Does a Low Mean Blood Pressure in the Neonate Under Anesthesia Lead to Cognitive Deficits?

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Case

A 3-day-old presents for surgery to deal with a tethered cord. This congenital disorder is characterized by a membrane (the filum terminale) abnormally anchored to the spinal cord at the L2 level or lower. If untreated, there may be progressive lower extremity weakness and incontinence, due to stretching on the spinal cord from the child's movements. Early surgery yields better outcomes.

The "untethering" surgery involves a careful dissection to free the spinal cord. Neuromonitoring and nerve testing intraoperatively are essential to preserve motor function in the lower extremities and avoid incontinence later in life. The need for intraoperative nerve monitoring prohibits the use of muscle relaxants. The neurosurgeon rightly insists that the infant stay completely still while she is dissecting out the spinal cord. Sevoflurane is kept at 3.6 atm%, slightly above the MAC of 3.3 atm% for neonates. In addition, an infusion of remifentanil is added. You realize the blood pressure will be lower than ideal, but you don't want the patient to move, which would be catastrophic. Your colleague comes in the room to give you a lunch break, and starts to harangue you about the persistent blood pressure of 50/28 (35)…

"You may not know it, but you are probably not perfusing the brain and above all the spinal cord," your colleague says derisively.

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Questions

Is autoregulation present at birth? If not, is a mild level of hypotension a threat to the central nervous system at a critical mean arterial blood pressure (MAP)?

PRO: "As you know, the variables involved are cerebral perfusion pressure (CPP), MAP, intracranial pressure (ICP), and central venous pressure (CVP). CPP = MAP − ICP (or CVP, whichever is higher)." Your colleague continues with a smug look on his face, "In this case we cannot calculate CPP. We do not know the CVP. The ICP is almost impossible to measure noninvasively, although the wide-open diamond-shaped posterior fontanelle and square-shaped anterior fontanelle will be bulging if it is high. Having said that, MAP is what we can control related to brain perfusion. The normal MAP in a full-term 3-day-old is 40 mmHg! Talk about a narrow window for error!!!"

CON: "Three days ago the infant went through labor and delivery, during which the umbilical cord was periodically being compressed during contractions—with presumed decreased oxygen to the brain. What's different now? General anesthesia most likely decreases the amount of oxygen that the brain needs by decreasing the cerebral metabolic rate. If you are really worried about perfusing the brain, employ near-infrared spectroscopy (NIRS), which in my opinion, is greatly underutilized. Jöbsis first reported in 1977 that the relatively high degree of transparency of myocardial and brain tissue in the near-infrared (NIR) range enabled real-time non-invasive detection of tissue oxygen saturation using transillumination spectroscopy [1]. By 1985, Ferrari and colleagues reported some of the first human cerebral oximetry studies using near-infrared spectroscopy (NIRS in patients with subarachnoid haemorrhage) [2]. According to Bhatia et al, 'Episodes of angiographic cerebral vasospasm were strongly associated with a reduction in the trend of the ipsilateral NIRS signal. Furthermore, the degree of spasm (especially more than a 75 % vessel diameter reduction) were associated with a greater reduction in the same-sided

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NIRS signal demonstrating real-time detection of intracerebral ischaemia' [3]."

PRO: "The NIRS is constantly changing with the $EtCO_2$. Not to mention the variation if the surgery becomes bloody and the hematocrit drops. There are no defined trigger points to tell me when the infant's brain is becoming ischemic, whether the interference with the signal be anemia or pH status."

CON: "Well, fine, even if you don't look at the NIRS, the MAP estimates cerebral blood flow pretty well. If there's nothing else bad going on in the brain, a MAP over 45 mmHg is great, between 35 and 45 mmHg is probably OK, and only when you get under 35 you are getting into trouble. Rhondali et al. [4] looked at this in children under 6 months old, with the $EtCO_2$ level held relatively constant. If you want the transcranial Doppler to show good perfusion, aim for a MAP of 45 mmHg. The NIRS still looks decent and shows increased oxygenation versus an awake infant with MAPs between 35 and 45 mmHg, probably because sevoflurane decreases the cerebral metabolic rate. With a MAP below 35 mmHg, cerebral perfusion is likely poor, but you are stuck between a rock and a hard place because most pressors in babies will compromise splanchnic flow and renal flow [4]."

PRO: "Yeah, but Rhondali's study was done in healthy infants, with an ideal fluid balance. Who is to say that with longer surgeries or sicker kids, those numbers are right? Why not better safe than sorry and keep the blood pressure up? And besides, do those sketchy monitors correlate with long-term outcomes for these kids, our most vulnerable population?"

CON: "Are you not concerned with intraventricular hemorrhage (IVH) as you try to keep the pressure up? It has evolved in the literature from case reports to actual studies. IVH DOES happen."

PRO: "If intraventricular hemorrhage is going to occur, it has likely already happened in utero, during delivery of the infant, or otherwise way before the infant gets to the operating room. This may or may not be applicable to full-term infants, but in one large meta-analysis of preterm low birth weight and very low birth weight infants, over half of IVH occurred in the first 6 h of life [5]."

Summary

The data on safe minimal blood pressures for infants undergoing general anesthesia are still in its, well, infancy. Large database studies correlating intraoperative blood pressures and long-term cognitive outcomes are needed. Close attention is warranted to this area of research in the future.

References

1. Jöbsis FF. Noninvasive, infrared monitoring of cerebral and myocardial oxygen sufficiency and circulatory parameters. Science. 1977;198(4323):1264–7.
2. Ferrari M, Giannini I, Sideri G, Zanette E. Continuous non invasive monitoring of human brain by near infrared spectroscopy. Adv Exp Med Biol. 1985;191:873–82.
3. Bhatia R, Hampton T, Malde S, Kandala NB, Muammar M, Deasy N, et al. The application of near-infrared oximetry to cerebral monitoring during aneurysm embolization: a comparison with intraprocedural angiography. J Neurosurg Anesthesiol. 2007;19 (2):97–104 (Case Reports Comparative Study).
4. Rhondali O, Pouyau A, Mahr A, Juhel S, De Queiroz M, Rhzioual-Berrada K, et al. Sevoflurane anesthesia and brain perfusion. Paediatr Anaesth. 2015;25(2):180–5.
5. Al-Abdi SY, Al-Aamri MA. A systematic review and meta-analysis of the timing of early intraventricular hemorrhage in preterm neonates: clinical and research implications. J Clin Neonatol. 2014;3 (2):76–88.