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REGULAR ARTICLE

Survey of 23 Nordic university hospitals showed that 77% lacked written procedures for measuring and interpreting blood pressure in infants

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ABSTRACT

Aim: This study determined the use of standardised procedures for infant noninvasive blood pressure (NIBP) measurements in the Nordic countries and aimed to identify factors included in the standardisation and interpretation of NIBP measurements in infants.

Methods: A cross-sectional electronic questionnaire survey was sent to 84 physicians in all 23 university hospitals in Sweden, Norway, Denmark, Finland and Iceland and was completed from February to March 2017. The survey contained respondent characteristics, the presence and description of standardised procedures for NIBP measurements, daily practice of NIBP measurements and methodological considerations and interpretation of NIBP measurements in a healthy six-month-old child.

Results: We received responses from 55 of 84 physicians working in all 23 Nordic university hospitals, in paediatric cardiology (n = 22), general paediatrics (n = 16), paediatric nephrology (n = 14) and other fields (n = 3). Less than a quarter (23%) said their hospital issued specific NIBP procedures relating to infants and they referred to 19 different sources of information. The factors that were most commonly assessed for interpretation were age (100%), arousal state (78%) and cuff size (76%).

Conclusion: Most of the university hospital units treating children lacked age-specific written procedures for measuring and interpreting infant NIBP, and there is a strong need for common Nordic guidelines.

INTRODUCTION

Measuring noninvasive blood pressure (NIBP) is a daily procedure in most paediatric departments. When we were planning and developing standard operating procedures for NIBP measurements in infants from three months of age for a large prospective birth cohort study, we found that guidelines for measuring NIBP mainly addressed children from one to 18 years of age (1,2). This lack of guidelines may reduce the reliability of NIBP in daily practice and research, as several factors such as cuff size (3), arousal state (4) and measurement methods (3) are known to affect the measurements.

The main aim of this study was to determine the use of standardised procedures for measuring NIBP in infants in Nordic countries. The second aim was to identify factors included in the standardisation and interpretation of NIBP measurements in infants.

Abbreviations
BP, Blood pressure; NIBP, Noninvasive blood pressure.

Key notes

- This study determined the use of standardised procedures for infant noninvasive blood pressure (BP) measurements by surveying physicians in the Nordic university hospitals.
- They received 55 responses covering all 23 hospitals and only 23% had access to age-specific written procedures for measuring and interpreting infant BP in their unit.
- The large variations in methodological considerations and in the assumed normal range of BP indicate a need for common guidelines.

MATERIALS AND METHODS

This study was a questionnaire-based, cross-sectional electronic survey of physicians working in paediatrics in Nordic university hospitals, performed from February to March 2017.

There were two stages to the recruitment process. First an experienced paediatric cardiologist was identified as the coordinator in each of the five Nordic countries, and they subsequently identified four physicians in every university hospital, one from each of the following fields: paediatric cardiology, nephrology, intensive care and general paediatrics. The inclusion criteria for the physicians were that they needed to have first-hand knowledge of both the procedures and daily practice of NIBP measurements in their respective units. Physicians representing all 23 Nordic university hospitals in Norway, Sweden, Denmark, Finland and Iceland were included in the study.

The electronic questionnaire contained four parts. We asked for the respondent's characteristics, such as the field they worked in and how many years of experience they had, the presence and description of standardised procedures for NIBP measurements and the daily practice of NIBP measurements in their unit. The questionnaire also presented the case of a healthy six-month-old baby and asked the respondents about their methodological considerations and interpretation of NIBP measurements. The full questionnaire is presented in Appendix S1.

Statistical analysis

IBM SPSS Statistics for Mac, version 24 (IBM Corp, Armonk, NY, USA) was used to analyse the data. Due to the small sample size and dependence within each hospital, descriptive statistical methods were used. The VIOPLOT module for Stata/SE 14.2 for Mac, 16th Revision (StataCorp LP, College Station, TX, USA), was used to create Figure 3 (5).

RESULTS

The survey was sent to 84 physicians working within paediatrics in the Nordic university hospitals. In 8 of the 23 hospitals, there were only three physicians who fulfilled the inclusion criteria, making the total 84 instead of 92. In total, 55/84 (65%) completed the survey: Denmark (11/15) from four hospitals, Finland (17/19) from five hospitals, Iceland (2/4) from one hospital, Norway (13/23) from six hospitals and Sweden (12/23) from seven hospitals. This means that at least one clinician responded from each of the 23 hospital included in the survey. Respondents represented the fields of cardiology (n = 22), general paediatrics (n = 16) nephrology (n = 14) and others (n = 3) in all Nordic university hospitals. We received no responses from physicians working in intensive care units and these accounted for two-thirds of the lack of responses. Of the respondents, 50 (91%) were specialists in paediatrics, with a mean of 18 years (range 3–37) years of experience in their working field.

We found that only 16 physicians (29%) had access to paediatric age-specific procedures for NIBP measurements in their units and only 13 of these (23%) included specific procedures for infants (Fig. 1). Of the 13 physicians who reported that specific infants' procedures were available, six reported that they followed the entire procedure and seven said they followed parts of the procedure in daily practice. The most commonly used method for measuring NIBP, reported by 95% of the respondents, was oscillometry, followed by auscultatory measurements (16%) and Doppler ultrasonography (15%).

The specific factors that most were commonly considered when interpreting infant NIBP measurement results were age (100%) followed by arousal state and cuff size (Fig. 2), while birthweight and body mass index were the least commonly considered.

Three-quarters of the respondents (75%) said they interpreted blood pressure (BP) results based on reference values from published studies, while 29% reported said they relied on their personal experience, 13% based their interpretation on department traditions and 35% relied on other sources. As these findings show, some physicians relied on more than one source when interpreting results. The 41 respondents who reported using published reference values reported 48 references in total, including 19 different references based on five original studies (Table 1). The most commonly reported references were the Report of the Second Task Force on Blood Pressure Control in Children (6), which was mentioned by 10 physicians, and The Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents (1) from the USA, which was cited by five physicians. These two reports were the original references for 20 of the 33 other reported sources for reference values. Other reported sources were national guidelines, the website uptodate.com, local guidelines, unspecified publications from the American Heart Association, different medical textbooks and an assortment of different single studies.

The assumed normal range of NIBP of a six-month-old healthy infant varied widely, as shown in Figure 3. The upper and lower limits of assumed normal values overlapped in both systolic and diastolic BP.

The physicians' actions on a hypothetical systolic BP 10 mmHg above the assumed normal range in a six-month-old infant were reported as follows: no action (7%), expectancy, as in not interfering but actively await further clinical development (13%), repeat the measurement at a later time (89%) and further appropriate investigation (44%). None of the physicians suggested starting treatment based upon the measured NIBP result.

DISCUSSION

This study documented a lack of standardised procedures on how to measure NIBP in infants in Nordic university hospitals and variations in the methodological considerations and interpretation of results. It also reports the assumptions of normal BP ranges of a six-month-old healthy infant.

Our study found a lack of available standard procedures or guidelines for infant NIBP in 77% of units in the Nordic university hospitals that regularly measure infant BP. This

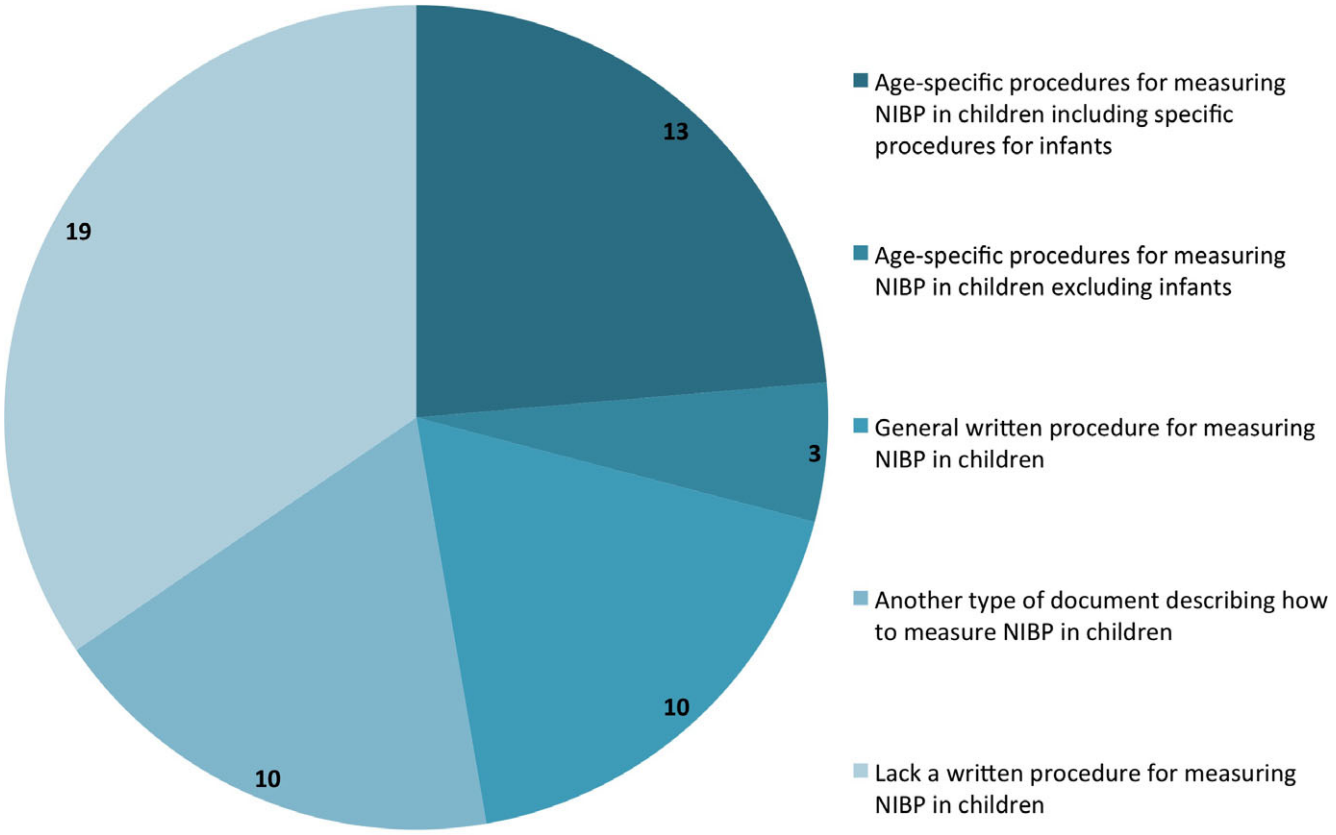

Figure 1 This is a pie chart of the reported availability of standard procedures for noninvasive blood pressure measurements in children in the units where the respondents worked. The numbers written in each sector are the absolute number of responses.

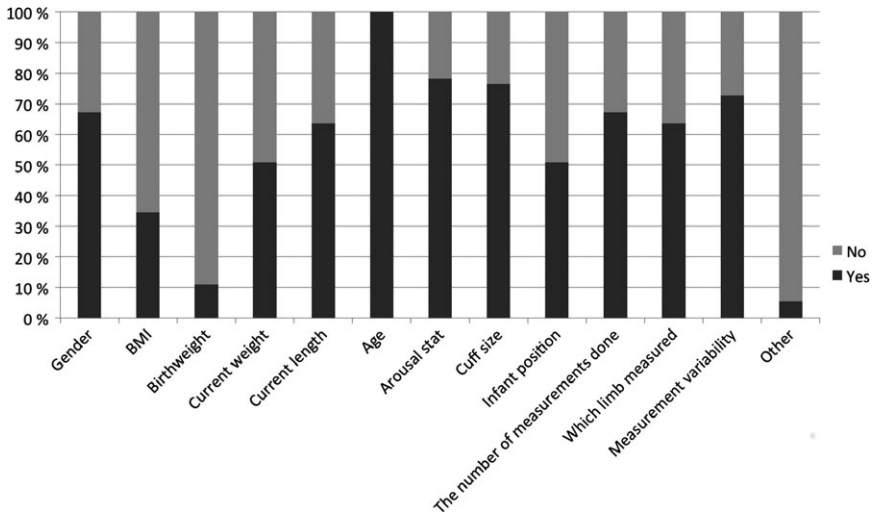

Figure 2 This shows which factors the respondents took into consideration when interpreting a noninvasive blood pressure result, presented as a 100% stacked bar chart.

probably reflects the lack of studies on the potential influence of methodological factors on BP in infants beyond the newborn period. The most commonly reported guideline sources, the Second Task Force (6) from 1987 and the Fourth Report (1) from 2004, only briefly mentioned the methodological aspects of NIBP measurements in infants. NIBP measurements in children older than one year of age are described in Nordic (7–9) and other international guidelines (2). However, some publications present detailed and practical suggestions for NIBP measurements in

Table 1 Original studies relevant for reference values for blood pressure in infants referred to by the respondents

Source	Author	Year	Method of NIBP	Number	Comment
Normative oscillometric blood pressure values in the first five years in an office setting (16)	Park and Menard	1989	Ocillometric	660	
Significance of blood pressure in infancy (12)	Zinner et al.	1985	Doppler ultrasonography	554	Basis for the reference values in the Second Task Force.
Blood pressure during the first five years of life: relation to ethnic group (black or white) and to parental hypertension (13)	Schachter et al.	1984	Doppler ultrasonography	392	Basis for the reference values in the Second Task Force.
Systolic blood pressure in a population of infants in the first year of life: the Brompton study (11)	de Swiet et al.	1980	Doppler ultrasonography and random zero sphygmomanometer. Diastolic BP was not measured.	1895	Basis for the reference values in the Second Task Force.
Changes in blood pressure during the first year of life (17)	Uhari	1980	Doppler ultrasonography	245	

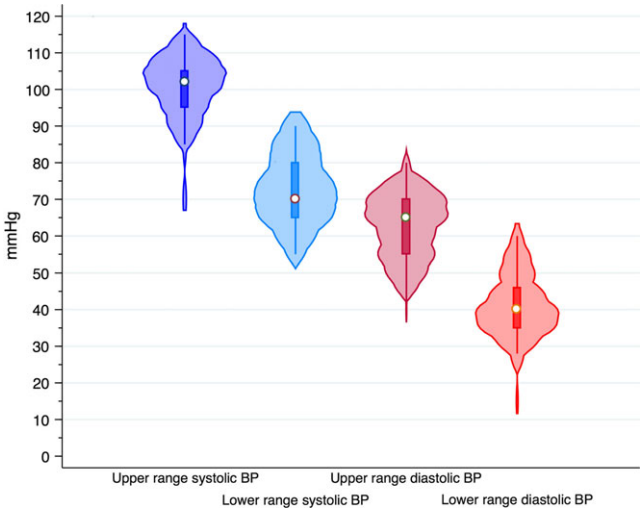

Figure 3 This is a violin plot of the respondents' assumptions of normal upper and lower limits of both systolic and diastolic blood pressure in a term born six-month-old infant. The plot consists of a boxplot with an overlay of the probability distribution. The thick bar in each boxplot represents the interquartile range, the thin lines extend to the upper adjacent value (the closest value smaller than or equal to the third quartile plus 1.5 interquartile range) and the lower adjacent value (the closest value equal to or greater than the first quartile minus 1.5 interquartile range), while the white dots mark the median values.

infants. Dionne et al. (4) described a procedure for NIBP measurements in neonates that may be applicable in infants. In addition, a practical description of infant NIBP measurements, including a detailed checklist containing 10 items, was presented by Stebor et al. (10) in 2005. A comprehensive update of The Fourth Report, the Clinical Practice Guidelines for Screening and Management of High Blood Pressures in Children and Adolescents (3), was published in August 2017. It did not include any further details on how to measure NIBP in infants.

Few publications present reference values for NIBP in term born infants after the newborn period. The most common source of reference values reported in this study was the Second Task Force published in 1987, which is the only report of reference values in infants based on several original publications of NIBP measurements. Successive updates only add data to the BP tables for children from one year of age, not for infants. The Fourth Report, which was published in 2004, was also commonly referred to in the present study, but presents no BP values for children below one year of age (1). These two reports represent the original sources for most of the other sources for reference values reported by the respondents of the present study. Several respondents referred to documents without references to the original sources.

The reference values for BP in infants in the Second Task Force were based on three studies from the 1980s, which all used the Doppler ultrasonography technique (Table 1) (11–13). The largest of the three was the Brompton study (11) published in 1980, which included 1895 infants. However, only systolic BP was registered (11). It should be noted that several of our respondents applied reference values for one-year-old children to younger children. Some authors have suggested that there may be little difference in the first year of life (11,14). However, the BP reference values for one-year-old children in the Fourth Report were based on auscultatory measurements (1), which differed from the BP values obtained by the oscillometric method (3) most commonly used by our respondents. A limited number of studies used oscillometric devices and these studies were not included in the Fourth Report or the Second Task Force (15,16).

The Clinical Practice Guidelines for Screening and Management of High Blood Pressures in Children and Adolescents recommended continued use of the normative BP curves from 1987 for infants, given the lack of more contemporary data (3). As shown in Figure 3, the assumption of a normal BP range in a six-month-old infant varied greatly between the respondents in our survey, as well as the action taken on a hypothetical systolic BP 10 mm Hg above the assumed normal values. The lack of established guidelines and reference values thus causes large variations in the treatment and use of resources in different hospitals.

Our survey is likely to be representative of all hospitals in Nordic countries and probably also elsewhere. We focused on the university hospitals because they treat a larger number of children, are more likely to use NIBP measurements in infants in their daily practice and usually guide medical practice elsewhere in their countries. The study was strengthened by the good response rate from all working fields, except intensive care, and the fact that it included all 23 university hospitals in the five countries. We also explored the standardised case of a healthy six-month-old child in the questionnaire. By carefully selecting respondents from the individual specialities in each university hospital, the study accurately investigated the units of the invited physicians. The number of invited respondents limited the possibility of using statistical methods beyond descriptive methods. Even though every respondent was chosen by a national coordinator to ensure that the respondents fulfilled the inclusion criteria, we cannot exclude the possibility that some physicians within the same hospital work within the same unit. The lack of responses from intensive care physicians probably indicated a different role of NIBP measurements in this field, in which NIBP assessments are often used for guidance of pressure support and volume substitutions. Neonatologists were not specifically included in the present study, as it aimed to assess NIBP measurement after the newborn period. Response bias may have affected the results of the survey, especially if respondents answered in such a way to present themselves and their units in a more favourable light. Generalisability of the study results may have been limited by our selected group of respondents and the lack of site-visits to compare clinical practice. We believe that the findings were sufficiently clear to document the lack of standardised measurement conditions and interpretation of normal BP values.

CONCLUSION

An electronic survey was sent to 84 physicians working in all 23 Nordic university hospitals to determine the use of procedures for measuring BP in infants, and we received at least one response from each hospital. Standardised, infant-specific procedures were not available in 77% of the hospitals. There were large variations in the methodological considerations, interpretation of results and assumptions of normal BP ranges. The findings indicate a strong need for common practical guidelines in all Nordic hospitals.

CONFLICT OF INTEREST

The authors have no conflict of interest to disclose.

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None.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article:

Appendix S1 Blood pressure measurements in infants (1–12 months).