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How do pediatric anesthesiologists define intraoperative hypotension?

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Summary

Introduction: Although blood pressure (BP) monitoring is a recommended standard of care by the ASA, and pediatric anesthesiologists routinely monitor the BP of their patients and when appropriate treat deviations from 'normal', there is no robust definition of hypotension in any of the pediatric anesthesia texts or journals. Consequently, what constitutes hypotension in pediatric anesthesia is currently unknown. We designed a questionnaire-based survey of pediatric anesthesiologists to determine the BP ranges and thresholds used to define intraoperative hypotension (IOH).

Methods: Members of the Society of Pediatric Anesthesia (SPA) and the Association of Paediatric Anaesthetists (APA) of Great Britain and Ireland were contacted through e-mail to participate in this survey. We asked a few demographic questions and five questions about specific definitions of hypotension for different age groups of patients undergoing inguinal herniorraphy, a common pediatric surgical procedure.

Results: The overall response rate was 56% (483/860), of which 76% were SPA members. Majority of the respondents (72%) work in academic institutions, while 8.9% work in institutions with fewer than 1000 annual pediatric surgical caseload. About 76% of respondents indicated that a 20–30% reduction in baseline systolic blood pressure (SBP) indicates significant hypotension in children under anesthesia. Most responders (86.7%) indicated that they use mean arterial pressure or SBP (72%) to define IOH. The mean SBP values for hypotension quoted by SPA members was about 5–7% lower across all pediatric age groups compared to values quoted by APA members ($P = 0.001$ for all age groups).

Conclusions: There is great variability in the BP parameters used and the threshold used for defining and treating IOH among pediatric anesthesiologists. The majority of respondents considered a 20–30% reduction from baseline in SBP as indicative of

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significant hypotension. Lack of a consensus definition for a common clinical condition like IOH could have implications for patient care as well as future clinical research.

Keywords: pediatric hypotension; pediatric anesthesia; intra-operative hypotension; definition

Introduction

The importance of blood pressure (BP) monitoring in the acute care and ICU setting is very clear (1–3). Data from adult (4) and pediatric victims of trauma (5) suggest that systolic blood pressure (SBP) is a predictor of mortality, and in many clinical situations, BP is used as a surrogate for tissue perfusion. Routine monitoring of BP is, therefore, one of the recommended standards of care by the ASA. Intraoperative hypotension (IOH) has been shown to be a very common consequence of induction of anesthesia in adults (6). Recent adult-derived data also suggest that IOH may be associated with significant early and long-term postoperative morbidity (7) and 1-year mortality (8). However, a recent review described a large variation in the threshold values used to define IOH across anesthesia studies in adults (9). These investigators described the potential negative implications that variable definitions for IOH have for incidence and outcomes studies.

Pediatric anesthesiologists routinely monitor the BP of their patients and make diagnostic and therapeutic decisions based on deviations from 'normal'. Unfortunately, there is a paucity of evidence related to IOH in children leaving a gap in understanding of what constitutes a clinically meaningful definition of IOH in this population. Most published work defines hypotension in children as SBP below the 5th percentile for age in accordance with the Task Force on Blood Pressure Control in Children (10). However, the BP readings upon which these guidelines are based were derived from large cohorts of healthy children at rest, using the auscultatory method (11). Children undergoing general anesthesia for a surgical procedure are not in their 'normal' state of health, and intraoperative BP is most commonly recorded by the oscillometric method. Published guidelines may, therefore, be irrelevant during the intraoperative period. Indeed, a recent study of SBP in critically ill children suggested that values for hypotension derived from healthy children may inappropriately define thresholds for critically ill or injured children (12). These investigators suggested that further study is warranted to evaluate appropriate SBP threshold values for hypotension in that population. Similar studies are required in children undergoing general anesthesia to provide a body of evidence to guide treatment decisions and outcomes studies.

The purpose of this survey was to determine the BP thresholds that pediatric anesthesiologists currently use to treat IOH. The primary objective was to identify the most commonly used definitions of IOH for children of various age groups. As a secondary objective, we sought to determine the BP parameter(s) that respondents use to define hypotension in their patients.

Methods

Registered members of the Society for Pediatric Anesthesia (SPA) and the Association of Paediatric Anaesthetists (APA) of Great Britain and Ireland for the year 2007 were contacted through e-mail to participate in this survey of IOH. The questionnaire (Appendix 1) was pretested by administering it (via e-mail) to all the pediatric anesthesia staff (attending, nurse anesthetists, and fellows) at our institution. A few questions that were noted to be ambiguous by the pilot participants were removed from the survey. Institutional Review Board approval was obtained from the University of Michigan Health System, and the research board of the SPA and APA gave permission to distribute the survey using members' e-mail addresses. The list of registered members of the two societies for the year

2007 was used as our sampling frame. We sent the survey to every physician with a registered e-mail address and sent out reminders every 2 weeks for the next 6 weeks to nonresponders.

The questionnaire consisted of three sections: (i) basic professional characteristic information about the respondents; (ii) five questions asking respondents to quote a SBP value at which they will initiate therapy for children of diverse age groups undergoing anesthesia for inguinal hernia repair; and (iii) four multiple choice questions about other BP parameters for defining hypotension and whether the type of surgery should influence the definition of hypotension. For the purposes of this survey, we defined significant hypotension as the lowest BP value that will prompt the practitioner to initiate treatment. Respondents were not required to give specific treatment modalities for hypotension. Instructions for completing the surveys and how to return them through e-mail were clearly written on the questionnaires, and clear assurances were given that all responses would be treated anonymously.

Statistical analysis

Data analysis was performed with SPSS® v.15.0 for Windows (SPSS Inc. Chicago, IL, USA). The proportion of responders to the survey was calculated. Baseline characteristics (societal affiliation) of responders were compared to nonresponders using Pearson chi-square test. Basic demographics of the responders were described with simple frequencies and percentages. Simple measures of central tendency (mean, median interquartile range, and mode) were used to describe the values quoted for hypotension for each of the defined age groups. Pearson chi-square test was used to compare the responses to the survey questions given by members of the SPA and APA. Pearson correlation coefficients were calculated for association between the values quoted for hypotension and number of years of practice and practice location.

Results

The overall response rate was 56% (483/860). Of these, 76% were SPA members, while the remaining 24% were from the APA. A majority (72%) of the respondents worked in academic institutions, while 8.9% work in institutions with fewer than 1000 annual pediatric surgical caseload. About 54.5% of the respondents indicated that they had been practicing pediatric anesthesia for 10 or more years, while 7% of respondents indicated they did not anesthetize neonates in their practice. Most responders (86.7%) indicated that they use mean arterial pressure (MAP) or SBP (72%) to define IOH, while 31% of respondents indicated they used diastolic BP. Fifty-five percent of respondents indicated that the type of surgery influences their definition of hypotension.

Definition of hypotension

A majority (96%) of participants in this survey quoted specific SBP values they considered indicative of hypotension in children of various age groups. A wide range of SBP values at which therapy would be initiated were quoted for all the age groups (Figure 1). Expectedly, the median SBP hypotension limit quoted by the respondents increased progressively depending on the child's age group.

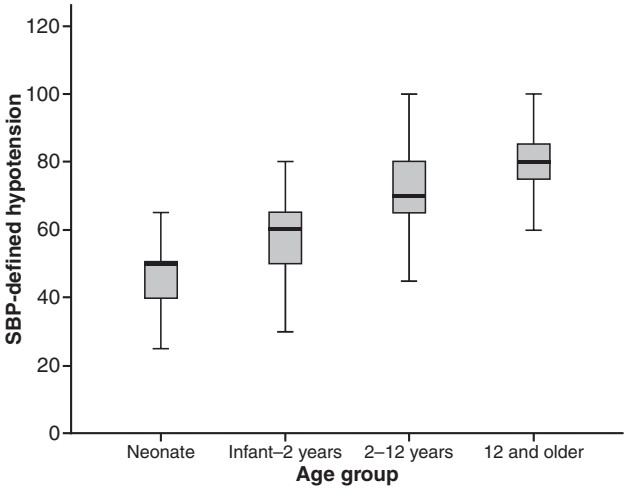

Figure 1
Box plot displaying the SBP values quoted by respondents as indicative of significant hypotension in various age groups of children. The lower and upper borders of each box mark the 25th and 75th percentiles, respectively, while the dark horizontal line within each box indicates the median SBP values. The whiskers above and below each box mark the 90th and 10th percentiles, respectively. Between-group median SBP comparisons are significantly ($P < 0.001$) different. SBP, systolic blood pressure.

We next compared the values for hypotension quoted by members of the SPA and the APA for children of various age groups. The mean SBP values for hypotension quoted by SPA members were about 5–7% lower across all pediatric age groups compared to values quoted by APA members ($P = 0.001$ for all age groups) (Table 1).

Preoperative BP and definition of hypotension

Seventy-two percent of respondents indicated that the baseline BP was important for defining clinically significant hypotension, while 18% thought it was not. Of those who believed change from baseline was important, 78% reported a 20–30% decrease in SBP would be considered significant (Figure 2). When proportionate decrease in SBP was considered, SPA members seem to tolerate a steeper decrease in SBP from baseline than APA members (Table 1).

Table 1
Values and methods used to define IOH by societal affiliation

Age group	*SPA members (n = 337)*	*APA members (n = 115)*	P *value*
SBP threshold values mean (SD) mmHg for IOH			
Neonates	45.5 (8.5)	49.6 (8.4)	0.001
Infant-2 year	54.8 (8.3)	59.6 (9.1)	0.001
Children 2–12 years	66.9 (8.9)	70.1 (6.8)	0.001
Adolescents	78.4 (10.0)	84.5 (5.3)	0.001
Change from baseline SBP indicative of IOH (% respondents)			
10–20% decrease	12.3	10.3	n.s.
20–30% decrease	70.3	89.7	0.001
30–40% decrease	10.9	0.0	0.001
>40% decrease	6.5	0.0	0.001
Parameters used to identify IOH (% respondents)			
SBP	78.3	96.2	0.001
MAP	86.3	85.7	n.s.
DBP	46.3	30.6	0.002

Values are mean (SD) mmHg SBP unless otherwise indicated. All *P* values generated with Pearson chi-square test.
APA, Association of Paediatric Anaesthetists; IOH, intraoperative hypotension; DBP, diastolic blood pressure; MAP, mean arterial pressure; SBP, systolic blood pressure; SPA, Society of Pediatric Anesthesia; n.s. not significant.

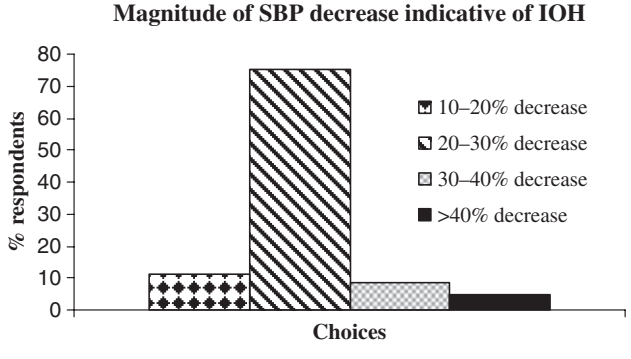

Figure 2
Histogram showing decreases in SBP value from baseline that is considered indicative of hypotension. All observations are proportion of respondents. SBP, systolic blood pressure.

Discussion

To our knowledge, this is the first study to evaluate the definition of IOH used by an international group of pediatric anesthesiologists. We found a great variability in the threshold values used to define significant IOH in children. The majority of respondents reported that a 20–30% decrease in SBP from baseline values indicates significant hypotension in a healthy pediatric patient undergoing inguinal hernia repair. Additionally, when compared to members of the APA, members of the SPA appear to tolerate lower BP values in their patients.

Determination and recording of BP is a mandatory standard of care in all patients receiving anesthesia (13). Additionally, BP monitoring is one of the mainstays of evaluation of the pediatric victim of trauma (3–5) and in the pediatric intensive unit setting (14). Moreover, several outcome studies have shown the predictive value of hypotension in the head injured or septic child (4,14). Hypotension is very common under anesthesia (7,15), and hypotensive anesthesia is commonly used to reduce surgical blood loss or improve surgical visualization (16). Despite all the available literature on the etiology and consequences of hypotension, what constitutes hypotension to the pediatric anesthesiologist in the operating room (OR) setting is largely unknown. Consistent with a recent review of adult anesthesia literature (9), this survey of pediatric anesthesiologists found a wide variability in reported threshold values for hypotension for all age groups of children, indicating a lack of consensus or understanding of what defines IOH. Recently, Bijker *et al.* (9) described the potential negative implications that variable definitions had toward defining the incidence of IOH and its association with adverse outcomes in adults. Furthermore, Warner and Monk (17) addressed the negative impact that the lack of consensus definition has on outcome research and on the public perception of the specialty of anesthesiology. Perhaps most importantly, this lack of

robust definition may cloud clinical decisions related to changes in BP including use of hypotensive anesthesia, fluid management, adjustments of volatile anesthetics, and use of vasopressors.

Interestingly, a high proportion of respondents indicated they use threshold SBP and/or MAP to define IOH. Yet the most widely used parameter for defining hypotension in children is SBP (18). SBP threshold values have been shown to be a predictor of mortality in pediatric trauma (2) as well as in children with septic shock (14). Furthermore, a higher percentage of studies of hypotension in adults and children published in main anesthesia journals have used absolute or relative decreases in SBP values (9). On the other hand, there are very little objective data regarding the value of MAP in pediatric patients (18). Additionally, there is no pediatric age-related MAP nomogram for clinicians to use as reference. While a standard definition of IOH based on age-adjusted SBP would make it possible to compare outcomes studies across settings, further investigation into how SBP as well as MAP changes relate to outcomes is warranted in both pediatric and adult settings.

Previous studies in critically ill neonates and children have highlighted the difficulties in applying standard definitions of hypotension across populations (18,19). These studies have suggested that use of current, population-based BP thresholds alone may be insufficient to guide practice decisions. Bijker *et al.* (9) found no consistent definition of IOH in adults and suggested that IOH be approached as a 'dynamic phenomenon' rather than be addressed in accordance with 'arbitrarily chosen thresholds'. Data from the present study suggest that the majority of pediatric anesthesiologists may indeed consider IOH as a 'dynamic phenomenon' in that a 20–30% reduction in SBP from baseline was considered by most to indicate clinically significant hypotension. Importantly, this definition may be easiest to apply compared to the widely used BTF definition of hypotension (SBP <5th percentile for age). Unfortunately, baseline BP readings are sometimes unavailable in the pediatric setting because of poor cooperation, emergent procedure, or even lack of documentation. Additionally, defining 'baseline' in the operative setting may be difficult because BP obtained in children just prior to surgery may be 'abnormal' given effects of anxiety, pain, hypovolemia, or other unknown factors on BP. Until a larger body of evidence is available for guiding decisions, however, change from baseline values may provide the most useful definition of IOH. Consideration of the intraoperative trends in BP, as well as other markers of perfusion such as peripheral perfusion and urine output, provides additional data toward clinical decision making in this setting.

A rather high proportion of responders reported that the type of surgery (major vs minor) would influence their definition of hypotension. Given that hypotension is a clinical diagnosis rather than a syndrome, the type or severity of surgery should not influence its diagnosis. On the other hand, surgical severity scores that include factors such as surgery duration, degree of tissue trauma, and other factors have been shown to correlate with surgical stress (20). Therefore, the impact of IOH on patient outcome may indeed vary by procedure or even underlying patient condition. However, we believe that for consistency in comparison with data from different institutions, there should be a consistent definition of IOH guided by the knowledge that the clinical consequences may indeed be affected by several factors.

Lastly, this study identified significant differences in the threshold limits used for IOH between members of the SPA and APA. SPA members appear to tolerate lower BP limits than responders who are members of the APA. Interestingly, the median values quoted by the APA members are closer to those recommended in the Pediatric Advanced Life Support (PALS) manual (12). It may be speculated that PALS certification may have influenced the responses of APA members; however, data related to certification of the two societies were not collected. This observation could also simply reflect a regional difference in practice.

Study limitations

Limitations inherent to surveys may have affected these study results. Responder bias is a potential concern relating to the uncertainty about potential differences between responders and nonresponders (21). There was no significant difference in institution (teaching vs nonteaching hospital) between survey responders and nonresponders; however, other characteristics as well as the management practices of physicians in the nonresponder group

remain unknown. Additionally, questions in this survey required respondents to consider the 'healthy' child undergoing only one type of surgery (i.e., inguinal hernia). Perceived treatment thresholds may vary depending on underlying patient conditions as well as by surgery. Lastly, this survey did not address what risks (if any) are associated with hypotension in the relatively healthy pediatric patient under anesthesia. Apart from studies in head injured and septic children outside of the OR (5,14), the clinical significance of transient or prolonged IOH is currently unknown. Future studies that examine outcomes in these and other populations of children relative to specific definitions of IOH are warranted. Such studies will help to refine the definition for clinically significant IOH.

In conclusion, this international survey found that a wide variety of SBP values were reported as thresholds across all age groups, yet a majority of respondents used a 20–30% decrease from baseline to define significant IOH in children. These findings suggest a lack of evidence and knowledge regarding the clinical significance of IOH in children. Further study of how changes in intraoperative BP relates to treatment decisions and outcomes is warranted to better define clinically significant IOH in children.

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Disclosure

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