To the Graduate Council:

I am submitting herewith a thesis written by Ginger A. Dillard entitled "Comparison of Axillary, Inguinal and Tympanic Temperatures to Rectal Temperatures in Infants." I have examined the final copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science in Nursing.

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COMPARISON OF AXILLARY, INGUINAL AND TYMPANIC TEMPERATURES TO RECTAL TEMPERATURES IN INFANTS

A Thesis

Presented for the

Master of Science in Nursing Degree

University of Tennessee, Knoxville

Ginger Dillard

December 1992

DEDICATION

To the memory of my mother, Lucy Anderson, whose unconditional love and support have always strengthened me.

ACKNOWLEDGMENTS

I would like to express my sincere appreciation to my committee: Dr. Mitzi Davis for her patience, guidance, and encouragement as chair, and Dr. Pat Droppleman and Dr. Johnie Mozingo for their assistance, input, and expertise.

Many thanks to the nurses and secretaries in the neonatal and obstetrical units at Johnson City Medical Center Hospital for their cooperation and assistance in obtaining informed consent and in data collection. Thanks also go to Sandra Perry for her assistance with typing and Dr. Carol Gordon for her expertise and assistance with statistical analysis. Special thanks to all the parents who willingly allowed their child to participate in this study.

I am also very grateful for the special support and understanding given me by family members Richard and Peggy Anderson, and Ceola and Larry Cox, and my husband Craig and daughter Tabitha. Their patience and support have been instrumental to successful completion of this research and my graduate studies. Most of all, I would like to thank our heavenly father, through whom all good things are possible.

ABSTRACT

The purpose of this study was to examine relationships of axillary, inguinal, and tympanic temperatures to rectal temperatures in infants from 24-42 weeks gestation. A total of 62 infants were included in this study, with infants studied both as a total group and by assignment according to gestational age: 24-27 weeks, 28-31 weeks, 32-35 weeks and 36-42 weeks.

Analysis of variance was performed to determine if the axillary, inguinal, and tympanic measures differed significantly from the rectal measures depending on gestational age groups. Least significant difference revealed infants 24-27 weeks gestation had axillary-rectal temperature and inguinal-rectal temperature differences that were significantly different than other age groups. There was also a significant difference in rectal-tympanic temperatures, between infants with gestational ages 36-42 weeks and infants 24-31 weeks.

Pearson r was performed to determine the strength of correlation between the rectal and other routes. Overall, the axillary method had the strongest correlation with the rectal method, followed by the inguinal method. The correlation of the axillary, inguinal, and tympanic temperatures with the rectal temperature increased as gestational age increased. Correlation of the axillary, inguinal, and tympanic temperatures to the rectal temperature was extremely poor in

infants 24-31 weeks gestation regardless of route. Moderate correlations were noted in infants 32-42 weeks gestation in the axillary and inguinal routes, but not between the tympanic route and other routes.

TABLE OF CONTENTS

CHAPTER		PAGE
I.	Comparison of Axillary, Inguinal and tympanic Temperatures to Rectal Temperatures in Infants	
	Introduction	1
	Statement of the Problem	6
	Statement of the Purpose	7
	Nominal Definitions	7
	Assumptions	8
II.	Literature Review	9
	Introduction	9
	Cold Stress	9
	Variables Influencing Temperature Maintenance	12
	Gestational Age	12
	Supplemental Heat Source	15
	Methods of Temperature Measurement	18
	Stabilization	20
	Conventional Temperature Measurement	21
	Tympanic Temperature Measurement	27
	Inguinal Temperature Measurement	37
	Summary	38
III.	Methodology	40
	Research Design	40
	Operational Definitions	40
	Subjects	41

Instrumentation 46
Accuracy 47
Procedure 48
Data Analysis 49
IV. Results 51
V. Discussion 61
Limitations 68
Conclusions 69
Suggestions for Further Study 70
References 72
Appendices 82
A. Form B 83
B. Consent to Participate 88
C. Record Form 89
Vita 90

LIST OF TABLES

TABLE		PAGE
I.	Subject Characteristics.	43
II.	Birthweight and Weight at Time of Study in Grams	45
III.	Age in Days by Gestational Group	46
IV.	Correlation Matrix of Study Variables.	52
V.	Temperatures at Various Sites	53
VI.	Mean Differences Between Temperatures	55
VII.	Analysis of Variance	57
VIII.	Infants Reaching Temperature Stabilization at all Four Sites	58
IX.	Temperature Stabilization Times by Gestational Age Group	59
X.	Mean Stabilization Times	60

CHAPTER I

Comparison of Axillary, Inguinal and Tympanic Temperatures to Rectal Temperatures in Infants

Introduction

Over the past two decades medical professionals have discovered numerous factors that may influence survival rates of neonates. Maternal age and health, perinatal infection, congenital problems, the use of certain medications, and lack of prenatal care are known to influence morbidity and mortality in the newborn, and often contribute to conditions such as prematurity, sepsis, and the development of hyaline membrane disease.

As early as 1900, subnormal temperature was identified as a factor influencing morbidity and mortality in infants (Budin, 1900). "Cold stress" is the term used to describe the series of biophysiological events that occur in the neonate in response to suboptimal temperature fluctuations. Various studies have shown these biophysiological events to be manifested in the clinical setting by responses such as increased oxygen requirements, hypo or hyperglycemia, increased metabolic rate, neurologic irritability, and metabolic acidosis (Harpin, Chellappah, & Rutter, 1983; Sauer, Dane, & Visser, 1984).

In order to prevent the occurrence of cold stress, an infant's temperature should be maintained within an acceptable range known as the optimal thermal temperature. Optimal temperatures have been defined as the range of temperatures within which the metabolic rate, physical processes, and evaporation are at a minimum (Bligh & Johnson, 1973). In order to assist the infant in maintaining an optimal thermal temperature, caretakers must have an accurate indicator of body temperature.

The most reliable indicator of overall body temperature is the core body temperature, considered to be a measure of the central temperature of the blood and vital organs. Methods utilized for obtaining core temperature measurements are both difficult and dangerous as measurements must be made by insertion of a catheter into the pulmonary artery, or insertion of a catheter five centimeters into the rectum (Mather, Nahas, & Hemingway, 1953; Mayfield, Bhatia, Nakamara, Rios, & Bell, 1984). Core temperature measurement by either of these procedures in the neonate is impractical because measurement involves either a surgical procedure for catheter insertion, or the risk of bowel perforation, rectal fissures, and excoriation (Fonkalsrud & Clatworthy, 1965; Greenbaum, Carson, Kimcammon, & O'Laughlin, 1969; Horwitz & Bennet, 1976).

Because of the risks associated with pulmonary and rectal methods of core body temperature measurements, researchers

have investigated axillary temperature measurement as an estimate of core body temperature measurement (Buntain, Pregler, O'Brien, & Lynn, 1977; Schiffman, 1982; Torrance, 1968). Researchers have also investigated alternate sites of temperature measurement in neonates, including skin temperature, inguinal temperature, and tympanic temperature (Bliss & Holtz, 1989; Mayfield, et al., 1984; Moen, Chapmen, Sheehan, & Carter, 1987).

Studies assessing the accuracy of predicting rectal temperature from axillary, inguinal, and tympanic measurements have raised many questions. These include the best techniques for thermometer placement, length of time to leave the thermometer in place, and variations in temperatures between term and preterm infants (Eoff, Meler, & Miller, 1974; Giuffre, Heidenreich, Gersten, Dorsch, & Heidenreich, 1990; Haddock, Vincent, & Merrow, 1986; Stephen & Sexton, 1987).

Mayfield et al. (1984a) compared temperatures obtained via axillary, epidermal, core and rectal routes in term and preterm infants. Close agreement was noted between axillary and rectal temperatures in term newborn infants. The greatest difference in mean temperatures at different sites was .22°C. An even closer association was noted in preterm infants. Temperatures at each site, with the exception of the rectal, had the same mean. The mean rectal temperature was .10°C less than the means at the other sites. The closer

association found in preterm infants was presumed to result from preterms' decreased body fat limiting thermal insulation (Mayfield et al., 1984).

Moen et al. (1987) also noted a close agreement between rectal and axillary temperatures in preterm infants. Axillary and rectal temperatures were obtained at 3, 5, 8, and 10 minutes on 12 separate occasions over a period of 48 hours. The mean discrepancy was .02°C at 3 and 5 minutes, .03°C at 8 minutes and .04°C at 10 minutes.

Haddock et al. (1988) examined rectal and axillary temperatures in preterm infants in relation to gestational age, gender, race, weight, and heat source to determine if these variables significantly influenced temperature readings. The only statistically significant variable was gender. Female infants took longer to reach stabilized rectal temperatures than did male infants. A significant difference in rectal and axillary temperatures was also noted between male and female infants. Differences were thought to be related to variations in the pelvic structure of males and females.

Torrance (1968) compared axillary and rectal temperatures of 120 preterm infants. No significant difference was demonstrated between mean axillary and mean rectal temperature. A later similar study of 30 term infants revealed significant differences between axillary and rectal temperatures (t = 9.65

$p<.01$). However, strong correlations were found ($r = .92$) (Eoff et al., 1974).

Other routes of temperature measurement have also been compared to the rectal route. Rectal, inguinal, and axillary temperatures were studied. Bliss-Holtz (1989) noted that differences in inguinal and rectal temperatures were greater than differences in axillary and rectal temperatures. The inguinal and rectal temperatures had a higher correlation indicating inguinal temperatures were more sensitive to changes in rectal temperatures than were axillary.

Tympanic temperatures have also been proposed as an alternative method of determining temperatures in infants. Stratton (1977) found tympanic measurement to be slightly higher than rectal temperature measurement in a study on ten term infants. Mayfield et al. (1984a) found conflicting results in a similar study on 70 term infants. Rectal temperatures were significantly higher than axillary temperatures.

The results of these studies support the premise that axillary temperatures reflect rectal temperatures in term infants; however, the reliability of other methods such as the inguinal and tympanic method in predicting rectal temperature is yet to be established.

Environmental and physical factors have also been linked to variations in temperature readings. One study found higher axillary than rectal temperatures in infants cared for

under radiant warmers (Moen et al., 1987). Another study documented a consistent trend of higher axillary temperature for those infants under radiant warmers when compared to infants in isolettes (Haddock et al., 1988). Gestational age was also shown to influence temperature. Two studies (Mayfield et al., 1984a; Moen et al., 1987) found that axillary temperatures had a stronger correlation with rectal temperatures in infants of decreasing gestational age.

Statement of the Problem

Maintaining an optimal thermal temperature in the neonate is vital for the prevention of cold stress and its associated manifestations. The accuracy of techniques such as axillary, inguinal, and tympanic measurement in predicting core body temperature must be determined if they are to be used in the clinical setting. Although axillary temperatures have been investigated extensively, some studies have indicated that the inguinal and tympanic methods may be more reliable and practical in the prediction of core body temperature (Bliss-Holtz, 1987). In addition, regulations are now being established by OSHA which encourage limiting the use of the glass and mercury thermometers due to environmental safety hazards. Further research is needed to determine reliability of alternate methods of temperature assessment in infants of all gestational ages.

Statement of the Purpose

This study explored the relationships of axillary, inguinal, and tympanic temperatures to rectal temperatures in infants from 24-42 weeks gestation. The results may help caregivers obtain the safest, most accurate assessment of temperature.

Subsidiary questions were:

1. What are the correlations of the axillary, inguinal and tympanic temperatures to the rectal temperature and do the correlations vary with gestational age?

2. What are the differences between the rectal temperature readings and the axillary, inguinal and tympanic readings in infants of different gestational age groups?

3. Is temperature stabilization at various sites affected by gestational age?

Nominal Definitions

For the purpose of this study the following terms were used:

1. Infant: A newborn baby seven days of age or less.

2. Preterm infant: An infant born before the 37th week of gestation as calculated from the mother's last normal menstrual cycle and confirmed by Ballard assessment.

3. Gestational age: Infants' age in weeks from conception to birth as determined by the Ballard method.

4. Ballard method: An instrument for determining the gestational age of an infant by assigning numerical values to physical characteristics.

5. Radiant warmer: An open bed with a radiant heat source used in the care of infants to assist with the stabilization and maintenance of temperature.

6. Core temperature: The central indicator of thermal status determined by deep rectal placement of the thermometer or by catheters in the pulmonary artery following procedures such as pulmonary artery bypass or open heart surgery.

Assumptions

1. The glass and mercury thermometer is a reliable method of obtaining body temperature.

2. The rectal temperature is an adequate index of core temperature.

3. The Ballard score as assigned by nurses at time of delivery is an accurate estimation of gestational age.

CHAPTER II

Literature Review

Introduction

Several factors are presented in this section that are important considerations when performing a physiologic study on methods of temperature measurement in the neonate. The importance of maintaining a "normal" body temperature is discussed, as well as variables influencing temperature maintenance. A review of classic and current literature is presented that details various conclusions regarding measurement in the adult, pediatric, and infant populations.

Cold Stress

It is generally accepted that newborn infants should be cared for in a neutral thermal environment--the environment in which oxygen consumption and metabolic rates are at a minimum (Sauer, Dane, & Visser, 1984). As early as 1900, the effects of extreme body temperature fluctuations on newborn infants were described. Studies by Budin (1900) indicated that suboptimal temperatures led to increased morbidity and mortality in low birthweight infants. Following this discovery researchers began to investigate the physiologic effects of abnormal body temperature on the newborn, as well as methods to determine and control abnormal body temperature.

The survival rates, morbidity, and mortality associated with extremes in body temperature have been investigated. In an early study, Silverman et al. (1958) placed 91 infants under 3 days of age in isolettes with environmental temperature maintained at 31.7°C. These infants were paired with 91 infants placed in isolettes with environmental temperature maintained at 28.9°C. Infants were kept under these conditions until they were 5 days of age, at which time they were placed in a neutral thermal environment. Infants were categorized based on weight. Eighty-four infants weighed more than 1500 grams, 70 infants weighed 1000-1500 grams, and 28 infants weighed less than 1000 grams. Axillary temperatures were measured every 6 hours. Survival rate of infants cared for in isolettes maintained at 31.7°C was 93% (N = 38) for those weighing more than 1500 grams, 86% (N = 30) for those weighing 1000-1500 grams, and 50% (N = 7) for those weighing less than 1000 grams. Survival rates for infants cared for in isolettes with environmental temperatures maintained at 28.9°C was 79% (N = 33) for infants greater than 1500 grams, 77% (N = 27) for infants 1000-1500 grams, and 14% (N = 2) for infants less than 1000 grams. Fifteen (16%) of the infants in the normothermic group (environmental temperature 31.7°C) died prior to completion of the study, compared to 29 (32%) of the infants in the hypothermic group (environmental temperature 28.9°C). Warmth alone was felt to have tripled the chances of survival

for the very small babies (Silverman, Fertig, & Berger, 1958).

Physiologic responses to suboptimal temperature in the neonate are referred to as consequences of "cold stress." Responses originally described as "neonatal cold injury syndrome" by Elliott and Mann (1957) refer to suboptimal temperature ("cold") and to the demands imposed on the body ("stress") (Mann & Elliott, 1957; Dodman, 1987).

Several studies have identified physiologic responses to hypothermia in the neonate. Grausz (1968) noted an association between metabolic demand and increased oxygen consumption and the development of metabolic acidosis in hypothermic infants. Chessels & Wigglesworth (1970) found hypothermia to be associated with the development of disseminated intravascular coagulation. Increased incidence of apnea (Daily, Klaus, & Meyer, 1969) as well as increased incidence of respiratory distress due to pulmonary vasoconstriction have been documented (Nalepka, 1976). Mann & Elliott (1957) found that hypoglycemia occurred more frequently in infants with abnormal body temperatures. Temperature has also been shown to influence growth and fat accumulation (Glass, Silverman, & Sinclair, 1968; Heimler, Sumners, Grausz, Kien, & Glaspey, 1981).

Variables Influencing Temperature Maintenance

Gestational Age

Temperature maintenance was an important consideration in this study. Conduction, convection, radiation, and evaporation are four routes of heat loss from the body (Nalepka, 1976). The ability of an infant to reduce heat loss from these various routes is determined by factors related to health and gestational age as well as environmental controls such as supplemental heat sources.

Decreased gestational age contributes to heat loss primarily in the form of evaporative loss. The increased body surface area in proportion to weight leads to a greater evaporative loss in preterm infants. In contrast to the full term infant or adult, the preterm infant is deficient in the development of superficial skin layers, primarily the stratum corneum, increasing the likelihood of evaporation. The amount of keratin which assists in temperature maintenance is also decreased in the preterm infant (Evans & Rutter, 1986; Doyle & Sinclair, 1982; Hull, 1988; Sedin, Hammarlund, & Stromberg, 1983).

Evaporative water loss has been shown to be directly related to the degree of heat loss from the skin (Hammarlund, Sedin, & Stromberg, 1983; Harpin, Chellappah, & Rutter, 1983; Maurer, Micheli, Shultz, Freymond, & Jequier, 1984). The preterm newborn has little or no subcutaneous fat for

insulation. Muscle mass is small and blood vessels are close to the skin surface, increasing potential heat loss in these small infants (Nalepka, 1976).

Baumgart (1984) demonstrated the relationship between maturity and evaporative heat loss. Using techniques to simulate the effects of mature dermal layers in decreasing heat and water loss, eight very low birthweight infants with a mean birthweight of 1.1 kilograms, were fitted with a transparent saran plastic blanket as covering for the skin. Their metabolic rate, oxygen consumption, and degree of insensible water loss were measured and were decreased in comparison to a control group (Baumgart, 1985).

A second study measured the degree of water loss from the skin by applying a semipermeable polyurethane membrane directly to the skin of 10 preterm infants. The polyurethane membrane was to act as an artificial barrier to the environment. Water loss was measured prior to application, after application, and following removal of the artificial skin. Transepidermal water loss was measured over skin surfaces covered with the membrane and over adjacent naked skin. Results indicated that transepidermal water loss was significantly less (53-72%) in comparison to adjacent naked skin. After removal of the polyurethane membrane, transepidermal water loss immediately returned to amounts similar to adjacent naked skin areas (Knauth, Gordin, McNelis, & Baumgart, 1989).

Other factors influencing temperature maintenance include the presence of brown fat and hypothalmic function. Brown fat assists in the ability of an infant to maintain body temperature due to its capacity to release energy. The amount of brown fat has been shown to increase from 28 weeks gestation to term, a change which would make preterm infants at even greater risk for temperature fluctuations (Hull, 1966; Dawkins & Scopes, 1966). The hypothalamus is the regulatory control center for temperature maintenance. The role of the hypothalamus may be altered due to prematurity, medications, delivery trauma, or birth asphyxia (Bruck, 1978; Bruck & Schwennicke, 1971; Cooper, 1968; Day, 1943).

To determine if gestational age influences temperature stabilization times and correlation with other routes, Mayfield et al. (1984a) obtained axillary, rectal, core, and skin mattress temperatures in term and preterm infants. Subjects were 99 term and 44 preterm infants with mean gestational ages of 39.6 weeks in the term infants and 32.6 weeks in preterm infants. Stabilization times (intervals required for a temperature reading to remain unchanged for two consecutive minutes) were shorter in preterm infants than fullterm infants. Significantly lower temperatures were observed in preterm infants at all sites when compared to full term infants (mean 36.66-36.76 preterm, 36.82-37.04 term). Temperatures were more highly correlated in all sites of

preterm infants than of full term infants (Mayfield et al., 1984).

A group of 30 infants 37 weeks gestation or less participated in a study comparing axillary and rectal temperatures. A t-test was performed to determine if axillary temperatures were significantly different than rectal temperatures. The mean difference was .18°F. This is statistically significant ($t = -2.17$, $p = .38$). Sixty percent of the infants had an axillary temperature that was higher than the rectal temperature. The difference between axillary and rectal temperatures ranged from -1.4°F to .8°F. Comparisons were made to determine whether the differences in temperature varied according to gestational age, weight, sex and race. No statistically significant variables were identified (Haddock et al., 1988).

Supplemental Heat Source

Supplemental heat source may influence temperature. Convectionally warmed isolettes and radiant warmers are the two heat sources most commonly used to assist infants with temperature maintenance. Mayfield et al. (1984a) studied agreement between axillary, rectal, core (deep rectal), and skin mattress temperature in 44 preterm and 99 full term infants. Sixty-six percent (N = 29) of preterm infants were in isolettes compared to 6% (N = 5) of term infants. Ninety-three percent of term infants and 10% of preterm infants were in open cribs and one term and five preterm infants were under

radiant warmers. Significant temperature differences were noted between term and preterm infants in all sites. Rectal, axillary, and skin mattress temperatures varied -.8 to 1.3°C from core temperatures in term infants and from -.4 to .7°C in preterm infants. This difference was attributed to the controlled environments of the preterm infants with 89% of preterm infants in either incubators or radiant warmers, compared to 6% of term infants in either incubators or radiant warmers.

Haddock et al. (1988) noted significantly higher axillary temperatures than rectal temperatures in infants cared for under radiant warmers (50%, N = 15). This difference was not noted in infants cared for in isolettes (47%, N = 14) (one in open crib).

Wheldon and Rutter (1982) studied the heat balance of 12 healthy preterm infants. Infants were studied first in an incubator and then under a radiant warmer. Environmental temperatures were preset in the incubators and radiant warmers. Infants' heat production and heat loss by radiation, convection, and evaporation were determined. Rectal and skin temperatures were obtained and were within normal limits in infants cared for in isolettes and under radiant warmers. Convective heat losses in the isolettes were low, and radiant heat losses were the greatest. Infants beneath the radiant warmer gained heat by radiation. Infants lost heat primarily by convection. Infants' metabolic heat production increased

slightly under the radiant warmer. Transepidural water loss was significantly higher under the radiant warmer. The most immature baby (28 weeks gestation) was excluded from these results. She could not be kept warm in the incubator regardless of high air temperatures because evaporative heat loss from the skin was so high. Evaporative heat loss exceeded metabolic heat production in both the isolette and radiant warmer in this small infant. However, a 13% increase in heat production was noted when the infant was placed under the radiant warmer (Wheldon & Rutter, 1982).

Baumgart (1985) studied mechanisms of heat loss and heat gain in infants cared for under radiant warmers. Ten preterm infants were nursed under radiant warmers to calculate convective and evaporative heat loss, metabolic rate, and radiant heat need. Infants were maintained under three different environmental temperature settings: 35.5°C, 36.5°C, 37.5°C. Convective heat loss increased significantly with increased environmental temperature. Evaporative heat loss also increased, but not significantly. Metabolic rate decreased insignificantly with increased temperature settings and radiant heat needed to maintain infants at higher temperatures increased significantly. Convective heat loss exceeded evaporative heat loss by 200% and was the major route of heat loss under the radiant warmer. Temperature did not significantly alter metabolic rate or evaporative water loss.

In addition to differences in insensible water loss between radiant warmers and isolettes (Bell, Weinstein, & William, 1980; Marks, Gunther, Ross, & Maisels, 1981), there are also differences in brands of radiant warmers and isolettes. Five preterm infants with birthweights less than 1000 grams were maintained in either "Ohio" or "Air Shields" isolettes on servocontrol settings. Infants maintained identical average rectal and skin temperatures regardless of isolette brand. However, infants cared for in the "Ohio" brand required lower air temperatures to maintain normal body temperature when compared to the "Air Shield" brand, which suggests that the "Ohio" brand conserves more heat. Infants in the "Ohio" brand also had a greater loss in total body heat and cooler extremities, suggesting that infants cared for in the "Ohio" brand experienced a greater total heat loss. Heat exchange in the "Ohio" isolette was felt to be similar to that of a radiant warmer, which is known for decreasing radiant heat loss and increasing convective and evaporative heat loss (Chessex, Blouet, & Vaucher, 1989). Variations were also noted in air flow mechanisms of isolettes (Okken, Blijham, Franz, and Bohn, 1982).

Methods of Temperature Measurement

In preparing for a study to determine the safest, most reliable indicator of temperature, research dealing with various methods of temperature measurement was reviewed. The

most traditional methods to assess temperature in infants are axillary and rectal temperature measurement. Other less popular methods include skin, inguinal, and tympanic measurement. Studies have noted discrepancies in the ability of these routes to correlate with the core (deep rectal) method, which is considered the "standard" most accurate measurement of body temperature other than measurement via the pulmonary artery (Mayfield et al., 1984a; Schiffman, 1981).

In most studies involving infants, the rectal temperature is used for comparison to other routes rather than actual core temperature measurement due to risks associated with true core measurement obtained by deep rectal insertion. Risks such as perforation are increased when obtaining a core temperature via the rectal route (Giuffre, Heidenreich, Carney-Gersten, Dorsch, & Heidenreich, 1990; Greenbaum, Carson, Kimcammon, & O'Laughlin, 1969). Risks also include stimulation of the colon and the defecation reflex, leading to loss of fluids and electrolytes, and death resulting from perforation with subsequent development of peritonitis and sepsis (Fonkalsrud & Clatworthy, 1965; Greenbaum et al., 1969; Horwitz & Bennett, 1976). The goal of temperature measurement should be to find the safest, most efficient, and reliable indicator of core temperature measurement. Controversy continues to exist concerning the best method, tool, and measurement technique.

Stabilization

The axillary temperature is most often recommended for use in the pediatric setting (American Academy of Pediatrics, 1971; Horwitz & Bennett, 1976). The amount of time required to obtain a stabilized axillary reading varies from study to study. One study failed to document stable axillary temperatures after a 10-minute period and 98% of these temperatures increased from the 7-minute reading to the 10-minute reading (Schiffman, 1981). A second study reported stabilization between 3.8 and 4.4 minutes (Mayfield et al., 1984). A third study documented stabilization times from 2 to 11 minutes with an average of 6 minutes (Haddock et al., 1988). Axillary temperatures were still unstable after 11 minutes in another study (Stephen & Sexton, 1987). These differences may be related to variations in subjects and controls. Term and preterm infants were included in one study and thermal support was either a radiant warmer or isolette (Mayfield et al., 1984). Term infants in isolettes were included in another study (Schiffman, 1987) and preterm infants in yet another study with 50% being under radiant warmers, and 50% in isolettes (Haddock et al., 1988).

Guidelines established by the American Academy of Pediatrics recommend a 5-minute time period for obtaining axillary temperature measurement. Because of the critical condition of some infants, this time frame may lead to untolerated stress. Because of this and because of research

discrepancies, efforts are underway to improve upon the existing methods and develop newer methods of obtaining temperatures in infants (American Academy of Pediatrics, 1971).

Conventional Temperature Measurement

In addition to stability issues, there are also differences in opinion concerning the accuracy of various measurement techniques in temperature measurement. Infants and children seen in a well baby clinic, an acute care clinic, and patients receiving services in the hospital were studied to determine differences in axillary and rectal temperatures. One hundred fourteen children from 2 weeks to 18 months of age from the well baby clinic, 155 patients from 2 weeks to 48 months of age from the acute care clinic, and 42 children from 1 to 48 months of age from inpatient services participated. Temperatures were taken with digital thermometers calibrated to be within .1°C of the National Bureau of Standards thermometer. Temperatures were recorded four times over a 16-hour time frame. The mean difference in axillary and rectal temperatures was .8° to 1.°C. Axillary temperatures were .4°C higher to 2.0°C lower than rectal temperatures. The ability to identify fever by the axillary route was also explored. Rectal temperatures were determined in infants with axillary temperatures $\geq$ 37°C. Based on these findings, researchers estimate that seven out of every ten

infants with axillary temperatures ≥37°C would have a rectal temperature ≥ 38°C. Researchers concluded the axillary route was neither appropriate for predicting rectal temperature due to documented temperature difference or for detecting fever. The use of the axillary method for routine screening of temperatures in infants was discouraged (Weiss & Reagen, 1991).

The accuracy of axillary temperature measurement was compared to either oral or rectal temperature measurement in a study of 156 children 14 years of age or less. All temperatures were obtained with an electronic thermometer. Oral or rectal routes were assigned based on age and degree of cooperation. Correlations were performed on febrile and non-febrile children. Correlation for afebrile children was .74 for the oral and axillary routes and .70 for the rectal and axillary routes. Correlation for febrile children was .77 for the oral and axillary routes, and .68 for the rectal and axillary routes. Fifteen of the 32 children labeled febrile by the oral route were correctly identified by the axillary route. Seventeen of the 37 children labeled febrile by the rectal route were identified correctly by the axillary route.. It was concluded that axillary temperature was too insensitive to identify fever when taken with an electronic thermometer and should not be used in the clinical setting (Ogren, 1990).

Temperatures were taken on 281 infants at home and 656 infants in the hospital. All were under 6 months of age.

Temperatures were obtained using mercury-in-glass thermometers via the axillary and rectal routes. Rectal thermometers were left in place at least 1 minute or until the mercury stopped rising. Axillary thermometers were kept in place a minimum of 3 minutes or until the mercury stopped rising. The mean difference between axillary and rectal temperatures was .8°C for temperatures obtained at home, and .6°C for temperatures obtained at the hospital. Correlation of both data sets combined was .7°C. Rectal temperature was higher than axillary temperature in 98% of the measurements. Of the temperatures obtained at home, eight infants were febrile. Only two (25%) of the febrile infants were detected by the axillary method. Of the temperatures obtained in the hospital, 93 were febrile via the rectal route but only 68 infants (73%) were detected by the axillary route. Authors concluded that axillary temperature was too insensitive a predictor of body temperature to be used in a hospital setting (Morley, Hewson, Thornton, & Cole, 1992).

Mayfield et al. (1984a) compared the differences in axillary, rectal, and skin mattress temperatures to deep rectal temperatures in order to determine the ability of these routes to predict normal, hypothermic and hyperthermic conditions in infants (Mayfield et al., 1984). Ninety-nine term and 44 preterm infants participated in this study. Supplemental heat sources were recorded for comparison purposes. Ninety-four percent of term infants were in open cribs and 66% of preterm

infants were in isolettes. Significant temperature differences were noted between term and preterm infants in all sites except the skin mattress site. Stabilization times were reached quicker in preterm infants. The differences between core temperatures and temperatures obtained in the other sites ranged from .3°C to 1.3°C in term infants and .4 to .7°C in preterm infants. These differences were believed to be related to differences in supplemental heat sources. The ability to identify normal, hypothermic, and hyperthermic temperature via the rectal, axillary and skin mattress routes was determined by comparing each of these routes to the deep rectal or core temperature. More errors in measurement were noted in term infants than in preterm infants. Each method equally identified fever in the preterm infant. This study concluded that axillary and rectal temperatures were a suitable substitute for core temperature measurement in infants (Mayfield et al., 1984).

Axillary and rectal temperatures were compared to determine correlation between the two routes in order to determine accuracy of the axillary method. Subjects were 25 infants from 28-36 weeks gestation cared for under radiant warmers. Temperatures were taken simultaneously and recorded 12 times over a 2-day period at 3, 5, 8 and 10-minute intervals. Correlation between axillary and rectal routes was 0.66, 0.69, 0.71, and 0.71 for the 3, 5, 8, and 10-minute measurement times respectively. A *t*-test was used to

determine the degree of discrepancy in the axillary and rectal routes. No statistically significant differences were noted. Axillary temperatures were slightly higher than rectal temperatures at each time interval (mean discrepancy .02 to .04°C) (Moen, Chapman, Sheehan, & Carter, 1987).

Haddock et al. (1988) compared rectal and axillary temperatures of 30 preterm infants who were less than 37 weeks gestation. These subjects were in the intensive and intermediate care nurseries and weighed 900 to 2060 grams. Fifty percent of the infants were cared for beneath radiant warmers, 47% in isolettes, and one infant was in an open crib. Axillary temperature readings were taken every minute for 12 minutes. Rectal readings were taken every minute for 6 minutes. Axillary readings were found to be higher than rectal readings in 60% of the infants. Sixty-seven percent of these infants had axillary temperatures .2°F to .4°F higher than the rectal temperature. One infant had an axillary temperature 1.4°F higher than the rectal temperature. Thirteen percent of the infants had identical rectal and axillary readings. Axillary temperatures were statistically higher than rectal temperatures in infants cared for under radiant warmers. No significant differences were found between axillary and rectal temperatures in infants cared for in isolettes. No significant relationships were found between gestational age, weight, race, or sex, and differences in axillary and rectal temperatures. Female

infants required a longer amount of time to reach stabilized rectal temperatures than did male infants (Haddock et al., 1988).

A study compared axillary and rectal temperature measurements in 46 full term infants who were between 38 and 42 weeks gestation. The sample consisted of 21 male and 25 female infants. Temperature measurements were obtained simultaneously in both routes and were recorded at intervals of 1, 2, 3, 4, 5, 7, and 10 minutes. Significant differences were observed in the axillary and rectal temperatures at each time interval (range of difference .23 to .77°F), which indicated that axillary temperature did not accurately reflect rectal temperature. Rectal-axillary correlation was performed for each time interval. A strong positive correlation between the rectal and axillary routes was found at each interval (correlation range from 1-10 minutes were r = .76 to .92) indicating a relationship does exist between rectal and axillary temperatures. Although strong correlations were obtained, because of the range of differences between axillary and rectal temperatures, it was concluded that axillary temperature may not be a sufficiently accurate substitute for the rectal method in the clinical setting, despite the strong correlation factor (Schiffman, 1981).

In another study, axillary and rectal temperatures were compared in 30 full term infants using a mercury in glass

thermometer. Measurements were taken every 5 minutes. Thermometers were kept in place for 5 minutes in each site. The range of temperatures was from 96.0 to 99.4 axillary, and from 97.2 to 99.8 rectally. Correlation between the two routes was .92 which indicates that the axillary temperature can most likely be substituted for the rectal temperature with confidence (Eoff, Meler, & Miller, 1974).

Tympanic Temperature Measurement

Tympanic temperature measurement is the newest method for assessing temperature. Investigations of tympanic temperature measurement began in the 1960s. The tympanic membrane is supplied by the internal carotid artery. This artery also supplies the central receptors of the hypothalamus and may influence thermal control directly through sensory receptors. Changes in body heat were shown to induce similar changes in temperature measured directly at the tympanic membrane (Benzinger, 1969). Complications of direct tympanic measurement at the tympanic membrane include membrane rupture, infection, and pain. For these reasons instruments have been developed to indirectly sense tympanic membrane temperature by the placement of a probe in the external auditory canal that contains infrared sensors (Rogers, Curley, Driscoll, Kerrigan, LeBlanc, Libman, & McCarty, 1991).

Studies of tympanic measurement are well documented in the adult and pediatric populations and to a smaller degree in infants. Cooper, Cranston and Snell (1964) obtained oral, rectal, and tympanic temperatures on 16 adult subjects. By using repeated measures, a total of 154 sets of temperatures were obtained. Correlation ($r = .91$) revealed tympanic temperature was an accurate reflection of sublingual temperature and was not associated with the danger and discomfort of direct membrane measurement. Rectal temperature correlations with the tympanic method were also performed but results were not reported.

The accuracy of tympanic temperatures was investigated in adult cardiac surgery patients in the intensive care unit following open heart surgery. Temperatures were measured at the right and left tympanic membrane, the pulmonary artery, and the rectum. All three sites were found to be accurate measures of temperature with the standard deviation not exceeding .13°C. This study concluded that the tympanic method was a reliable method of measurement in this adult population (Shinozaki, Deane, & Perkins, 1988)

Tympanic measurement was compared to pulmonary artery and rectal measurements in adult ICU patients. Nine patients participated in the study and multiple measurements were obtained (number not given). Pulmonary artery catheter (PAC) measures were correlated with either the rectal or tympanic route. The study noted no statistically significant

variations between mean PAC, tympanic membrane, and rectal temperatures (Milewski, Ferguson, & Terndrup, 1991).

Tympanic temperature measurement has been studied often in the pediatric population. Tympanic measurement was compared to rectal and oral temperatures in children from 1 month of age through 10 years. The majority (88.5%) of the rectal and oral temperatures were higher than that of the tympanic temperatures. Rectal temperatures averaged .76°C higher than tympanic with a difference of 1°C or more in 34% of subjects. The mean difference between oral and tympanic temperatures was .53°C. Ten of 35 subjects with elevated rectal or oral temperatures from 38°C to 39°C were correctly identified by the tympanic method. None of the patients with either rectal or axillary temperatures of 39°C or more were identified as being febrile by the tympanic route. This study concluded that the correlations between the tympanic and rectal route ($r = .77$), and tympanic and oral route ($r = .75$) were not high enough to infer a fixed standard correction factor. The authors concluded that the tympanic method was unsatisfactory in detecting clinically significant temperatures (Rhoads, Bchir, & Grandner, 1987).

Tympanic temperature measurement was performed on 964 pediatric clinic patients from birth to 10 years of age. Children under 48 months of age had rectal temperatures measured with glass and mercury thermometer compared to tympanic temperature measurement, and children over 48 months

had oral temperatures measured with glass and mercury thermometers compared to tympanic temperature measurement. All participants had tympanic membrane temperatures measured with noncontact infrared tympanic membrane thermometers. Patients were divided into subgroups according to age, temperature, and presence or absence of otitis media to determine the influence of these factors on tympanic temperature measurement. Fifty percent were between 4 and 48 months of age, 32% older than 48 months of age, and 18% less than 3 months of age; 77% had normal bilateral tympanic membranes. Tympanic membrane measurements were reproducible with a mean difference of .01°C ± .02°C between right and left measurements. Unilateral otitis media, present in 3% of infants, did not affect agreement. For all patients and sites, the mean difference in temperature between tympanic and glass and mercury measurement was .06°C ± .03°C. There were no statistically significant differences noted among age groups in febrile or afebrile states. The ability of the tympanic thermometer to correctly identify febrile states when compared to glass and mercury reading was 75%. Researchers concluded the tympanic method was a sufficiently accurate method for assessing temperature in this group of pediatric patients. In addition the staff was satisfied with the speed of temperature measurement and it was accepted with enthusiasm by the patient and parent (Kenny, Fortenberry, Surratt, et al., 1990).

Temperature measurements were obtained on 184 pediatric patients from 6 days to 17 years of age. Tympanic measurements were compared to either oral or rectal measurements depending on the age and cooperation of the child. Rectal temperatures were recorded using a mercury in glass thermometer in 100 subjects. Oral temperatures were recorded in 84 subjects using a mercury in glass thermometer. Six tympanic temperature measurements were recorded on each subject using both the right and left ear. Correlations of repeated tympanic measures with either the rectal or oral route ranged from .82 to .93 in children greater than 3 months of age. Range of correlation for infants less than or equal to 3 months was r = .58 to .79. The number of children in each age category was not specified. This study concluded that the tympanic thermometer correlated well with oral and rectal reading, except in infants less than 3 months of age. The tympanic method accurately detected fever in 90% of cases (Chamberlain, Grandner, Rubinoff, Klein, Waisman, & Huey, 1991).

A total of 144 patients from 2 months to 18 years of age participated in a study comparing tympanic measurements to oral, rectal, or axillary depending on age and activity level of the child. Oral temperatures were obtained in 82 patients (57%), rectal in 35 (24%), and axillary in 27 (19%) for comparison with tympanic temperatures. Mean differences between each route and the tympanic method were determined.

The rectal temperature had the greatest mean difference and was on an average .48°C higher than the tympanic. The oral route had a mean difference of -.06 and the axillary a mean difference of .18. The range of differences from tympanic measurement in degrees Celsius was -.19 to .79 for the oral route, -1.33 to .36 for the rectal route, and -.94 to 1.29 for the axillary route. Analyses was performed to determine if age or presence of otitis media influenced temperature difference. There were no statistically significant findings. The author concluded the tympanic device was unreliable when compared to conventional methods of temperature measurement (Freed & Fraley, 1992).

Terndrup and Milewski (1991) compared readings of two tympanic thermometers to an electronic rectal thermometer. Three hundred three (303) children under 16 years of age were included in the study. The mean age of participants was 1.6 ± .9 years. The mean rectal temperature (38.0°C ±.05°) was significantly greater than the mean "First Temp" tympanic reading (37.6 ± .05) but was not significantly different from the "Thermoscan" tympanic reading (38.0°C ± .05°). Overall correlation of rectal temperature and "First Temp" (r = .69) and Thermoscan (r = .70) was good with no significant differences noted. Correlations were also performed on infants less than 2 months of age (N = 31). Correlations were .69 and .62 for "First Temp" and Thermoscan respectively. Conclusion was that tympanic membrane

temperatures are usually reliable, but should be tested further prior to use in critical care settings.

Children less than 3 years of age who presented to an emergency department participated in a study to compare correlation of axillary and tympanic membrane measurements to rectal temperature measurement. Two hundred twenty-four patients participated; 87 (39%) were febrile. Tympanic measures were obtained by a non-contact infrared sensing device that was gently inserted into the external ear canal. Axillary and rectal measurements were obtained using an electronic thermistor probe. Both measuring devices were calibrated several times, both before and during data collection, to ensure accuracy. Presence of otitis media and membrane perforation were recorded. Correlation with the rectal method was .75 for the axillary route, and .81 for the tympanic route. Otitis media did not influence tympanic temperature readings. Fever was predicted accurately in 48% of patients via the axillary route and in 55% of the patients via the tympanic route. These results indicated that neither the axillary nor the tympanic methods of temperature measurement were significantly accurate for use in the clinical setting (Muma, Treloar, Wurmlinger, Peterson, & Vitae, 1991).

Tympanic membrane temperatures were compared to electronic temperatures obtained via the rectal, oral and axillary routes. Subjects consisted of 108 pediatric

patients 1 month to 16 years of age. A total of 295 observations were recorded. Electronic readings differed from tympanic readings by an average of .2-.5 degrees Celsius. Correlations were significant (rectal-tympanic r = .58, oral-tympanic r = .52, and axillary-tympanic r = .41) but of low to moderate strength. The tympanic reading was closer to the electronic rectal reading than to axillary or oral. Results indicated that correlations of the tympanic thermometer with the electronic thermometer were not strong enough to encourage its use in the clinical setting (Rogers et al., 1991).

In a pediatric outpatient setting Ros (1989) compared tympanic membrane temperatures to rectal and oral temperatures. One hundred two patients participated in the study. Poor correlation was found with the tympanic method between both conventional methods (r = .76). Age was not a significant factor affecting correlation. Ros discouraged the use of the tympanic thermometer as a substitute for glass and mercury thermometer in the pediatric setting (Ros, 1989).

Infants and preschoolers participated in a study to determine the correlation between rectal temperatures obtained using an electronic digital thermometer and a tympanic thermometer. Participants were 3 weeks to 5 years of age with an average age of 11.9 months. Measurements were obtained sequentially and revealed highly significant correlations for total group temperatures taken with the

tympanic thermometer and temperatures taken with the rectal thermometer (r = .93). The correlation coefficient for patients less than 3 months old was significantly weaker (r = .64, N = 8) in comparison to the total group and in comparison to infants 4-12 months of age (r = .93, N = 46) and infants greater than 12 months of age (r = .95, N = 25). Febrile patients with documented temperature via the rectal route were identified, correctly in 96.8% of the cases for the total group. For patients greater than 3 months of age, fever was identified correctly in 100% of febrile patients. This study indicated the tympanic thermometer was a reliable instrument for use in pediatric populations greater than 3 months of age. Results were inconclusive for infants less than 3 months of age (Stewart & Webster, 1992).

Patients at the Cleveland Clinic Foundation participated in a study comparing tympanic membrane temperatures to rectal and oral temperatures obtained using an electronic thermometer. Rectal and tympanic temperatures were compared in a group of 43 children up to 5 years of age. Oral and tympanic comparisons were performed on 94 children age 3 to 18 years. A strong correlation was noted between the tympanic method and both the oral (r = .68) and rectal (r = .77) routes, indicating the tympanic method may be a reasonable tool for measuring temperature (Talo, Macknin, & Vanderbrug, 1991).

Studies to evaluate the accuracy of the tympanic thermometer in the newborn and premature infant are limited. Core temperature, measured five centimeters beyond the anus and tympanic measures were compared in a group of 24 preterm and 70 term infants. Ninety-four percent of term infants were in open cribs, and 66% of preterms were in isolettes. One term infant and five preterm infants were under radiant warmers. A significant correlation was found between core and tympanic measures in both term ($r = .84$) and preterm infants ($r = .87$). Mean core and tympanic membrane temperatures in term infants were 37.01°C and 36.83°C respectively. Mean core and tympanic temperatures in preterm infants were both 36.69°C. The results of this study indicate that the tympanic temperature is a reliable indicator of core temperature in both term and preterm infants (Mayfield et al., 1984b).

Measurements were performed on 22 full-term and 12 preterm infants to determine accuracy of a tympanic device in comparison to a digital axillary reading. Two sets of correlations were determined on both term and preterm infants. First correlations were determined between the axillary reading and a left and right tympanic reading in both term and preterm infants. Temperature measurements were obtained a second time in each of these routes and correlations determined once again for term and preterm infants. In full term infants, small but significant

differences were noted between the right tympanic and axillary routes. The average tympanic reading was .15°C higher than the axillary reading. In the preterm group, both the first and second right tympanic temperature measurements were significantly higher than the axillary temperature measurement with a mean difference of .19°C to .22°C. Correlations of the axillary temperature to the right and left tympanic temperature for both data sets range from .45 to .68 for full term infants and .43 to .62 for preterm infants. A small but significant difference was noted between right tympanic and axillary temperature in full term infants. The right tympanic was higher than the axillary temperature by a mean of .15°C. Axillary and tympanic temperatures were moderately correlated in both full-term and preterm infants. Findings suggest that the tympanic route is probably as accurate an indicator of body temperature as is the axillary method (Weiss, 1991).

Inguinal Temperature Measurement

Another non-traditional site for temperature measurement currently being investigated in infants is the inguinal site. Increased amounts of brown adipose tissue pockets found in the axilla may increase local temperature, making the axillary temperature erroneously high. Because the inguinal area is virtually free from these influences, this site may be an ideal alternative. This notion was explored in a study

of 62 female and 58 male infants weighing 2570-4900 grams. Infants were under radiant warmers at a preset temperature during this study. Sequence of thermometer placement was determined by drawing from random numbers and thermometers were kept in place until temperatures stabilized for a 90 second period. The mean difference between axillary and inguinal temperature was .6°F, between rectal and inguinal .8°F, and between rectal and axillary .2°F. The largest difference was recorded between mean temperature at the rectal and inguinal sites although these two sites also had the highest correlation of .91. It was concluded that the inguinal site may be more representative of rectal temperature and less influenced by local effects of brown fat (Bliss-Holtz, 1989).

Summary

The literature review noted discrepancies in correlations, stabilization times, and mean temperature differences. Because of these variations in temperature readings from site-to-site, further research is necessary to confirm the safest and most accurate method for use in clinical practice.

All studies support the rectal route of temperature measurement by the glass and mercury method in the neonate as being most accurate. Support for the use of the axillary route for temperature measurement in infants was equally

divided. Researchers who were not in favor of the axillary route as an alternative route of rectal temperature measurement in the neonate cited poor correlations, inability to predict fever, and discrepancies when compared to the rectal route (Morley et al., 1992; Ogren, 1990; Schiffman, 1982; Weiss & Reagen, 1991). Other researchers noted strong correlation, minimal differences, and sufficient accuracy with the axillary method (Eoff, 1974; Haddock et al., 1986; Mayfield et al., 1984a; Moen et al., 1987). Tympanic measurement in newborns is limited. Two sources found the tympanic temperature to be highly correlated with the deep rectal route (Mayfield, 1984b) and the axillary route (Weiss & Reagen, 1991).

CHAPTER III

Methodology

Research Design

This study used a descriptive design involving 62 preterm infants. Correlations of rectal temperature measurement with axillary, inguinal, and tympanic temperature were determined. Axillary, rectal, and inguinal temperatures were obtained with a glass and mercury thermometer. Tympanic temperatures were determined with an electronic sensing probe. Each instrument recorded temperature readings on a scale which assigned numerical values to temperatures. This chapter describes criteria for sample selections, subject characteristics, instrumentation, and methods for data analysis.

Operational Definitions

For the purpose of this study the following terms were used:

1. Gestational age: Gestational age as determined by the Ballard score with a possible range from 24-42 weeks gestation.

2. Rectal temperature: Temperature in degrees Fahrenheit as determined by inserting a glass and mercury thermometer a

maximum distance of 1 1/2 centimeters into the rectum until stabilization was obtained for two consecutive minutes.

3. Axillary temperature: Temperature in degrees Fahrenheit as determined by inserting the ball of a glass and mercury thermometer into the axilla adducting the arm until stabilization was obtained for two consecutive minutes.

4. Inguinal temperature: Temperature in degrees Fahrenheit as determined by inserting the ball of a glass and mercury thermometer into the skin fold at the site of the femoral pulse and adducting the leg until stabilization of temperature was obtained for two consecutive minutes.

5. Tympanic temperature: Temperature in degrees Fahrenheit as determined by covering the external auditory opening with the probe of an electronic tympanic thermometer until a signal (beep) was given which signaled temperature was ready to be recorded.

6. Weight: Gram weight of infant on the day of study obtained by an electronic digital scale with the infant fully unclothed.

7. Stabilization Time: The amount of time in minutes required to obtain two unchanged temperature measurements.

Subjects

Subjects were obtained from the intermediate and intensive care nurseries at a Northeast Tennessee community hospital which houses a 20-bed neonatal intensive/

intermediate care nursery. Infants participating in this study were divided into four gestational age groups for comparison purposes; 24-27 weeks gestation, 28-31 weeks gestation, 32-35 weeks gestation and 36-42 weeks gestation.

Parents of all infants who were admitted to the nursery during the course of data collection were asked for permission to include their infant in the study. Sixty-two infants participated. Fewer than 10 parents declined.

The criteria for exclusion from the study included history of rectal fissures or bleeding, necrotizing entercolitis, and/or oxygen saturations less than 85% if receiving oxygen therapy. Also, infants greater than seven days of age were excluded. Infants were eligible to participate in the study only if they were under a radiant warmer on servo-control setting.

Tables I, II and III show the characteristics of subjects including oxygen source, gender, and gram weights, and age in days. Note that 100% of the very small babies were on ventilator support compared to 19% of the full term babies (36-42 weeks). Gender was approximately equal between all gestational age groups. Fifty percent of infants included in the study were less than 2 days of age in all gestational age categories. The remainder were between 3 and 7 days of age.

Table I

Subject Characteristics

Descriptors	N/%
Group I 24-27 Week Gestation	
Gender	
Male	5(50%)
Female	5(50%)
O_2 Source	
Roomair	--
Ventilator	10(100%)
Oxyhood	--
Nasal Cannula	--
Group II 28-31 Weeks Gestation	
Gender	
Male	6(54.5%)
Female	5(45.5%)
O_2 Source	
Roomair	2(18.2%)
Ventilator	6(54.5%)
Oxyhood	3(27.3%)
Nasal Cannula	--
Group III 32-35 Weeks Gestation	
Gender	
Male	11(55%)
Female	9(45%)
O_2 Source	
Roomair	12(60%)
Ventilator	5(25%)
Oxyhood	2(10%)
Nasal Cannula	1(5%)

Table I (Continued)

Descriptors	N/%
Group IV 36-42 Weeks Gestation	
Gender	
Male	11(52.4%)
Female	10(47.6%)
O_2 Source	
Roomair	14(66.7%)
Ventilator	4 (19%)
Oxyhood	2 (9.3%)
Nasal Cannula	1 (4.8%)

Table II

Birthweight and Weight at Time of Study in Grams

Group 1		X	S.D.	Min.	Max
N = 10	Birthwt	792.1	217.7	478	1159
	Studywt	776.9	238.4	420	1159
Group 2					
N = 11	Birthwt	1285.4	216.5	1060	1562
	Studywt	1273.6	240.6	1015	1562
Group 3					
N = 19	Birthwt	2016.6	474.9	1489	3225
	Studywt	1961.5	477.5	1489	3225
Group 4					
N = 21	Birthwt	2816.9	653.3	1596	4048
	Studywt	2780.7	672.2	1596	4048
Total Group					
N = 62	Birthwt	1959.5	890.8	478	4048
	Studywt	1925.9	884.4	420	4048

Table III

Age in Days by Gestational Group

	24-27 Wks Gestation		28-31 Wks Gestation		32-35 Wks Gestation		36-44 Wks Gestation	
	N	%	N	%	N	%	N	%
<1	2	(20)	1	(9.1)	5	(25)	3	(14.3)
>1 <2	3	(30)	5	(45.5)	10	(50)	10	(47.6)
>2 <3	1	(10)	3	(27.3)	2	(10)	7	(33.3)
>3	4	(40)	2	(18.2)	3	(15)	1	(4.8)

Instrumentation

The glass and mercury thermometer, which is widely recognized as a reliable instrument for measuring temperature, was chosen for assessment of rectal, inguinal, and axillary temperature in this study. Temperature measurement with this instrument has also been endorsed by the American Academy of Pediatrics (American Academy of Pediatrics, 1971). Original studies confirming accuracy of this instrument compared glass and mercury temperature readings to temperature readings obtained at the pulmonary artery via direct catheter insertion following open heart surgery. Glass and mercury thermometers were found to be accurate (Mather et al., 1958). Numerical values for temperature measurement with the glass and mercury

thermometer were read directly from the mercury level and recorded.

A tympanic thermometer with an infrared sensing device was used to obtain tympanic temperatures. This instrument has been shown to be accurate in adult and pediatric populations in numerous trials, but the ability of this tool to accurately measure temperature in infants, particularly preterm infants, is not well documented. The Genius thermometer was used in this study.

Accuracy

Accuracy of the glass and mercury thermometers was established prior to beginning of data collection and after each set of 20 temperature measures. Thermometers were inserted into a warm water bath maintained at 37° Celsius and readings were compared to readings obtained on a National Standard Thermometer. Thermometers with temperature variations greater than .2°F from the National Standard Thermometer were not used in the study.

To ensure accuracy, the tympanic measurement device (the Genius) was calibrated according to manufacturer recommendations. Calibration was performed routinely by the bio-medical engineering department of the hospital by placing the probe of the tympanic thermometer into a simulated canal embedded in an electrical appliance supplied by the manufacturer. Two separate "canals" emit infrared energy to

a "high" set point of 102.2°F and a "low" set point of 98.3oF. If the thermometer varies ± .2°F, adjustments are made on the tympanic thermometer to establish the same reading as the calibrator thermometer, and are then re-checked to establish accuracy. The calibrator is serviced annually by the manufacturer.

Procedure

For this study, infants were selected according to variables specified. Written consent was obtained from at least one parent or guardian. Each infant was assigned a code number for analysis purposes and to ensure anonymity of participants. Demographic data were obtained from the chart. Glass and mercury thermometers were prepped as specified to ensure reliability and were shaken down to 94°F. Simultaneous temperatures were taken at three sites--the axillary, rectal, and inguinal--and then tympanic temperatures were immediately obtained and recorded. Two nurses, who were instructed on placement technique and procedure, assisted with temperature measurement. Axillary temperatures were obtained by placing a glass and mercury thermometer in the mid axillary line with the bulb of the thermometer positioned in the axilla. The arm was held against the side of the body while the temperature was being taken and readings were taken every minute until temperature stabilized for two readings. Inguinal temperature was

obtained at the femoral pulse by placing the bulb of the thermometer in the femoral fold and adducting the leg so that the bulb was covered.

Rectal temperatures were obtained by first marking the thermometer with a non-toxic pencil at 1.5 centimeters from the bulb so that each thermometer was inserted a maximum of 1.5 centimeters into the rectum. The bulb was then lubricated with lubrifax and was inserted a maximum of 1.5 centimeters into the rectum and readings recorded every minute until a two-minute stabilization period was reached. Tympanic temperatures were taken by placing an infrared sensing device over the external auditory opening and pressing a scan button which "beeped" when the tympanic reading was ready to be recorded.

Temperatures were obtained during a scheduled assessment period and were done prior to bathing or feeding. Infants under radiant warmers were clothed in a diaper only. Temperatures were obtained no sooner than four hours after birth as reflected in the chart.

Data Analysis

Data obtained from the subjects were analyzed using the Pearson r, ANOVA, and least significant difference methods. The Pearson product moment correlation was used to compare correlation coefficients for total and individual groups. An alpha level of .05 was used to reduce the probability of a

type one error. Site to site temperature correlations were performed on all infants as a group and on all infants in each gestational age group to determine if correlations varied with gestational age.

In order to compare temperature means from various gestational ages, analysis of variance was used. The subjects were divided into four groups based on gestational age and the mean temperature for each route was recorded and compared to the means for the other gestational groups through analysis of variance. Least significant difference analysis was used to determine group differences. A two-way ANOVA was used to determine if gender influenced temperature differences between groups.

CHAPTER IV

Results

This study investigated various routes of temperature measurement in term and preterm infants. The axillary, inguinal, and tympanic temperatures were compared to rectal temperatures in order to determine if the temperatures obtained via these routes were sufficiently accurate to use in the clinical setting.

Temperatures were obtained simultaneously in all sites. The reading used for comparison was the "stabilized" temperature, defined as a temperature unchanged for two consecutive minutes. In some instances, drops in oxygen saturation mandated that measurements be discontinued before stabilization was reached in all sties. In those cases only the sites reaching stabilization were used for analysis.

This study attempts to answer three questions. The following paragraphs, figure, and tables summarize the results related to each question.

Question 1: What are the correlations of axillary, inguinal, and tympanic temperature to rectal temperatures and do the correlations vary with gestational age? Pearson r (correlation coefficient) was used to determine the strength of correlation between temperatures obtained via the rectal route and other routes. (See Table IV.) For infants of 24-27 weeks gestation, there was no significant correlation

Table IV

Correlation Matrix of Study Variables

	Axillary r (n)	Inguinal r (n)	Tympanic r (n)
24-27 weeks rectal	.18 (7)	.21 (6)	.19 (8)
28-31 weeks rectal	.40 (9)	.29 (9)	.37 (10)
32-35 weeks rectal	.62^ (19)	.72^ (19)	.26 (19)
36-42 weeks rectal	.63^ (20)	.46* (20)	.47* (21)
Total group rectal	.55^ (55)	.50^ (54)	.25* (58)

* $p<.05$
^ $p<.01$

between the rectal route and other routes, indicating little agreement between the rectal temperatures and temperatures taken at other sites. The strength of correlation increased overall as gestational ages increased. For the total group the axillary route was most strongly correlated with the rectal route (r = .55). The inguinal route (r = .50) was next.

Question 2: What are the differences between the rectal temperature readings and the axillary, inguinal, and tympanic readings in infants of different gestational age groups? Mean temperatures at each site were calculated for

gestational age groups and are presented in Table V. All stabilized temperatures in each gestational age group were included in this calculation. Mean rectal temperatures were then compared to mean axillary, inguinal, and tympanic temperatures. As noted in Figure 1, rectal temperatures differed from other temperatures most strikingly in the infants of 24-27 weeks gestation. As a whole, mean differences were less in more mature infants with tympanic differences decreasing in a step-wise progression from 24-27 weeks to 36-42 weeks. Temperatures reaching stabilization

Table V

Temperatures at Various Sites

		Axillary	Inguinal	Tympanic	Rectal
24-27 wks	mean	98.37	98.23	99.58	97.65
	SD	.48	.29	.90	.87
28-31 wks	mean	98.06	97.76	99.65	97.97
	SD	(.64)	.51	.87	(.77)
32-35 wks	mean	98.43	98.34	99.64	98.41
	SD	(.65)	.66	.90	(.70)
36-42 wks	mean	98.6	98.34	99.54	98.68
	SD	.44	.61	.94	.45

The means were calculated from all temperatures that were stabilized in each route.

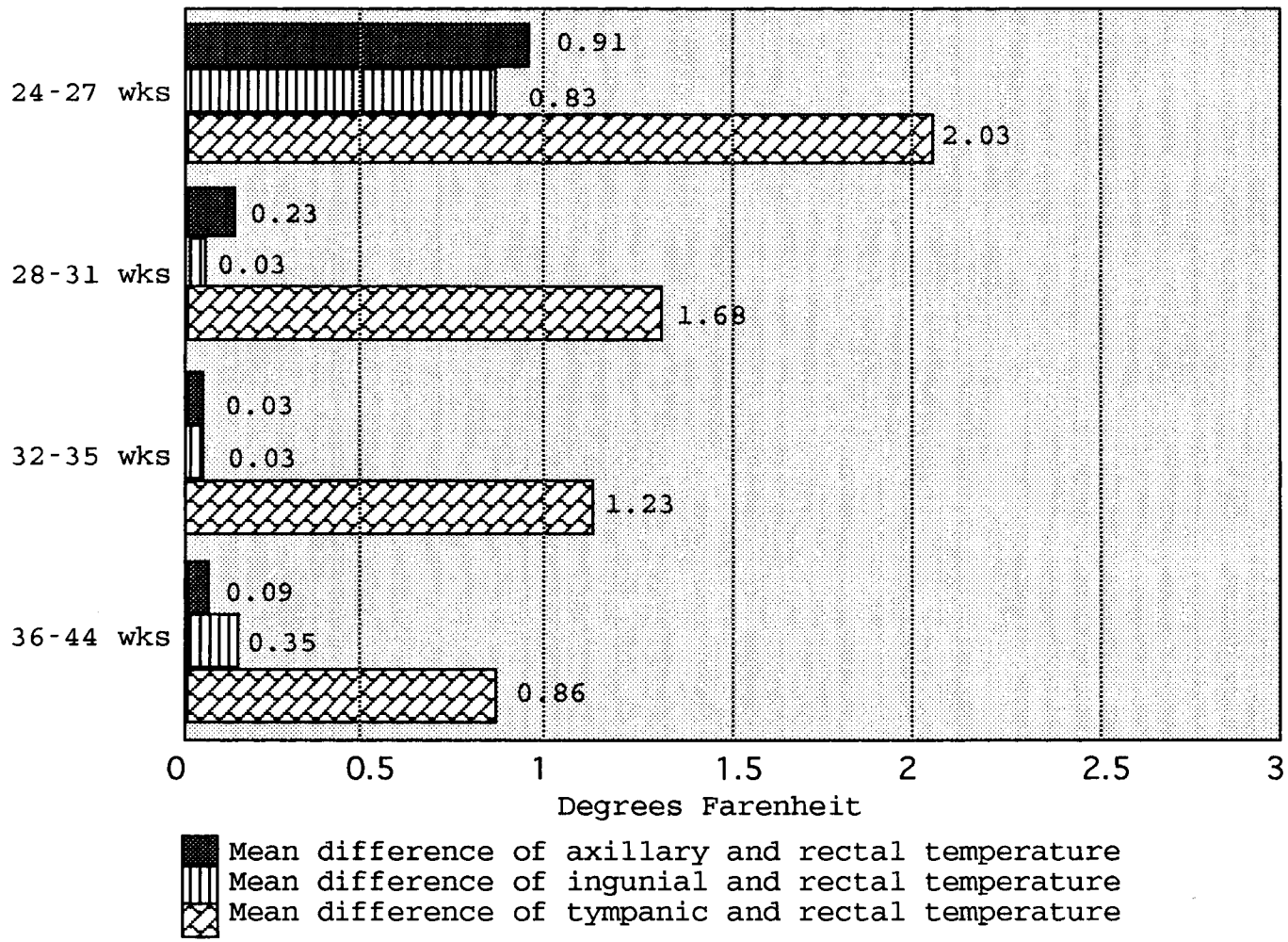


Figure 1. Mean Temperature Differences by Gestational Age Group Temperatures reaching stabilization in both the rectal route and either the axillary, inguinal or tympanic route.

via both the rectal route and either the axillary, inguinal or tympanic routes were included in this analysis.

Table VI presents the differences in mean temperatures at various sites in each age group. Mean inguinal and axillary temperatures were significantly different from rectal temperatures only in infants of 24-27 weeks gestation. In this group of infants, the difference in rectal and tympanic temperatures was significantly greater than in the 36-42 week gestation group. For all routes, differences from mean rectal temperatures were greatest in infants of 24-27 weeks gestation. Gender did not influence temperature difference between groups.

Table VI

Mean Differences Between Temperatures

	Rectal-Tympanic	Rectal-Inguinal	Rectal-Axillary
24-27 weeks	2.03*	.83*	.91*
28-31 weeks	1.68	.03	.23
32-35 weeks	1.23	-.03	.03
36-42 weeks	.86^	-.35	.09

*Temperature differences varied significantly from temperature differences in other age groups.

^Temperature difference varied significantly from temperature differences in infants from 24-31 weeks.

Analysis of variance revealed a significant difference in rectal and axillary temperatures between groups ($F = 5.7$; $p<.001$). Least significant difference analysis was performed to determine which groups differed. Infants of 24-27 weeks gestation were significantly different from other groups. Rectal-inguinal temperature difference was significant ($F = .60$; $p<.001$). Least significant differences revealed that infants 36-42 weeks gestation were significantly different from infants 24-27 weeks gestation and 28-31 weeks gestation. Table VII presents ANOVA summary information.

Question 3: Is temperature stabilization at various sites affected by gestational age? Numbers and percentages of infants whose temperatures stabilized in all sites are presented in Table VIII. Of particular interest were the infants in the gestational age category of 24-27 weeks. Forty percent (4 of 10 infants) did not demonstrate stabilized temperature readings in all sites before they developed significant oxygen desaturation. Only 4.8% (1 of 21) infants in the 36-42 week gestational age group developed oxygen desaturation requiring discontinuation of measurement before stabilized readings were obtained at all sites.

Table VII

Analysis of Variance

Source	D.F.	Sum of Squares	Mean Squares	F Ratio	F Prob.
	Rectal/Axillary Temperature Difference				
		Gestational Group			
Between Groups	3	5.5740	1.8580	5.6730	.0020
Within Groups	51	16.7034	.3275		
Total	54	22.2775			
	Rectal/Inguinal Temperature Difference				
		Gestational Group			
Between Groups	3	6.5477	2.1826	5.9749	.0015
Within Groups	50	18.2644	.3653		
Total	53	24.8120			
	Rectal/Tympanic Temperature Difference				
		Gestational Group			
Between Groups	3	9.8393	3.2798	3.5504	.0203
Within Groups	54	49.8835	.9238		
Total	57	59.7228			

Table VIII

Infants Reaching Temperature Stabilization at All Four Sites

	24-27 Wks Gestation N = 10	28-31 Wks Gestation N =11	32-35 Wks Gestation N = 20	36-44 Wks Gestation N = 21
Stable	6 (60%)	9 (81.8%)	19 (95.0%)	20 (95.2%)
Not Stable	4 (40%)	2 (18.2%)	1 (5.0%)	1 (4.8%)

Stabilization times varied with route and gestational age. At least 50% of the temperatures were stabilized within a three-minute time frame regardless of route or gestational age, and at least 75% were stabilized by four minutes regardless of route or gestational age. Tables IX and X show temperature stabilization times and mean stabilization times by gestational age group.

Table IX

Temperature Stabilization Times by Gestational Age Group

Group	Route											
	Rectal			Axillary			Inguinal			Tympanic		
	T	%	N	T	%	N	T	%	N	T	%	N
24-27 wks	1			1			1			1	100%	10
	2	25	2	2	14.3	1	2	33.3	2			
	3	62.5	5	3	85.7	6	3	16.7	1			
	4	12.5	1	4			4	33.3	2			
							5	16.7	1			
28-32 wks	1			1			1			1	100%	11
	2	20	2	2	20	2						
	3	50	5	3	80	8	3	50	5			
	4	30	3	4			4	50	5			
32-35 wks	1			1			1			1	100%	20
	2	26.3	5	2	10.5	2	2	15.8	3			
	3	63.2	5	3	52.6	10	3	52.6	10			
	4	10.5	2	4	31.6	6	4	21.1	4			
				5	5.3	1	5	5.3	1			
							6	5.3	1			
36-42 wks	1			1			1			1	100%	21
	2	61.9	13	2	10	2	2	20	4			
	3	28.6	6	3	50	10	3	30	6			
	4	9.5	2	4	25	5	4	30	6			
				5	15	3	5	20	4			

T = Time in Minutes

% = Percentage of Gestational Group

N = Number

Table X

Mean Stabilization Times*

	Rectal	Ax	Ing
24-27 wks	3.28	2.86	2.5
28-31 wks	3.10	2.80	3.5
32-35 wks	2.77	3.31	3.31
36-42 wks	2.27	3.45	3.5

*Table includes all stabilized temperature calculations

CHAPTER V

Discussion

The importance to the preterm infant of maintaining an optimal temperature cannot be overstated. Cold stress and its complications can be prevented, however, only if caretakers have an accurate means of assessing temperature. The rectal temperature taken with glass and mercury thermometer has been assumed to be a good indicator of core temperature, but rectal assessment in infants is associated with a number of problems. Concerns about complications such as perforations and bradycardia in the infant and contamination of the environment from use of glass and mercury thermometers have provided impetus for finding an alternate means of temperature assessment. A suitable substitute for rectal temperature measurement in the infant must be a safe, reliable, and efficient indicator of core temperature. This study compared axillary, inguinal, and tympanic temperature measurements to rectal measurements in preterm and term infants under radiant warmers in the first week of life.

Rectal temperature has long been accepted as the best indicator of core temperature and was chosen in this study as the standard to which other methods would be compared. The accuracy of rectal temperature measurement with glass and mercury thermometers available in the clinical setting,

however, cannot be assumed. In screening for measurement tools to use in this study, between 20 to 30 thermometers were compared against a National Standard Thermometer before finding three that were sufficiently accurate. Readings of various thermometers varied .2° to -1.4° from the National Standard Thermometer. This lack of standardization does not affect the findings of this study, which used only thermometers with demonstrated accuracy, but does have implications for practice.

To be an acceptable substitute for rectal temperature measurement, temperatures obtained in other sites should correlate with the rectal temperature and should vary from the rectal temperature in a predictable manner. This study examined the correlation of rectal temperatures to simultaneously obtained axillary, inguinal, and tympanic temperatures in the infants as a whole and in different gestational age groups. In the more mature infants (32-35 weeks and 36-42 weeks gestation) there were statistically significant correlations between rectal temperatures and axillary temperatures ($r = .62$ and $.63$). These correlations were very similar to those obtained by Moen (1987) in preterm infants 28-36 weeks ($r = .66$ to $.71$), but are less strong than those of Bliss-Holtz (1989), who studied infants greater than 2500 grams ($r = .89$). It appears that rectal and axillary temperatures are more highly correlated as gestational age increases. Inguinal temperatures were also

significantly correlated with rectal temperatures in infants > 32 weeks (r = .72 and .46). Bliss-Holtz found significant but much stronger correlation in infants of similar maturity (r = .91). Only in infants 36 weeks gestation or older were tympanic temperatures significantly correlated to rectal temperatures (r = .72). This correlation was the strongest found. Mayfield (1984b) also found strong correlations between tympanic and rectal temperatures in both term (r = .84) and preterm (r = .87) infants. Preterm infants in Mayfield's study were not as immature as infants in this study. Correlation coefficients in the first two gestational groups (24-27 weeks and 28-31 weeks) were extremely poor with none exceeding r = .21 in the least mature group. The literature lacks comparison data for infants this small and immature. Overall, the strength of correlation increased directly with increasing gestational age. The question of adequate correlation remains, however. The statistically significant correlations of .62 or .63 between rectal and axillary temperatures found in the more mature infants in this study may or may not lead to the conclusion that axillary temperatures are sufficiently accurate. At this point it is up to the clinician to decide.

A second criterion for the adequacy of an alternate temperature measurement is the predictability of its variance from the standard rectal measurement. The mean tympanic temperature was higher than mean rectal temperature in all

groups, but the standard deviation was also greatest (.87 - .94). Of the 58 infants from whom both measurements were available, the tympanic temperature was higher than rectal in 91% of the infants. The degree of difference, however, was unpredictable. The difference was less than 1° in 23 infants, between 1° and 2° in 13 infants, between 2° and 3° in 12 infants and > 3° in 5 infants. The inability to infer a fixed or standard correction factor makes interpretation of tympanic temperatures difficult.

A similar problem exists in comparing axillary and rectal temperatures. The mean difference in temperatures at these sites for the total group was only .13°F, which would appear to make them practically interchangeable. However, of the 55 infants for whom both measurements were available, 17 had rectal temperatures greater than axillary, 13 had identical temperatures, and 25 had axillary temperatures greater than rectal. The extent of difference was also remarkable. One infant had an axillary temperature 2.6°F greater than rectal and another infant had a rectal temperature 1.0°F greater than axillary. The unpredictability of the relationship between axillary and rectal temperatures was greatest in infants of lower gestational age, but poses a problem in all groups.

The relationship between rectal and inguinal temperatures cannot be inferred from the data in this study. Measurements were available at both sites in 56 infants. Of these, inguinal temperature was greater than rectal in 23 infants

and rectal greater than inguinal in 25. Again the mean difference of only .43°F must be examined in light of the fact that these infants had inguinal temperatures as much as 2.6°F greater than and 2.0°F less than axillary temperatures.

This research was somewhat unique in that it included very premature infants, a group poorly represented in previous studies. Several observations can be made. First of all, it was impossible in many cases to compare temperatures at various sites because the infant's physiologic status became compromised before measurements stabilized. When comparisons were possible, no significant correlations were found between rectal temperatures and temperatures obtained at any other site in infants less than 32 weeks. Degree of difference between temperatures at different sites was also greatest in the least mature groups. Rectal temperatures were consistently lower than axillary, inguinal, or tympanic temperatures in infants 24-27 weeks. The difference was as much as 2.6°F between rectal and axillary and rectal and inguinal temperatures and 3.8°F between rectal and tympanic temperatures. The fact that infants in this study were under radiant lights may have contributed to the relatively lower rectal temperatures. This supposition is supported by the work of Haddock and associates (1988), who found a consistent trend of higher axillary temperatures in infants under radiant warmers than in those in isolettes. None of these alternate sites appear

to provide temperature readings that can be rationally or systematically compared to rectal temperatures. Until further research is available, the decision of which measurement to use in very premature infants will have to be based on comprehensive assessment of the infant's clinical status and the risks and benefits involved.

One factor which should be considered is safety. In this study the tympanic temperature measurement was unquestionably the safest, quickest, and most easily tolerated. Of all the methods, the tympanic was the only one that was both fast and safe enough to obtain temperatures without associated sequela in 100% of subjects. No repositioning was required and results were available almost immediately.

The axillary assessment was also relatively non-stressful to the infants. The need for repositioning was minimal and the thermometer placement was accomplished with ease.

Temperature measurement via the rectal route was the most invasive and was associated with greatest potential risk. Proper positioning of the infant and of the thermometer were essential but were part of the routine care of experienced and competent intensive care nurses. Despite this, one infant in the 24-27 week gestational age group developed significant bradycardia (heart rate of 83) immediately upon insertion of the rectal thermometer.

The inguinal route was less invasive than the rectal, but of the three sites measured with the glass and mercury

thermometer, proper placement was most difficult in the inguinal site. In order to conceal the bulb of the thermometer with skin folds, the leg must be adducted. This required repositioning of the infants. In preterm infants with decreased body fat, it was difficult to maintain skin fold coverage of the bulb even after adduction. This unnatural positioning of the leg was followed at times by increased movement and resistance by larger infants. Measurement while in the prone position was impossible with infants 24-27 weeks gestation due to their extended position. Measurement was possible while prone in full term infants, whose flexed lower extremities provided the necessary seal to cover the bulb of the thermometer.

A final factor to be considered in choosing a method for temperature assessment in infants is relative ease or difficulty for the caretaker. Methods that are efficient and simple not only save time, but are more likely to be done consistently and correctly. Adequate time required for the instrument to measure a temperature accurately must be allowed. The time needed is reflected by stabilization time or the time required to obtain two unchanged temperature readings. In this study, stabilization was not always obtained except via the tympanic route. The time and manipulation involved with the axillary, rectal, and inguinal measurement led to oxygen desaturations and bradycardia in some infants. This problem was greatest in infants in the

lowest gestational age group, but at least one infant in each group failed to demonstrate stabilized temperatures in all sites before measurements had to be discontinued. Of those infants who demonstrated stabilized rectal temperature readings, all reached stabilization within 4 minutes. Stabilization required up to 5 minutes in the axillary site and 6 minutes in the inguinal site. These observations support the American Academy of Pediatrics' recommendation that rectal and axillary thermometers be kept in place at least 5 minutes. They are inconsistent, however, with the findings of Schiffman (1981) who found that 98% of axillary temperatures continued to increase after 7 minutes. Different heat sources may again explain the inconsistency. There has been inadequate research on which to base recommendations for inguinal measurements, but based on this study at least 6 minutes may be necessary to reach a stabilized temperature. In contrast to Haddock's findings (1988), gender did not influence stabilization times in this study.

Limitations

The conclusions, interpretations, and inferences of this study should be considered with caution. Although this study generated data comparable to that of the literature in many respects, several caveats should be raised.

First of all, the small sample size overall, and particularly in some gestational age groups, may have

severely limited the power of the study to detect significant differences. The inability of many infants to demonstrate stabilized temperatures before experiencing physiologic instability further decreased the number of observations.

Another limitation is inherent in the characteristics of the sample population. Subjects in this study were infants in an intensive care nursery under radiant warmers on servocontrol setting in the first week of life. The findings are restrictive in their generalizability to other populations.

The "Genius" tympanic thermometer has been tested minimally in term and even less in preterm infants. This particular tympanic thermometer may be limited in its ability to assess tympanic membrane temperatures due to poor fit between the probe and structures in the auricle of small infants.

Infants in this study had all temperatures obtained simultaneously. This could have increased the stress, resulting in increased number of unstabilized temperatures.

Conclusions

The findings of this study suggest that:

1. The glass and mercury thermometer available in clinical settings may not be accurate. Treatment decisions should not be made on the basis of assessments made with instruments of unknown reliability, but in the context of a

complete clinical picture. Nurses should also strongly encourage purchasing departments to demand acceptable quality from their vendors.

2. The use of the "Genius" tympanic thermometer in infants should be discouraged until its reliability can be further assessed.

3. Axillary temperature does not correlate well with rectal temperature in infants 24-31 weeks gestation under radiant warmers. The decision to use axillary or rectal temperature measurements should be based on individual assessment of associated risks and benefits.

4. Inguinal assessments are more difficult to obtain in many infants because they require unusual positioning as well as adequate skin or fat folds to conceal the thermometer bulb. This study failed to identify advantages that would warrant their routine use, particularly in the very premature infant.

Suggestions for Further Study

The literature related to temperature measurement in preterm infants of 28 weeks gestation or less is very limited. More immature infants are difficult to study because of their decreased tolerance to manipulation. As more and more survive, however, research is mandatory if care is to be suited to their unique physiologic status.

Before firm recommendations for practice can be generated, more research with larger samples must be done. Infants under radiant warmers, in isolettes, and in open cribs should be compared. Infants older than 7 days also need study.

Little mention is made in the literature of the use of electronic thermometers versus glass and mercury thermometers in measurement of temperatures in infants. Their convenience coupled with the desire to phase out glass and mercury thermometers will encourage their use in the future. Research should be conducted prior to their widespread adoption to assure adequate reliability and accuracy. A more recent instrument, "Tempra Dots," or "paper thermometers" is illustrative of the innovative approaches to temperature measurement that must be systematically evaluated before use in this population.

Accuracy, efficiency, and minimal risk to the infant are the requirements for successful temperature assessment tools and procedures of the future. It is up to researchers to continue to seek scientific knowledge on which to base their interventions so that outcomes of the most vulnerable infants will be optimized.

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APPENDICES

FORM B

I. IDENTIFICATION OF PROJECT

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Title of Project: Comparison of Axillary, Inguinal, and Tympanic Temperatures to Rectal Temperatures in Infants

Department: College of Nursing

Starting date: Upon Approval

Estimated completion date: December, 1992

External Funding Agency: None

Grant submission deadline: NA

II. OBJECTIVES OF PROJECT

Temperatures in preterm infants may be determined by rectal, axillary, inguinal or tympanic measurement. The rectal temperature is considered the most accurate method, but is the most invasive and the most stressful to the infant. This study will compare axillary, inguinal, and tympanic temperatures to rectal temperatures of infants in an intensive care nursery to determine if these methods are sufficiently accurate. The results should assist caregivers to obtain the most accurate measurement of temperature with the least stress and/or risk to the infant.

III. DESCRIPTION OF SUBJECTS

Sample will be selected on a convenience basis from a Level 3 Intensive Care Nursery in a large community hospital in northeast Tennessee. Sixty infants from 24-40 weeks gestational age, as determined by the Dubowitz method, will be divided into four age groups: 24-27 weeks, 28-31 weeks, 32-35 weeks and 36-40 weeks. Each participant will have one set of temperature measurements obtained simultaneously at each of the four locations. Criteria for exclusion from the study include those infants who have rectal fissures or bleeding, necrotizing entercolitis, oxygen saturations less than 85% if receiving oxygen therapy, infants greater than seven days

old, and infants who are not positioned under radiant warmers for thermal control.

IV. METHODS OR PROCEDURES:

(1) Informed consent will be obtained from a parent. (2) Participants will be assigned a number for identification. (3) Demographic data will be collected and will include age at time of study, sex, birth weight and gestational age. (4) Infants will be placed into appropriate gestational age groups. (5) Recorded temperatures will be reviewed to ensure that the temperature has been stable for at least six hours. (6) Glass and mercury thermometers will be tested against a national standard thermometer to ensure accuracy and will be shaken down to 94°F. (7) Simultaneous temperatures will be taken at four body sites with the assistance of two nurses. (8) Axillary temperature will be obtained by placing the ball of the glass and mercury thermometer into the axilla and holding the arm against the side of the body until the temperature stabilizes for two consecutive minutes. (9) Rectal temperature will be obtained by first marking the thermometer with a nontoxic pencil at 1.5 centimeters from the bulb so that risks will be minimal. The bulb will be lubricated with lubrifax to allow ease of insertion, and be gently inserted into the rectum for 1.5 centimeters until a two-minute stabilization period is reached. (10) Inguinal temperature will be obtained by placing the bulb of the thermometer at the site of femoral pulse and adducting the leg until stabilization is reached. (11) In the event stabilization has not been achieved over a ten-minute period in these three locations, the procedure will be discontinued and the ten-minute reading recorded. (12) Tympanic membrane temperature will be taken indirectly with an infrared sensing probe that covers the ear canal and causes no discomfort to the infant. (13) Nurses will monitor oxygen saturations on a continuous basis for those infants receiving oxygen therapy to ensure saturations are maintained at an acceptable level greater than 85%. (14) Temperatures will be recorded every minute until stabilization is reached or timeframe has expired. (15) Measurements will be recorded in a notebook and placed in a locked file until analysis is complete.

V. RISKS AND PROTECTION MEASURES

A. Rectal Temperature

Assessment of rectal temperatures is a routine procedure for admission in the nursery. In addition,

rectal temperatures may be taken at any time throughout hospitalization without notification of a neonatologist at the discretion of the nursing staff. Nurses assisting in this study will be graduates of an accredited college of nursing. In addition, nurses participating in this study will be senior primary nurses with a minimum of two years experience in the intensive care nursery and will receive specific instructions and demonstration by the Project Director regarding methods for obtaining temperatures.

1. Potential for rectal perforation and excoriation. This risk factor is reduced by the use of lubrifax to ease insertion and by adhering to guidelines set forth by the American Academy of Pediatrics which recommends rectal thermometers be inserted no more than two centimeters; risk is minimal.

2. Potential for stimulating the defecation reflex with loss of fluid and electrolytes. The thermometer will not be manipulated when in the rectum to decrease this risk; risk is minimal.

B. Inguinal, Axillary, and Tympanic Temperature

No specific risks are identified except for irritability on the part of the infants due to limb restraint with the axillary and inguinal methods. Pacifiers will be provided if infants become irritable during procedures.

C. Confidentiality

Infants' confidentiality will be maintained by assigning coded numbers to data. Data will be available only to those participating in the study and will be kept in a locked file with direct access by Project Director only (Ginger Dillard).

VI. BENEFITS VERSUS RISKS

Risks identified in the previous section are minimal. The results of this study would add to the body of knowledge concerning temperature measurement techniques and would assist in the identification of the most accurate and least stressful technique.

VII. METHOD OF OBTAINING INFORMED CONSENT

At least one parent of each infant meeting the study criteria will be asked for permission to include the

infant in the study. Adolescent mothers are considered as mature minors and routinely sign all permit forms for their infants in the institution where the research will be conducted. Informed consent will be obtained by the researcher or another registered nurse working in the unit. Consent will be obtained in written form and witnessed by a registered nurse and a representative will be present to answer any questions. A sample consent form is attached.

VIII. QUALIFICATIONS OF THE INVESTIGATOR

The principal investigator is a registered nurse from a baccalaureate program and has been employed in the intensive care nursery for three years. The principal investigator has received advanced training in neonatal transport and stabilization and is the transport coordinator for the perinatal center in this region. The co-director has a Master of Science degree in Maternal Child Health and a Ph.D. Her clinical experience includes research with infants in the Intensive Care Unit. Registered nurses who are trained in neonatal assessment and have worked in the intensive care nursery for a minimum of two years will be given instructions and demonstrations regarding technique and assist in the data collection process.

IX. ADEQUACY OF FACILITY TO SUPPORT RESEARCH

This study will be performed in a 300-bed community teaching hospital. This hospital is a perinatal center and has 20 beds for both intermediate and intensive care infants. Adequate resources for data analysis are available through the Nursing Research Center of the College of Nursing.

X. RESPONSIBILITY OF PROJECT DIRECTOR

By the Compliance with the policies established by The University of Tennessee, Knoxville, Committee on Research Participation, the project director subscribes to the principles stated in "The Belmont Report" and standards of professional ethics in all research, development, and related activities involving human subjects under the auspices of The University of Tennessee, Knoxville.

a. Approval will be obtained from the University Committee prior to instituting any change in the research project.
b. Development of any unexpected risks will be reported to the University Committee.

c. A status report (Form D) will be submitted at 12-month intervals or as requested attesting to the current status of the project.
d. Signed consent statements will be kept for the duration of the project and for at least three years thereafter.

Project Director _____ _____
Ginger Dillard Date

Co-Director _____ _____
Dr. Mitzi Davis Date

XI. DEPARTMENTAL REVIEW

COMMENTS/RECOMMENDATIONS:

The application described above has been subjected to departmental review and has been approved.

Department Head

_____
Name

_____ _____
Signature Date

Chair, Departmental Review Committee

_____
Name

_____ _____
Signature Date

Faculty Advisor

_____
Name

_____ _____
Signature Date

CONSENT TO PARTICIPATE

I understand that I am being asked to allow my baby to be in a study to determine the most accurate, easiest and safest way to take temperatures of babies. This is important because changes in temperature may alert the nurses to changes in the baby's health status.

I understand that if I allow my baby to be in the research study, the baby will have temperatures measured at four different places: in the external ear, in the arm pit (axillary), in the bottom (rectal), and in the upper fold or bend of the leg (inguinal). My baby's temperature will be taken by experienced registered nurses who have been instructed on proper thermometer placement. Temperatures taken in the arm pit, bottom and in the upper fold of the leg will be obtained using an ordinary glass thermometer which I have been shown. This thermometer will be kept in place for no longer than ten minutes. Temperature in my baby's ear will be taken externally by an electronic thermometer which I have been shown. I understand obtaining temperatures is a procedure routinely performed on infants in the intensive care nursery. This study will differ from routine in that the temperatures will be taken in four different locations simultaneously.

I understand I will receive no benefits or rewards for allowing my baby to participate in this study other than to possibly improve the methods for obtaining temperatures in babies in the future. I understand the major risk associated with this study is that my infant may become irritable because of the need to hold the arm and leg still during the procedure. I understand that my baby will be monitored constantly for signs of irritability and should any undue stress result, the study will be discontinued.

I understand that my baby's name and test results will be kept confidential by assigning my baby a number for identification and results will be filed and available to the project director (Ginger Dillard) and committee members for analysis only. I should feel free to contact Ginger Dillard directly at the facility by calling 461-6671 for questions or concerns relating to this study.

I understand that my baby's participation in this study is voluntary and that I may refuse to allow my baby to participate or decide to not allow my baby to participate at any time throughout the study without penalty or loss of benefits to which my baby is otherwise entitled, and that signing this consent form does not obligate me to allow my baby to participate should I change my mind.

My child named below has permission to participate in this study. I have read this consent form and am fully aware of possible benefits and potential risks and have not been bribed or coerced in any way into allowing my child to participate.

Child's Name _____

Parent or Legal Guardian's Signature and Date _____

Witness _____

RECORD FORM

Yes No 1. Informed consent signed by parent, witnessed and attached.

Yes No 2. Demographic Data Collection complete
Infant ID# _____ Age _____
Sex _____ Gestational Age _____
Birthweight _____gms Present Weight _____gms

Yes No 3. External heat source radiant warmer on servo control.

Yes No 4. Axillary temperature between 97.4 (F) and 99.0 (F) for the last six hours.

Yes No 5. No history of rectal fissures, bleeding, or N.E.C.

Yes No 6. Oxygen saturation greater than 85% and respiratory data documented. if pulse oximeter in use.
Oxygen Source (Circle) Hood Cannula Ventilator Room Air

Time in Minutes	Rectal	Axillary	Inguinal	Tympanic
One				
Two				
Three				
Four				
Five				
Six				
Seven				
Eight				
Nine				
Ten				

Date of Data Collection _____ Time of Data Collection _____
Time of Data Completion _____
Two minute stabilization reached Yes No (circle) If answered "NO" please give explanation _____
Signature of nurses collecting data _____

PLEASE PLACE COMPLETED SHEET IN ENVELOPE PROVIDED AND SEAL AND PLACE IN PROJECT DIRECTOR'S FILE

VITA

Ginger Dillard was born in Nashville, Tennessee on December 12, 1963. She received her elementary and secondary education in the public schools of Washington County, Tennessee and was graduated from Daniel Boone High School in 1981. In the fall of 1983 she entered East Tennessee State University and graduated in May of 1987 with a Bachelor of Science Degree in Nursing.

She has held clinical positions in Neonatal and Adult Critical Care Nursing. In the fall of 1989, she began work on a Master's degree at the University of Tennessee Knoxville. In the spring of 1990, she became the Transport Coordinator of the Northeast Tennessee Regional Perinatal Center in Johnson City, Tennessee. In October of 1992, she accepted a position as Nursing Supervisor at Johnson City Medical Center Hospital. In December of 1992, she completed requirements for the Master of Science in Nursing.