intraoperatively.

**Keywords:** Neonate anaesthesia, Flip flop circulation, Yo Yo circulation, Neonatal surgery, Desaturation, Hypoxia.

### Introduction

Transitional fetal circulation is an important cause of intraoperative hypoxia which can be reversible and easily managed. However, a high index of suspicion needs to be maintained in order to diagnose and manage it.

The adult circulatory system is based on the lungs for oxygenation and the heart for pumping of blood. While a fetus, receives oxygenation from the mother via the placenta, therefore fetal circulation differs significantly from the adult. In order to bypass the pulmonary circulation, fetal blood flows via two extra connections – the foramen Ovale and the Ductus Arteriosus. Oxygenated blood in the fetus arrives from the umbilical vein and deoxygenated blood leaves via the two umbilical arteries.<sup>1</sup> At birth, when the fetus takes his first couple of breaths, functional closure of these connections occurs. Anatomical closure occurs over the next 3-4 weeks.<sup>2</sup>

In preterm neonates, in whom functional closure is delayed or sometimes in normal neonates in conditions like hypoxia, hypovolemia and hypercarbia, these pathways can open transiently. This shunting to and fro is sometimes called Flip-Flop or Yo Yo circulation.

### Case Report

A 1 day old, 1 kg neonate born at approximately 8.5 months of gestation at home, presented to emergency with abdominal distention and regurgitation from mouth. The child cried at birth, with no significant history of cyanosis on crying or feeding, difficulty in feeding, sweating as given by the father. No cyanosis on crying or murmur was appreciated in the pre operative period. The preoperative investigations of the neonate were within normal limits.

The neonate was taken for emergency exploratory laparotomy with written informed guardian consent, including post operative ventilation consent. A saturation probe was attached to the foot, showing a

saturation of 96% on room air and 99-100% with oxygen. He was intubated uneventfully with injection thiopentone and succinylcholine after Preoxygenation.

Post induction on ventilating the patient, a steady fall in the saturation was noticed (upto 78%). Oxygen concentration was immediately increased to 100% along with hyperventilation. The second pulse oximeter was also attached at the right hand to confirm saturation reading. This monitor showed a saturation of 99%. It was at this point that we thought of a possibility of shunting and a return to fetal circulation. We then tried reversing the factors which lead to flip flop circulation. An ABG was sent, and acidosis, hypoxia, hypercarbia and hypothermia were ruled out. Hyperinflation is a known but rare cause of conversion to fetal circulation. On decreasing the volume of ventilation, the saturation in the foot probe also increased to 100%. Following this, throughout the operative period (the patient was hand ventilated via the JR circuit), the foot probe (post ductal) saturation kept dipping and increasing on variation of operator and consequent tidal volumes. The preductal saturation (right hand probe) throughout stayed at 100%. The patient was reversed and extubated uneventfully after 3 hours of surgical time. Post operatively an Echo was done which was found to be normal.

### Discussion

When a fetus is born, the circulation converts to adult circulation, which involves functional closure of the Ductus Arteriosus (DA) and Foramen Ovale.<sup>2,3</sup> However, in conditions leading to increase in pulmonary vascular resistance, these connections may open leading to reversion to fetal circulation. This is known as Flip flop or Yo-Yo circulation. This transition to fetal circulatory can be transitional (as in our case) or persistent. Persistent fetal circulation.<sup>3,4</sup> can be primary, due to hypertrophy and increased musculature of walls of pulmonary vasculature. It can be secondary in

neonates with lung infection, prematurity, meconium aspiration and congenital heart disease.<sup>4,5</sup>

Transitional fetal circulation<sup>5</sup> can occur due to causes increasing the pulmonary vascular resistance (PVR), like hypoxia, hypercapnia, acidosis, hyperinflation and prematurity. In our case, transient increase in PVR occurred due to hyperinflation of the lungs, leading to the opening up of the Ductus Arteriosus, which led to reversion back to the fetal circulation. However, there is no placenta to supply oxygen, via the umbilical vessels in neonates. This leads to hypoxia and worsening saturation, as observed in our case. A vicious circle is then formed consisting of worsening hypoxia and acidosis, leading to further increase in PVR. The pulse oximeter attached to the right foot was distal to the DA (post ductal), thereby showing the falling saturation, this was due to intermingling of unoxygenated pulmonary blood with the oxygenated blood. The second pulse oximeter was attached to the right arm, which receives blood supply from vessels arising distal to the DA (pre ductal), therefore there was no intermingling of blood leading to a normal saturation. This difference in saturation, lead us to the diagnosis of Yo-Yo circulation.

We then set about ruling out the causes of increased PVR which might lead to this Yo-Yo circulation. Common causes are hypoxia which was ruled out as we were presently ventilating the baby with 100% oxygen and the preductal probe was showing a saturation of 100%. Hypercapnia was ruled out by consistent normal end tidal CO<sub>2</sub> readings. An ABG was sent to rule out acidosis, it was normal, hypothermia was not present. We then proceeded to reduce the volume used for ventilation, the post ductal pulse oximeter showed a steady rise in saturation following this, thus confirming our diagnosis. Hyperventilation further helped, as a decrease in PaCO<sub>2</sub> will lead to a decrease in PVR. Prematurity might also be a factor leading to transitional circulation in our case.

Keeping a high index of suspicion and monitoring of pre ductal and post ductal saturation in susceptible cases might be helpful. Also, keeping the infant warm, with a normal arterial tension of oxygen and carbon dioxide, preventing hyperinflation and causing minimal anaesthetic induced myocardial depression can be helpful in such cases.

### Consent

The patient's guardian (father) has reviewed the case report and given written permission for the authors to publish the case.

**Conflicts of Interest:** None.

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