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Infant Blood Pressure: The Validity of Calf Measurements

Delia Wessels, RN

Southern Adventist University

Abstract

Blood pressure monitoring is critical in the assessment and treatment of hospitalized infants. Two methods are commonly used to obtain measurements: Invasive arterial line measurement and noninvasive cuff measurements. The purpose of this study was to validate previous research supporting the use of noninvasive calf cuff measurements and to compare the values of calf and upper arm blood pressure measurements in hospitalized infants. A descriptive correlational design was used to investigate the convenience sample of 26 infants in a neonatal intensive care unit. Data obtained through chart review was analyzed using the Pearson r with a significance level of 0.05. Results showed a positive correlation between systolic values and mean arterial pressure calculations, but a low correlation between diastolic values. No definitive conclusions can be drawn from this study, and further study is recommended.

Infant Blood Pressure: The Validity of Calf Measurements

Introduction

Problem Statement

Blood pressure is one of the “vital signs” that are an indication of circulation and cardiovascular status in a patient. Accurate measurements are critical, as they are used to develop nursing diagnoses and expected outcomes, to determine methods of treatment (nursing as well as medical interventions), and to evaluate whether or not that treatment has been effective. In critically ill infants, two methods of measurement are commonly used: (a) Invasive monitoring via umbilical artery or radial artery lines, and (b) the noninvasive Dinamap cuff. The cuff measurements are currently being obtained from two locations: (a) The upper arm and (b) calf. This study compared infant calf and upper arm cuff measurements to determine the relationship.

Previous reports have criticized the accuracy of calf measurements, indicating a need for further research. Clearly, additional research is needed to explore this area to validate previous data, establish accuracy, and improve the current practice of blood pressure measurement. This study will examine the relationship between the noninvasive values obtained from the brachial and calf sites, controlling variables such as age and weight, variables not previously included.

Review of Literature

The nursing research CINAHL data base was researched back to 1984 for the topic infant blood pressure and revealed few articles. These were predominated by comparisons between invasive and noninvasive blood pressure readings, or between infant brachial (upper arm) and calf blood pressures. Many were generally brief, utilized small sample sizes, and recommended further study that either has not yet been done or is not yet published.

Concerning instrumentation for arterial pressure monitoring, “the gold standard . . . in the critically ill infant is direct, intra arterial recordings. . . . However, for the neonate, intra arterial blood pressure monitoring is not always possible or feasible for an extended period of time”(Gunderson & Cusson, 1994, p.51). This is particularly due to infants’ increased risk of infection, ineligibility for placement due to size, and other factors preventing the use of an umbilical or radial arterial line to be used for measurement. Therefore non-invasive monitoring must continue to be considered as a viable method for measurement because there is a good correlation between direct (intra arterial) and indirect brachial (cuff) measurements (Lynch 1987; Moniaci & Kraus 1997). However, dissenting reports reviewed by Gunderson & Cusson (1994) state that the calf readings don not accurately reflect the blood pressure values obtained from the direct arterial site. Therefore it is not a valid site for noninvasive blood pressure monitoring. This contradiction in outcomes supports additional study.

Blood pressure is normally expressed as a numerical ratio. It can be compared through a breakdown of its components (systolic and diastolic) or by computing a single value of the mean arterial pressure (MAP) (Polaski & Tatro, 1996).

Two methods are commonly used to monitor non-invasive blood pressure: (a) Manual auscultation using a stethoscope and mercury pressure gauge, and (b) the automated Dinamap electronic monitor. This electronic device senses the oscillometric waves (pulsations against the vessel wall) to determine the systolic and diastolic pressures. It inflates the cuff, then slowly as pressure is reduced, it searches for the pressure wave transmitted to the cuff. If no pressure wave is detected after three seconds, the cuff will deflate and the process repeated until readings are obtained. Oscillometric machines are more accurate than auscultation in infants and children (Gunderson & Cusson, 1994). Manual auscultation risks further errors by observer variation

which a computerized and automated device overcomes. There is, furthermore, excellent correlation between intra arterial pressure measurements and the Dinamap measurements ($r=.97$ SBP and $r=.90$ DBP).

Calf measurements may have to be used when the arm is not available (e.g. burns to upper extremities or presence of intravenous lines). Nurses in pediatric and neonatal areas prefer to utilize the calf as a measurement site because it is more accessible, with less need to disturb or undress the infant in order to take a measurement. (Axton, et al., 1995)

Studies report conflicting conclusions about noninvasive cuff measurements (Moniaci and Kraus, 1997; Gunderson & Cusson, 1994). These conflicting outcomes, as well as the lack of replicated studies, indicate a need for further investigation to establish the validity of calf and brachial blood pressure measurements. Thus the standard of care can be either maintained or improved.

Theoretical Framework

The theoretical basis for this study is derived from the principles embodied in Ernestine Wiedenbach's "The Helping Art of Clinical Nursing Theory" (Tomey & Alligood, 1998). This theory identifies the nurse as one who implements the procedures that may be needed "in order to identify and meet her patient's need-for-help." (p. 89) Her theory stresses the importance of identification, reporting, and consulting in nursing practice. Of the five essential attributes of a professional person Wiedenbach lists, three are pertinent here: (a) Clarity of purpose, (b) mastery of skill and knowledge essential for fulfilling purposes and procedures, and (c) interest in advancing knowledge in the area of interest and in creating new knowledge (Tomey & Alligood, 1998). This study incorporates the holistic view of the patient with the nurse's responsibility to maintain the highest level of health and safety for the neonate. This is done (a) by investigating the

possibility of decreasing the risk of infection and injury from arterial lines, and (b) by promoting healing through decreasing the disturbance and stimulus to the infant associated with obtaining brachial pressures.

Assumptions

1. Nurses' methods and protocols of blood pressure measurement are critical to determining standards of care.
2. Dinamap instruments have been calibrated prior to taking the blood pressure to ensure valid and accurate readings.
3. Measurements obtained by the nurses and utilized in this study were performed according to agency protocol without unusual errors or medical conditions.

Hypothesis

The infant calf and brachial blood pressures are positively related. The hypothesis will be accepted or rejected based on the alpha level set at 0.05.

Research Question

In an infant, is calf blood pressure measurement comparable to brachial blood pressure?

Definition of Terms

Blood Pressure. The pressure exerted by the blood against the walls of the blood vessels. Usually refers to the arterial blood and is expressed in terms of systolic (pressure at time of heart contraction) and diastolic (pressure between contractions). It is measured in millimeters of mercury at standard conditions and listed as part of a routine assessment on the chart (Miller-Keane, 1997). The two sites measured are: (a) brachial -- obtained from the right upper extremity just above the antecubital area with an inflatable cuff appropriate to the infant's size; and (b) calf -

- obtained from the right lower extremity just above the ankle with an inflatable cuff appropriate to the infant's size.

Neonate/Infant. Child from birth until the age of one year.

Mean Arterial Pressure (MAP). A quantitative, single numerical value used for data analysis. It is computed by multiplying the systolic pressure by two, adding the diastolic pressure, and dividing the sum by three (Polaski & Tatro, 1996). $MAP = \frac{(2 \text{ systolic} + \text{diastolic})}{3}$

Purpose

The purpose of this study was to compare the values of calf and upper arm blood pressure measurement in hospitalized infants and to validate reports supporting the use of noninvasive calf cuff measurements.

Methodology

Design

A descriptive, correlational design was utilized in this study. It determined the strength and direction of the relationship, if any, between brachial and calf blood pressure measurements with an automated Dinamap. In addition, it described the strength of the relationship between the measurements.

Sample

A convenience, nonrandom sample of twenty-six infants aged birth to one year was obtained from a Level III NICU from a children's hospital in the Southeastern United States. All infants in the study were admitted to the NICU within one or two days of birth and weighed less than five pounds (2.27 kg) at the time of measurement. Subjects included in the study had no intravenous lines in the extremities used to measure blood pressure nor any diagnosis of arterial or venous disease. Other characteristics, e.g. race and gender, were beyond the scope of this study.

Data Collection

Data were collected from admission records at which time both brachial and calf measurements were determined according to the NICU's protocol using the right upper extremity and the right lower extremity. Verbal permission was granted by both the human subjects review committee of Southern Adventist University (Appendix A) and by the case manager of the NICU at the facility (Appendix B). Human rights were protected in that no invasive procedures were performed nor identifying characteristics recorded. A sample of the form used for data collection is included in Appendix C. The raw data obtained is found in Appendix D. Figure 1 shows the raw data in graphical form.

Data Analysis

Descriptive statistics were used to describe the sample's interval data in terms of the mean, standard deviations, the mode, the median, and the Pearson r . The measurements were compared by site (brachial vs. calf) using MAP and by type (systolic vs. diastolic). Appendix E lists the numerical values of the data calculations. Figure 2 shows the statistical analysis of the raw data. Figure 3 shows the calculation of brachial and calf MAP values. Figure 4 shows the statistical analysis of brachial and calf MAP.

Discussion

The study showed a modest correlation between systolic blood pressures in the arm and calf ($r=0.63$, $p=0.0005$). The brachial and calf diastolic values were not significantly correlated ($r=0.24$, $p=0.235$). The brachial and calf pressures, as compared by MAP, also showed a modest correlation ($r=0.55$, $p=0.004$). The confidence of the brachial and calf systolic correlation and the brachial and calf MAP correlations support the hypothesis. However, the comparison of brachial

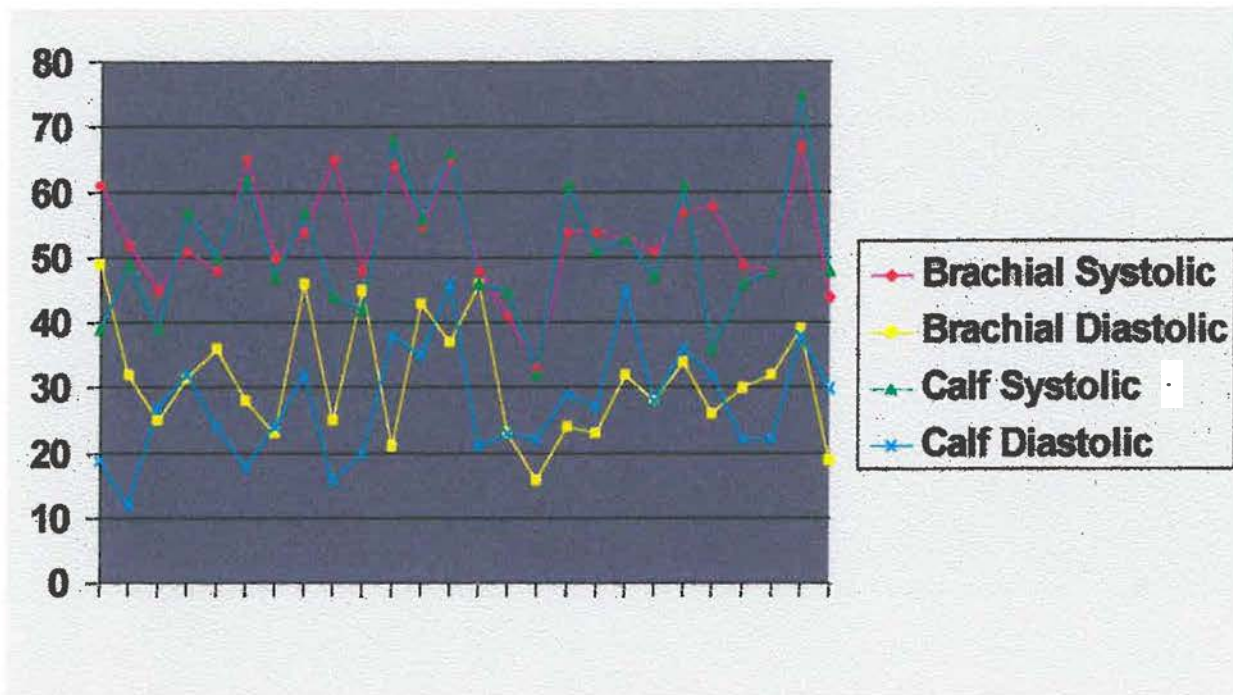


Figure 1: Raw data of blood pressure measurements.

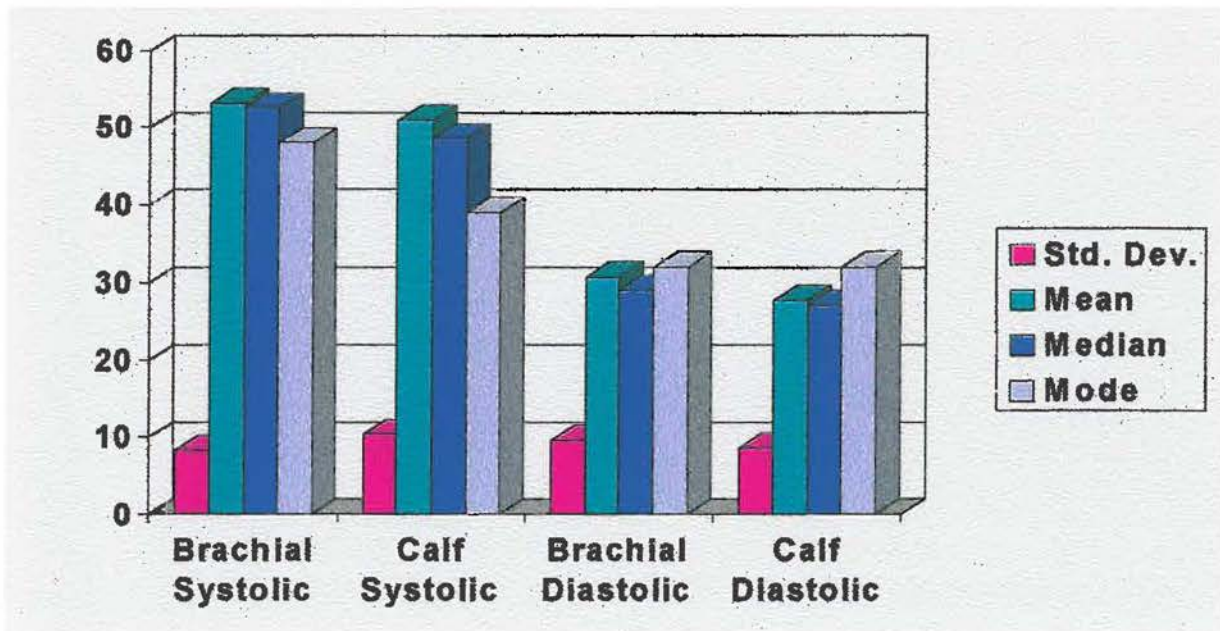


Figure 2: Statistical analysis of raw data.

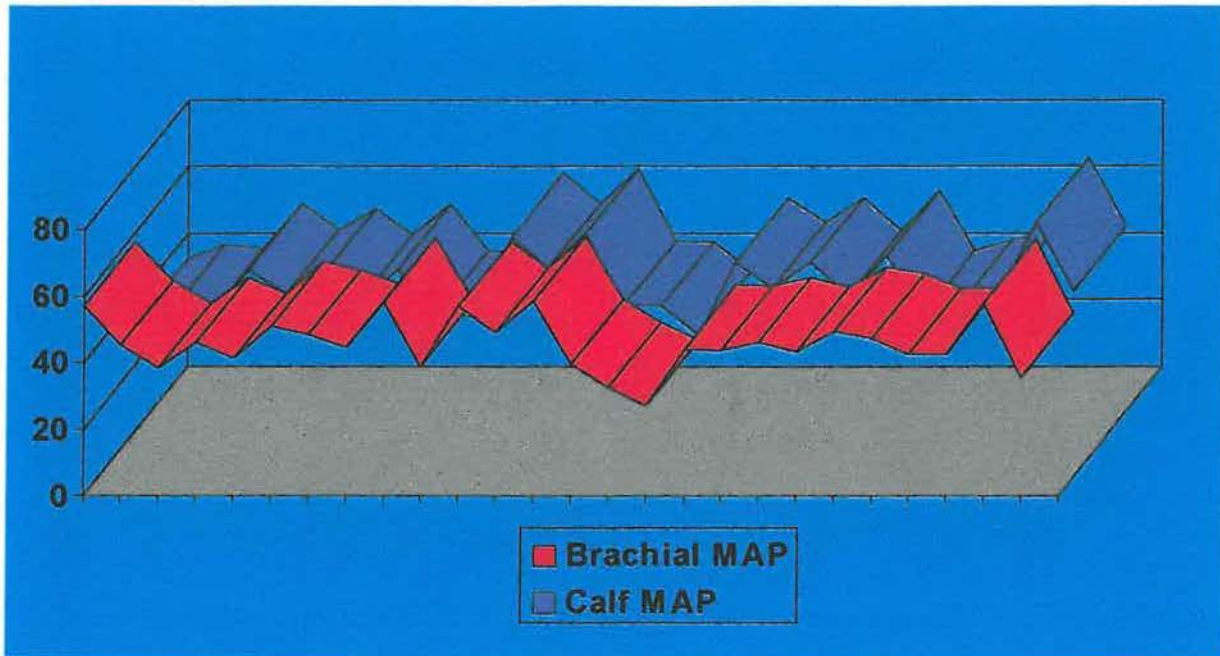


Figure 3: Calculations of brachial and calf mean arterial pressures (MAP).

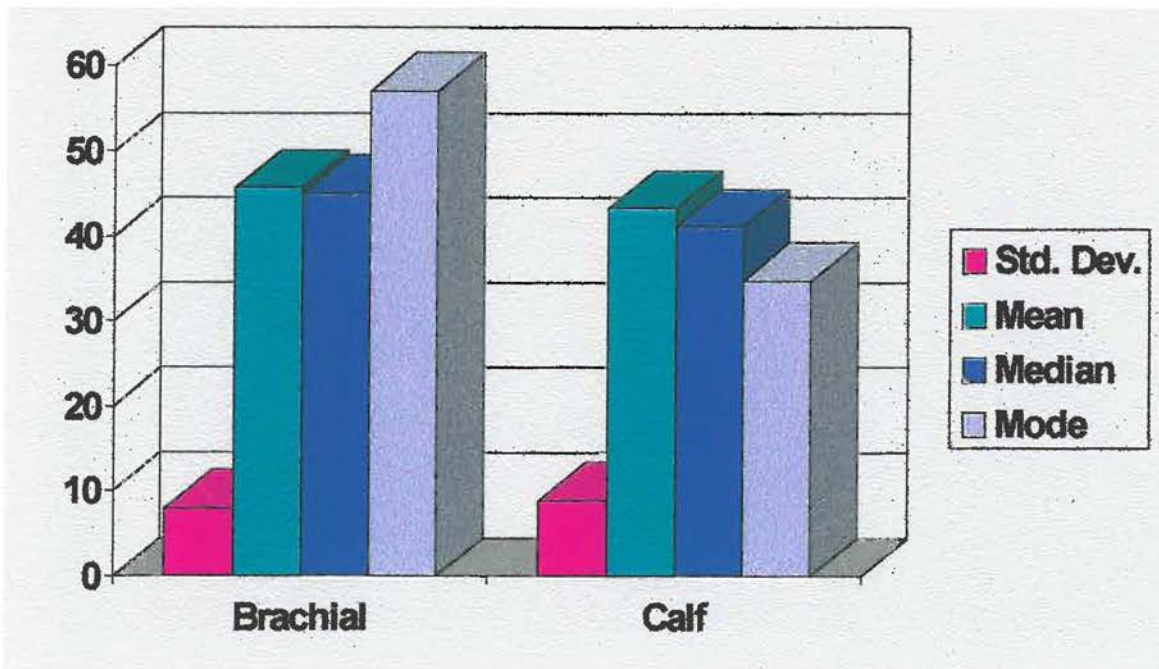


Figure 4: Statistical analysis of brachial and calf mean arterial pressures (MAP).

and calf diastolic values does not support the hypothesis at all, leading to a non-definitive conclusion. Further study with a larger sample, taking into account the additional variables of gender, race, and diagnosis is indicated.

Scope

The scope of this study was limited because of the small sample size utilized. Although twenty-six subjects is an appropriate number for statistical analysis, the sample selection was convenient rather than quota and non-random instead of randomized. Therefore conclusions cannot be extrapolated beyond this geographical region.

Recommendations for future study involve further sampling and analysis, taking into account the above mentioned variables and increasing sample size. Additional studies should be done on a national level (to account for deviations associated with race and geographical effects) with large sample sizes.

Limitations

This study is limited by three areas: (a) The small sample size available, (b) the type of data obtained and (c) the specificity to patients in this one facility. As a result, conclusions cannot simply be applied to other genres of patients or to other facilities. Furthermore, the study is limited by the exclusion of age, weight, gender, and race which may or may not have an effect on data.

External validity may be challenged on the grounds that each measurement may have been obtained by a different nurse allowing for observer/recorder error to occur. Because of the nature of the individual care of nursing practice, this is a limitation that would be considered normal and expected. It is also a limitation that would be seen with all other studies, unless a

single researcher took all the measurements; In that case the data would not represent reality. The Dinamap blood pressure monitors, although the same model, were independently calibrated, but may not have been intercalibrated, thereby potentiating an error.

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Appendix A

SOUTHERN COLLEGE
HUMAN PARTICIPANTS REVIEW FORM

Date 3 30 98

DIRECTIONS: Please type and submit in triplicate

1. A. Name DELIA A. WESSELS
 B. Department NURSING
 C. Title of study INFANT BLOOD PRESSURE - THE VALIDITY OF CALF MEASUREMENTS
 D. Date research will start: 4 3 98 Anticipated date of conclusion: 4 10 98
 E. Type of Project: Research
 Education (COURSE RELATED)
 F. Type of Support: Internal
 External
 (please specify granting agency) _____
 none

2. Brief description of procedures to be used. (If doing a study that uses a questionnaire, you must attach a copy of that questionnaire.) CHART REVIEW

3. Where will this study be conducted? ERLANGER MEDICAL CENTER - TC THOMPSON CHILDREN'S HOSPITAL NICU.

4. A. Will electrical or mechanical equipment be used? YES NO
 If "yes" how has equipment been checked for safety?

B. Is a psychologically noxious stimulus or stress of some sort (sense of insecurity or failure, assault upon values, fatigue, or sleep deprivation) to be used in this study? YES NO

C. If answering yes to either A or B.
 1. Describe the nature of the stress induced and/or the noxious stimulus or stimuli employed.

2. Describe the precautions you have taken with regards to any stress induced and/or any noxious stimulus employed.

D. Is deception to be used in this study? YES NO
 If "yes" what is the nature of this deception?

E. Have provisions been made for debriefing and any potentially necessary subject follow-up?

If "yes", please describe

YES NO

F. Describe, in detail, any risks to participants that were not addressed by the previous parts of this question. Also specify how you plan to minimize these risks.

NO RISKS

5. What will you do if participants exhibit signs of harm (e.g., crying, disoriented behavior)?

NO RISK

6. Will your participants be limited to students at Southern College?

YES NO

If "no" explain. LIMITED TO INPATIENTS AT THE NICU.

Fill in the following so that we know more about the characteristics of your participants.

A. Sex: ___ Male ___ Female Both

B. Age group(s): NEONATAL - IVR

C. Special ethnic group (please specify): N/A

D. General state of health: CRITICALLY ILL

E. How will participants be chosen? CONVENIENCE NON-RANDOM

7. How many participants will you need? 20-30

8. What educational gain do you think the participants will obtain from being in this study?

NONE

9. How will you ensure the confidentiality of each subject's data? Address the following five phases:

A. When collecting it. NO IDENTIFYING CHARACTERISTICS WILL BE COLLECTED OR USED.

B. When coding it.

C. When storing it.

D. When analyzing it.

E. When disposing of raw data.

10. How will your findings/results of study be used?

FOR RESEARCH PURPOSES ONLY.

11. I have enclosed a copy of the informed consent form and the sign-up sheet.

YES NO

If "no," why not? NO CONSENT NEEDED

12. All participants will fill out a written informed consent form before they begin the study.

YES NO

If "no," why not? NOT NEEDED.

13. My responsibilities as a researcher are clear to me.

YES NO

Type the name of each researcher under the corresponding signature line. All researchers must sign.

DELIA A WESSELS

Delia A. Wessels RN

4/6/98

Date

Date

Date

If you are a student your research advisor or supervisory instructor must respond to the following question.

14. I have personally discussed the proposed study with the researcher(s), and I approve of the study and will provide close supervision of procedures and ethical standards. Furthermore, these individuals have been informed of their responsibilities as a researcher; namely that:
- (a) they should not lightly miss sessions for which subjects have signed up;
 - (b) they should be prepared to describe the purpose and nature of the study to subjects at the completion of the study if the subject wishes;
 - (c) the subject has the right to terminate the session at any point;
 - (d) even if the subject doesn't terminate the session, the researcher should terminate the session if the subject shows signs of extreme discomfort;
 - (e) if a subject becomes distraught, comforting the subject takes priority over all other tasks;
 - (f) subjects' privacy is to be respected;
 - (g) subjects fill out the informed consent form before they participate in the study. YES NO

Kate G. Lamb
Signature of Research Advisor Date

KATE G. LAMB
Name of Research Advisor, typed

ACTION BY HUMAN PARTICIPANTS COMMITTEE AND DATE APPROVED

Signed Nina Saurin Date April 8, 98
Chairperson, Human Participants in Research Committee

Distribution: HPRC file; Academic Administration file; Investigator/Project leader

Appendix B



School of Nursing
P.O. Box 370
Collegedale
Tennessee 37315
423.238.2940
Fax 423.238.3004

April 2, 1998

Ms. Lou Ann Hobbs
T. C. Thompson Children's Hospital

Dear Ms. Hobbs:

Deliah Wessels is a senior nursing student in the baccalaureate nursing program at Southern Adventist University. As her senior research project, she is comparing the accuracy of blood pressure readings of infants taken at the brachial and the calf sites. She is requesting permission to look at current patient charts to gather her data.

Deliah would like to come on Sunday-Tuesday evenings (April 5, 6, 7) for data collection.

If there are any questions about this project, you may contact me at 239-2942 or Deliah at 238-2628. Thank you for your consideration of this request.

Sincerely,

Katie A. Lamb
Katie A. Lamb,
Dean, School of Nursing
Instructor, Nursing Research Methods

Appendix C

Data Collecting Table

| Right Brachial Pressures | Right Calf Pressures |
|--------------------------|----------------------|
| | |

Appendix D

Raw Data Measurements of Manual Blood Pressures

| Right Brachial Systolic Pressure | Right Brachial Diastolic Pressure | Right Brachial Mean Arterial Pressure | Right Calf Systolic Pressure | Right Calf Diastolic Pressure | Right Calf Mean Arterial Pressure |
|--|---|---|------------------------------------|-------------------------------------|---|
| 61 | 49 | 57.00 | 39 | 19 | 32.33 |
| 52 | 32 | 45.33 | 49 | 12 | 36.67 |
| 45 | 25 | 38.33 | 39 | 27 | 35.00 |
| 51 | 36 | 46.00 | 57 | 32 | 48.67 |
| 48 | 28 | 41.33 | 50 | 24 | 41.33 |
| 65 | 23 | 51.00 | 62 | 18 | 47.33 |
| 50 | 46 | 48.67 | 47 | 24 | 39.33 |
| 54 | 25 | 44.33 | 57 | 32 | 48.67 |
| 65 | 45 | 58.33 | 44 | 16 | 34.67 |
| 48 | 21 | 39.00 | 42 | 20 | 34.37 |
| 64 | 43 | 57.00 | 68 | 38 | 58.00 |
| 55 | 37 | 49.00 | 56 | 35 | 49.00 |
| 65 | 46 | 58.67 | 66 | 46 | 59.33 |
| 48 | 23 | 39.67 | 46 | 21 | 37.67 |
| 41 | 16 | 32.67 | 45 | 23 | 37.67 |
| 33 | 16 | 27.33 | 32 | 22 | 28.67 |
| 54 | 24 | 44.00 | 61 | 29 | 50.33 |
| 54 | 23 | 43.67 | 51 | 27 | 43.00 |
| 53 | 32 | 46.00 | 53 | 45 | 50.33 |
| 51 | 28 | 43.33 | 47 | 28 | 40.67 |
| 57 | 34 | 49.33 | 61 | 36 | 52.67 |
| 58 | 26 | 47.33 | 36 | 32 | 34.67 |
| 49 | 30 | 42.67 | 46 | 22 | 38.00 |
| 48 | 32 | 42.67 | 48 | 22 | 39.33 |
| 67 | 39 | 57.67 | 75 | 38 | 62.67 |
| 44 | 19 | 35.67 | 48 | 30 | 42.00 |

Appendix E

Statistical Analysis of Data

| | Brachial Systolic | Calf Systolic | Brachial Diastolic | Calf Diastolic | Brachial MAP | Calf MAP |
|-----------|----------------------|------------------|-----------------------|-------------------|-----------------|-------------|
| Mode | 48.00 | 39.00 | 32.00 | 32.00 | 57.00 | 34.67 |
| Median | 52.50 | 48.50 | 29.00 | 27.00 | 44.83 | 41.00 |
| Mean | 53.08 | 50.96 | 30.69 | 27.62 | 45.62 | 43.18 |
| Std. Dev. | 8.21 | 10.31 | 9.59 | 8.57 | 7.96 | 8.83 |