

Intra-operative hypotension in children: does it matter?

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Introduction

Mild intra-operative hypotension (IOH) in children is not usually a cause for concern. However, what is normal, and how low is low? Some studies in adults have shown that IOH is associated with increased mortality. A study of adult patients by Bijker *et al*¹ showed no causal relationship between mortality and IOH, but the definition of IOH was problematic. However, there was a trend towards increased mortality in the elderly with sustained IOH. In a population of healthy children, is brief, mild IOH even an issue when there is seemingly no causal relationship in elderly vascular patients? Probably not but, ethically, this study could never be performed. Thousands of children have undergone anaesthesia and have been subjected to episodes of mild brief IOH without any adverse outcomes.

Significance of blood pressure measurements

“Safe” reduction in blood pressure (BP) has been regarded as a maximum of 25% below baseline mean BP. In a study of older children (9–18 years) undergoing functional endoscopic sinus surgery under mild controlled hypotension, no adverse outcomes were noted.² Although adult studies of induced hypotension under anaesthesia have shown no adverse outcomes, no significant conclusions can be drawn because of small patient numbers and generally poor study design.

The critically ill or injured child may not tolerate IOH as well as the healthy child. In this subgroup, care must be taken to maintain perfusion to vital organs. The questions again emerge: what minimum BP is acceptable, and which parameter should be used, mean or systolic? Prehospital hypotension is associated with increased mortality. Most guidelines define hypotension as a systolic BP (SBP) below the 5th percentile for age. There are variations in values amongst the consensus groups. As there were no

studies defining mean BP (MAP) in children (values were all derived), Haque and Zaritsky³ utilised data from the National Center for Health Statistics. They developed new estimates of the 5th percentile SBP for children 1–17 years of age and derived a formula for the calculation of MAP. They found that most recommended values were lower than those in their study. The higher values are recommended as minimum values for treatment goals. From this recent study these formulae have emerged:

SBP (5 th percentile at 50 th height percentile)	=	2 x age in years	+ 65
MAP (5 th percentile at 50 th height percentile)	=	1,5 x age in years	+ 40
MAP (50 th percentile at 50 th height percentile)	=	1,5 x age in years	+ 55

MAP is a major determinant of tissue perfusion pressure. Thus, MAP should be monitored in critically ill children to guide resuscitation or determine when a BP has fallen too low. MAP pressure values do vary with height, so these should be adjusted for very tall or short children. In certain subgroups, e.g. brain injury and blunt trauma, higher SBP seems to improve outcome. In everyday anaesthesia practice, SBP is monitored more often than MAP. This was confirmed in a survey by Nafiu *et al*.⁴ Most anaesthesiologists monitored SBP and defined IOH as a drop of 20–30% below baseline.

There is no consensus as to what constitutes IOH in children. Standard BP tables use values obtained via auscultation, whereas intra-operative non-invasive BP (NIBP) is measured oscillotonomically. The values suggested as “normal” are for awake, unanaesthetised subjects. They do not take into account variables such as the effects of anaesthetic agents on cerebral and other organ blood flow and metabolism, temperature, or surgical stress induced hormones. In adults, a

few studies give some indication of the duration and depth of IOH required for an adverse event to occur. No such studies exist in children, as there are as yet no consensus values for IOH and there is uncertainty whether IOH is important in children.

Importance of IOH in children

Intuitively, IOH should be important in children. Critically ill children who present for surgery are often haemodynamically unstable in the peri-operative period, and/or have major comorbidities. If the outcome is poor, IOH cannot be solely to blame, although it may be a contributing (but difficult to prove) factor.

During induction of anaesthesia in children, blood pressure measurement is not as high a priority as oxygen saturation. How often has an uncooperative child been quickly gas induced, and then only have monitors been placed? The pulse oximeter or ECG usually takes precedent over the BP cuff. In adults, there is an urgency to know what the BP is. This is not common in a paediatric theatre.

The incidence of pre-incision hypotension in children was as high as 36% in a study by Nafiu et al.⁵ The delay can be as a result of difficulty with intravenous line placement, or prolonged induction, or of less urgency if it is healthy child. Risk factors for pre-incision hypotension were found to be baseline hypotension, age (older patients were more prone to hypotension), propofol co-induction, ASA ≥ 3 , and a long pre-incision period. In some of our state hospitals, prolonged starvation should be added as a risk factor. Hypovolaemic children may not necessarily be hypotensive and may even be paradoxically hypertensive in the early stages. This may be unmasked by anaesthesia. Respiratory events are still the major cause of anaesthesia mortality in healthy children, although the incidence of cardiac events is becoming more prominent in the group as a whole.

NIBP measurement

Although NIBP measurement is done routinely, it does not have the same importance in paediatric anaesthesia as in adult anaesthesia, and less care may be taken in cuff and site selection and application. The cuff should fit at least 75 % of the circumference of the limb, and 2/3 of the length. A larger, rather than smaller, cuff should be used if no suitable one is available. Smaller cuffs tend to overestimate the measurement. In infants and young children, the BP cuff is sometimes placed on the lower limb. Unlike in adults, where lower limb readings are higher, lower

limb readings in children under the age of 8 years are lower.⁶

Long term effects of IOH

The long term effects of IOH are very difficult to assess, as we do not know exactly what to look for, or what tests to use, or when to look for it. Catastrophic events related to extreme hypotension (i.e. cardiac arrest) are not difficult to link to an event, but more subtle changes may not necessarily be related to IOH. Perhaps bispectral index (BIS) monitoring may be a start, but this approach is not without its critics. Is a low BIS score a result of decreased cerebral perfusion because of IOH, or too deep a level of anaesthesia, or is it due some other reason? The BIS score has been shown to fall in the presence of bradycardia without hypotension.⁷ BP does not necessarily reflect tissue perfusion. However, it is the best we have at present, and we will continue to use it in conjunction with other indirect indicators of tissue perfusion.

Special circumstances

There is no "one size that fits all" solution to this problem. IOH is a "dynamic phenomenon depending on patient characteristics and surgical factors rather than a static phenomenon based on fixed arbitrary chosen thresholds".⁸ There are a number of circumstances where particular attention should be paid to BP. The obvious ones are the known cardiac or hypertensive patients. Critically ill patients should not be regarded as hypotensive anyway and be allowed to run at a lower pressure. These patients often require a higher MAP during the critical phase of their illness.

Patients with traumatic brain injury (TBI) have impaired cerebral autoregulation. This incidence approaches 70% in severe TBI in adults, and 40% in children. However, children under the age of 4 years are at particularly high risk for impaired cerebral autoregulation, regardless of the degree of TBI.⁹

As cerebral perfusion pressure (CPP) = MAP – intracranial pressure (ICP), the maintenance of an adequate MAP becomes vital, particularly in the presence of raised ICP. Age-related BP values, as recommended by the Brain Trauma Foundation, are more rational than absolute values.

Obesity is now an epidemic in most countries. Childhood obesity is a reality, and is directly related to decreased physical activity and the number of hours of television watched per day. Although we recognise the problem, it is not being managed or treated

adequately. What does a raised body-mass index (BMI) have to do with IOH? The “normal” BP may, in fact, be too low, as obesity is related to metabolic syndrome. Compounding the problem is the fact that the BP will be measured with too small a cuff, so falsely elevating the BP, which may then be brought down by deepening anaesthesia.

Obesity is associated with type 2 diabetes and 17% of these children will be hypertensive.¹⁰ Although these patients do not infarct during childhood, they will have accelerated atherosclerosis and its complications during young adulthood. They also have evidence of fatty streaking and atherosclerosis in their blood vessels during childhood. A significant proportion of these children have abnormal flow-mediated dilation of their brachial arteries. This is an indication of endothelial dysfunction. In this subgroup of patients, it would be prudent to avoid IOH.

As anaesthesiologists, we are sometimes also primary care physicians, detecting diseases no else has noticed. The obese child is an obvious case, but one which is often “overlooked”. Obese children should be screened for diabetes and dyslipidaemias¹¹, and the ideal time to sample blood would be under anaesthesia; the patients are starved and venous access is less traumatic.

Thyroid dysfunction is very rare and is not cost effective to test for in the absence of other supporting signs.

Unexplained hypertension should not be ignored and be allowed to drift downwards towards “normal” values, as there may be underlying renal artery stenosis, chronic renal failure, Takayasu’s arteritis or pheochromocytoma, or some other serious disorder.

Conclusion

IOH is poorly defined, in particularly paediatric populations. Its true significance is not known, as studies are not conclusive and cannot be ethically performed in a prospective manner. In healthy children, brief episodes of mild IOH are probably not significant. In at risk groups, careful attention to age-related perfusion pressure and MAP is required. The definition of IOH must be tailored to a specific patient group, surgery and, perhaps, even to a specific organ and outcome.

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