CRANIAL TRANSILLUMINATION IN NEUROLOGICALLY
INTACT FULL-TERM INFANTS

by
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Master of Science

College of Nursing
University of Utah
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UNIVERSITY OF UTAH GRADUATE SCHOOL

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Date

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Finally, a very special thank you is expressed to my family and especially to my parents, Reverend and Mrs. Ralph J. Jones, for their continuous help and support throughout the past two years.
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ABSTRACT

The purpose of this study was to document a normal range of measures observed in cranial transillumination obtained from testing neurologically intact full-term infants. Ranges, means, and standard deviations in millimeters of transilluminated light of five regions of the skull, i.e., anterior fontanel, frontal midline, left biparietal, right biparietal, and occipital midline regions, were determined. Additional variables, e.g. molding, age when tested, sex, birth weight, type of delivery, head circumference, and size of the anterior fontanel, were analyzed to ascertain if there was any relationship between these variables and the amount of light transilluminated.

The study was conducted at the Latter-day Saints Hospital during a 3-week time period. Forty-seven infants were tested between the twenty-fourth and seventy-second hours of life. Parental informed consent was obtained prior to conducting the transillumination procedure.

The data were analyzed through the University of Utah Computer Center utilizing a Univac computer. A breakdown program and Pearson product-moment correlation coefficient were obtained.
More light was observed in the anterior fontanel and frontal midline regions than the biparietal areas, and more in the biparietal areas than the occipital areas. Generally, the amount of transilluminated light seemed to decrease from the anterior to posterior regions of the head when suture lines were open or adjacent. When the sagittal suture line was overriding there was an increase in the amount of transillumination observed in the frontal midline area.

Total transilluminated light, i.e., the sum of the millimeter readings for the five skull areas, was also considered for each infant. The mean was 30.02 millimeters. Standard deviation was 5.77 millimeters. Thirty-one infants scored in this range. Fourteen infants scored in the second standard deviation. Two infants scored above the second standard deviation. These infants were presented.

Increasing amounts of light were noted in infants tested from 24 to 37 hours of age, then the amount of transilluminated light showed a slight decline. This trend should be further investigated. Problems and concerns noted during the study as well as recommendations and implications for future research in this area were discussed.
CHAPTER I
INTRODUCTION

During the last two decades many sophisticated and useful procedures for diagnosis of problems in the newborn have been developed. Increased emphasis on earlier identification of less overt neonatal abnormalities has also resulted in a reassessment of diagnostic procedures not routinely utilized. One of these is transillumination or the process of passing a light source over a body area for the purpose of detecting increased amounts of fluid collection.

Cranial transillumination as an aid to help detect and diagnose brain abnormalities and/or diseases in infants is not a new procedure. Rabe (1967, p. 78) and Sjögren and Engsner (1972, p. 426) stated that this procedure using a candle or sunlight as the light source was first described by Richard Bright in 1831. Since that time the procedure has been used extensively. The range of disorders revealed through its use has increased in number. However, the methodology of the technique itself, a system by which the results can be easily and objectively measured, and the specific normal ranges of transillumination findings for normal full-term newborn infants have not
Cranial transillumination is a simple procedure. Transillumination itself suggests that there is a passage of light through body tissues (Rabe, 1967, p. 78). The anatomical condition identified by this procedure is the presence of a clear fluid within 1 centimeter of the skull's surface (Sjögren & Engsner, 1972, p. 426). Thus, the procedure aids the examiner by helping to diagnose abnormal collections of intracranial fluid.

The procedure requires an ordinary flashlight to which a specifically designed rubber adaptor has been attached so that there is no leakage of light emitted between their uniting edges. The infant to be studied and the examiner enter a totally darkened room 3 to 5 minutes prior to the time the procedure is initiated. This span of time must elapse in order for the examiner's eyes to fully accommodate to the darkness. When the rubber adaptor with its attached light source is placed against the surface of a normal infant's skull, a very narrow circular bright red ring of light is seen about the edge of the rubber cuff. The entire surface of the infant's head is explored in a systematic fashion, and the pattern of transilluminated light is noted.

From the literature it is difficult to determine what is acceptable as a normal range of transillumination.

been documented in the literature.
in normal full-term newborn infants. Paine and Oppé (1966, p. 95), in their work with young infants, stated that a halo of light up to one-half of an inch might be normal. They added that the halo of light was usually wider in the front than it was in the back of the head. Gamstorp (1970, p. 10) stated that in a healthy baby the rim of light is 1 to 2 centimeters broad in the frontal region and roughly half of that reading is found in the occipital region. Horner's (1958, p. 594) transillumination findings in normal full-term newborn infants showed a ring of light around the adaptor for a distance of 1/2 to 1 centimeter. Chinn (1974, p. 127) stated that in the frontal region of the skull the transillumination should not exceed 1 to 2 centimeters beyond the flashlight's cone, and that the transillumination zone in the occipital area should be minimal or absent.

Rabe (1967, p. 82), in his article, gave one of the most detailed reports on normal transillumination available. He related that normal full-term infants show a wider illumination over the frontal region than over the parietal region, and wider over the parietal than the occipital region. He stated that the ring of light from the edge of the light source can extend up to 3 centimeters in the frontal regions of neonates. In the occipital area of newborns Rabe found a light ring
extending only 4 to 8 millimeters in distance. He also described the occurrence of small pseudopods of light which may be observed at the edge of the light pattern. These pseudopods, when present, measure only a few millimeters in length.

Sjögren and Engsner (1972, p. 427) advocated the use of an Oculus transillumination lamp and rubber adaptor to which a circular plexiglas scale plate has been added. They presented the use of this scale plate with its specific readings as a new method of recording the transillumination measurements. The results for normal newborns which Sjögren and Engsner (1972, p. 428) reported using this equipment are equivalent to a light halo of 5 to 6 centimeters in diameter for the frontal region with a 4 to 5 centimeter halo in diameter for the parieto-occipital area. They showed the equipment in pictorial form and explained how the transillumination rings of light can be measured in objective figures. However, the equipment required to carry out a duplicate study was not available.

In reviewing the literature, certain characteristics of the newborn infant were noted which might influence the transillumination findings obtained. First, specific regions of the skull transilluminate at varying degrees (Haslam, 1973, p. 31). Second, the thickness of the
infant's skull must be considered. Premature infants, especially, will show broader zones of illumination than will older infants (Gamstorp, 1970, p. 11). Rabe (1967, p. 82) noted that transillumination in a normal premature infant may reveal a rim of light around the light source measuring as great as 5 centimeters. Third, the amount of hair as well as the color of the infant's hair and skin must be considered (Rabe, 1967, p. 81). Dark haired infants do not transilluminate as well (Horner, 1958, p. 594; Rabe, 1967, p. 87).

Gamstorp (1970, p. 11) stated that any accumulation of fluid increases the width of the rim of light observed thus causing an abnormal pattern. Therefore, the trauma of the birth process with the molding of the fetal head to fit the mother's pelvic passageway could understandably influence the pattern of transillumination. Sjögren and Engsner (1972, p. 426) stated that the fresh blood from subdural hematomas will not transilluminate for about 3 weeks until after this blood has undergone hemolysis. On the other hand, subcutaneous tissue edema, as in caput succedaneum, transilluminates and may confuse the pattern which should be seen (Gamstorp, 1970, p. 11). Likewise, infants who have had intravenous fluids via scalp veins may also transilluminate abnormally (Rabe, 1967, p. 85). Gamstorp (1970, p. 11) also related that in an infant with
hydrocephalus and a cerebral mantle which is at least 1 to 2 centimeters thick, the transillumination pattern will be normal. However, if the mantle is less than 1/2 to 1 centimeter thick, then the baby's entire head will light up and glow like a red ball. One other factor which might influence the results is the power of the light source used during the examination (Paine & Oppé, 1966, p. 95). Thus, the need for standardized equipment, or at least the use of the same equipment with fresh batteries in use when each infant is examined, becomes apparent.

The need for transillumination as an essential part of the routine newborn physical examination is expressed in the literature. Primarily it should be used to help aid in the recognition of questionable or gross abnormalities and/or diseases of the brain. It is valuable as documentation for referral to the physician so that further studies can be carried out and the specific problem diagnosed. It is of further importance in the initiation and follow-up care made available to those infants and families involved. It has been recommended that any infant under the age of 12 months who is a candidate for adoption have this procedure completed prior to the placement of the infant into a new family unit (Horner, 1958, p. 595; Rabe, 1967, p. 88).

The literature reviewed reveals that with the exception of Rabe's description the technique of cranial
transillumination has been only generally described. Some values for transillumination readings in supposedly normal full-term infants have been reported. Discussions of the techniques used to more accurately measure the rim of light with the exception of Sjögren's and Engsner's (1972) work appear to be lacking. Specific information related to the newborn's age, the tests used to determine neurological and physical status, and an estimate of gestational age at the time of the examination are also lacking.

Therefore, the purpose of this study was to document the normal range of measures observed in cranial transillumination obtained from standardized testing of neurologically intact, full-term infants in a Salt Lake City hospital. The transillumination measurements obtained in five specific regions of the skull were studied to ascertain if there was a possible relationship between the amount of transillumination observed and such variables as the degree of molding, the sex of the infants studied, and the age when tested. Further, it was anticipated that the procedural methods could be refined so that the technique could be incorporated into a routine screening procedure of all newborn infants.

The major research question posed was: What is the mean and standard deviation of the concentric light rim observed with a standardized transillumination procedure of
neurologically intact, term infants? Additional data describing the sample studied were analyzed to provide evidence of any relationship which might exist between the amount of light and other variables, e.g., sex, birth weight, molding, type of delivery, head circumference, and size of the anterior fontanel.
CHAPTER II

METHOD

Data collection was conducted in the central newborn nursery of the Latter-day Saints Hospital in Salt Lake City, Utah. Information was obtained during a 21-day period beginning on August 28, 1973 and ending on September 17, 1973. The transillumination procedure itself was performed after having received informed written consent from the mother or father of each infant studied. All data were obtained by the investigator.

The study was limited to those neurologically intact full-term infants who scored between 37 and 41 weeks of estimated gestational age according to the examination designed by Dubowitz, Dubowitz, and Goldberg (1970). The final sample numbered 47 infants.

The transillumination procedure was carried out between the twenty-fourth and seventy-second hours of life. This time limit was imposed in order for infants to begin their adjustment to extrauterine life and allow for reduction of caput during the first 24 hours, and before the time of the infant's discharge from the hospital after 72 hours of age.

Definitions of terms used in this study include the following:
1. Transillumination is a procedure utilized to aid in detecting and diagnosing brain abnormalities and/or diseases by moving a light source such as a flashlight over the surface of an infant's skull.

2. Neurologically intact refers to the eliciting of infant responses as determined by the Dubowitz criteria (Dubowitz et al., 1970).

3. Term infants are those who were evaluated to be 37 to 41 weeks of gestational age according to the Dubowitz criteria (Dubowitz et al., 1970).

4. Five skull areas specifically delineated in this study were the anterior fontanel, the frontal midline area, the left biparietal region, the right biparietal region, and the occipital midline area.

Infants included in the study were those who met the following criteria:

1. Light or fair colored skin
2. Little or moderate amount of light colored hair
3. No evidence of cephalohematomas
4. No remaining caput observable at the time of transillumination
5. Not delivered with the aid of the vacuum suction extractor
6. Not given intravenous fluids via scalp veins

7. Normal-appearing transillumination patterns, i.e., consistent concentric light rim in all areas. One infant who had an abnormal transillumination pattern was not included in this study.

The equipment needed for this study included the following:

1. Three battery "D" flashlight with new batteries which were not replaced during the 3-week examining period. A standard rubber adaptor (POV Collar #9235 available through the MacBick Company, 243 Broadway, Cambridge, Massachusetts) designed for transillumination purposes. The edges of the flashlight and rubber adaptor were united by securely winding black electrical tape about their adjoining edges.

2. Water soluble, nontoxic colored ink markers used to mark the rim of light observed upon transillumination on the infant's scalp.

3. Narrow (1/4 inch in diameter) metric metal tape used to measure the amount of transillumination noted after the examination was completed.

4. Infant seat holder into which the infant was placed so that he remained in as upright a
position as possible during the transillumination procedure.

5. Strips of gauze used to fasten the infant into the infant seat.

6. An empty nursery crib in which the infant and infant seat holder were placed from the time they left the central nursery until they were returned after the procedure.

7. A completely darkened room in which the procedure was conducted.

8. A timer set for 3 minutes to ensure that adequate time had elapsed for the examiner's eyes to adapt to the darkened room.

During the proceedings all the required information was recorded on the data collection sheets which were developed for this study (Appendix A). This information was gathered from maternal and infant charts as well as through personal observations.

The transillumination procedure itself was closely adapted from that described by Rabe (1967, pp. 78-80). The procedure was conducted in the following manner:

1. Informed written consent (Appendix B) was obtained from a parent of each infant prior to the transillumination examination.

2. After collecting the equipment and chart
information needed, the examiner fastened the infant into the infant seat which was located within the confines of an empty nursery crib.

3. The examiner proceeded by rolling the infant and crib out of the central nursery, down the hall, and into a small darkened closet.

4. The examiner stood to the right side of the infant which was required due to the smallness of the closet. This positioning was assumed on all occasions. Ideally, the infant should be situated so that he is facing the examiner.

5. After allowing 3 minutes to elapse, determined by the timer, the examiner located the anterior fontanel of the infant by palpation.

6. The examiner then placed the rubber adaptor with its attached light source securely against the infant's head so that no light was allowed to leak from between this junction. The flashlight followed a circular movement around the infant's skull as described below.

7. The examiner then:
   a) gently moved the flashlight slowly forward along the skull's midline to the mid-frontal region;
   b) moved the flashlight laterally to the lateral
frontal region; and
c) moved the flashlight posteriorly to the mid-temporal region that is above the infant's ear. These movements were accomplished with minimal or no light leakage.

8. The infant's head was then held forward to a greater degree and supported by the examiner so that more flexion of the neck could be obtained.

9. The examiner then:
   a) moved the flashlight posteriorly until it reached the most inferior part of the occiput; and
   b) moved the flashlight anteriorly on the opposite side of the head until the mid-temporal region above the other ear was reached.

10. The infant's head was then released and allowed to rest against the back of the infant seat.

11. The examiner then:
   a) moved the flashlight laterally to the lateral frontal region; and
   b) moved the flashlight medially to the mid-frontal region.

12. After observing the general transillumination pattern of the infant's skull, the examiner then proceeded to mark transillumination measurements
in each one of the five following skull areas including the:

a) anterior fontanel;
b) frontal midline area;
c) left biparietal area;
d) right biparietal area; and
e) occipital midline area.

13. Since a normal transilluminated pattern has been stated to be a concentric rim of light surrounding the rubber adaptor, the edge of the adaptor's configuration was marked on the infant's head with a water soluble ink marker. A second mark was made at that point where the tip of the marker was no longer visible as it was slowly moved away from the edge of the rubber adaptor. This marking procedure was carried out in each of the five areas mentioned above.

14. After completing the procedure the examiner again rolled the infant and crib out of the closet, down the hall, and into the central nursery where the measurements could be read more accurately and recorded on the data sheet.

15. The ink marks were washed from the infant's skull.
16. The infant was then returned to his/her proper crib and location in the nursery.

17. The equipment and empty crib were then wiped down with a staphene saturated cloth before another infant was examined.
CHAPTER III
RESULTS AND DISCUSSION

The purpose of this study was to determine a normal range of cranial transillumination obtained by testing neurologically intact full-term infants in a Salt Lake City hospital. Forty-seven infants were tested: 26 males and 21 females. Infant birth weights ranged from 2665 grams to 4224 grams. Head circumferences ranged from 30.1 centimeters to 36.4 centimeters. Thirteen males were spontaneous vaginal vertex deliveries, and the remaining 13 were vaginal vertex deliveries aided by the use of forceps. Eight females were spontaneous vertex deliveries, 11 were vaginal vertex forcep deliveries, and 2 were delivered by Caesarian section. The degree of molding of each infant's head was determined at the time of the examination by palpating the coronal, sagittal, and lambdoidal suture lines to ascertain if they were open, adjacent, or overriding. Measurements were taken in five regions of the skull: anterior fontanel, frontal midline, left biparietal, right biparietal, and occipital midline.

By the Dubowitz examination all infants were determined to be 37 to 41 weeks gestational age. A breakdown showing the distribution as to the number of weeks and the
sex has been included (see Table 1). The reliability of the principal investigator in the use of the Dubowitz examination was tested by a fellow graduate student who had previous experience with this tool. Five infants were examined by both individuals, and the total points scored for each infant by both examiners were noted to be within two points of each other.

Statistical analysis of the data was obtained through the University of Utah Computer Center. The SPSS system with a Univac 1108 computer was utilized. Data were computed by a breakdown program and a Pearson product-moment correlation coefficient.

All transilluminated light measurements in this study were recorded in millimeters of light. In the past, inches or centimeters have usually been used to express the expected norms. Chinn (1974, p. 127), Gamstorp (1970, p. 10), and Horner (1958, p. 594) recommended that norms for the frontal area should not exceed 1 to 2 centimeters of light beyond the flashlight's cone. The mean of transilluminated light in the frontal midline area with the sagittal suture overriding was 8.4 millimeters with a standard deviation of 2.3 millimeters (Table 3). If the limits of the third standard deviation were calculated, the amount of transillumination could be as great as 15.3 millimeters. This 15.3 millimeter measurement corresponds to 1.5 centimeters, an amount notably less than that
TABLE 1

Distribution of Subjects as to Gestational Age and Sex

<table>
<thead>
<tr>
<th>Estimated gestational age in weeks</th>
<th>Males</th>
<th>Females</th>
<th>Total</th>
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<tr>
<td>37</td>
<td>1</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>38</td>
<td>2</td>
<td>0</td>
<td>2</td>
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<td>39</td>
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</tr>
<tr>
<td>41</td>
<td>9</td>
<td>1</td>
<td>10</td>
</tr>
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</table>

TABLE 2

Data Obtained in Centimeters on Size of Anterior Fontanel in 47 Infants

<table>
<thead>
<tr>
<th>Anterior fontanel data</th>
<th>Total (average of length plus width)</th>
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<tr>
<td>Ranges</td>
<td>Length</td>
</tr>
<tr>
<td>Smallest</td>
<td>1.2</td>
</tr>
<tr>
<td>Largest</td>
<td>5.0</td>
</tr>
<tr>
<td>Means</td>
<td>2.257</td>
</tr>
<tr>
<td>S.D.</td>
<td>.654</td>
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</table>
recommended in existing literature. Therefore, it is strongly recommended that measurements be recorded in millimeter units as these are more accurate, especially when dealing with specific regions of the skull.

The mean and standard deviation of the amount of light observed on transillumination in five areas of the head of neurologically intact, full-term infants were determined to answer the major research question. Table 3 shows these range, mean, and standard deviation values for the total sample as related to each of the skull regions considered. As indicated, more light was observed in the anterior fontanel and frontal midline regions than in the biparietal regions, and more in the biparietal areas than the occipital midline area. This trend is supported by the literature. The greatest difference in mean and standard deviation measures of the total sample was observed between the frontal midline and occipital midline areas. The difference of the means is 2.4 millimeters, and the difference of the standard deviations is 0.5 millimeters. Figure 1 indicates the variations in means and standard deviations between the frontal midline and occipital midline measurements in regard to the areas studied in Table 3.

In general, the amount of transilluminated light seems to decrease from the anterior to the posterior regions of the head when the suture lines are open or
TABLE 3

Ranges, Means, and Standard Deviations in Millimeters of Transilluminated Light of the Five Skull Areas Tested in Relation to the Total Sample, Sex, and Suture Lines: Open, Adjacent, and Overriding

<table>
<thead>
<tr>
<th>Skull area tested</th>
<th>Range of TL</th>
<th>Total sample</th>
<th>Male</th>
<th>Female</th>
<th>Sex</th>
<th>Coronal suture</th>
<th>Sagittal suture</th>
<th>Lambdoidal suture</th>
</tr>
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<tr>
<td>Anterior fontanel</td>
<td>3-10</td>
<td>Mean 6.9</td>
<td>6.8</td>
<td>7.0</td>
<td>7.5</td>
<td>7.0</td>
<td>6.8</td>
<td>7.9</td>
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<tr>
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<td>2.1</td>
<td>2.1</td>
<td>2.2</td>
<td>2.0</td>
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<td>Frontal midline</td>
<td>3-14</td>
<td>Mean 6.9</td>
<td>7.3</td>
<td>6.4</td>
<td>7.0</td>
<td>6.6</td>
<td>7.6</td>
<td>6.8</td>
</tr>
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<td></td>
<td>S.D. 2.3</td>
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<td>2.0</td>
<td>2.1</td>
<td>2.3</td>
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<td>Left biparietal</td>
<td>3-10</td>
<td>Mean 6.1</td>
<td>5.8</td>
<td>6.5</td>
<td>6.0</td>
<td>6.3</td>
<td>5.8</td>
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<td>1.4</td>
<td>1.8</td>
<td>2.0</td>
<td>1.4</td>
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<td>Right biparietal</td>
<td>3-11</td>
<td>Mean 5.6</td>
<td>5.4</td>
<td>5.7</td>
<td>6.5</td>
<td>5.5</td>
<td>5.6</td>
<td>5.4</td>
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<tr>
<td></td>
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<td>2.0</td>
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<td>Occipital midline</td>
<td>2-11</td>
<td>Mean 4.5</td>
<td>4.6</td>
<td>4.5</td>
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<td>4.5</td>
<td>4.9</td>
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<td>S.D. 1.8</td>
<td>1.7</td>
<td>2.0</td>
<td>2.0</td>
<td>1.4</td>
<td>1.4</td>
<td>2.5</td>
<td>1.4</td>
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</table>

\(^a\)TL means transilluminated light.
<table>
<thead>
<tr>
<th>Sample</th>
<th>Sutures</th>
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<tbody>
<tr>
<td>Total sample</td>
<td>Sex</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>Female</td>
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</table>

Frontal Midline with S.D.
Occipital Midline with S.D.

Fig. 1. Means and standard deviations in millimeters of transilluminated light for the frontal midline and occipital midline regions of the skull in relation to the total sample, sex, and suture lines: open, adjacent, and overriding.
adjacent. However, when all three suture lines are over­riding, there is an increase in the amount of light transilluminated in the frontal midline areas. This is especially noted in the sagittal suture area (Table 3).

Next the sum of the transilluminated light in the five skull areas for each infant was calculated. This was defined as total transilluminated light. These sums ranged from 20 millimeters to 46 millimeters. The mean was 30.02 millimeters. The first standard deviation was 5.77 millimeters, and the second standard deviation was 11.54 millimeters. Thirty-one, or 65.9%, of the infants scored within the first standard deviation of 24.25 millimeters to 35.79 millimeters. Another 14, or 29.7%, of the infants scored within the second standard deviation of 18.48 to 24.25 millimeters and of 35.79 to 41.56 millimeters. Two infants scored above the second standard deviation. Their cases will be discussed in following sections.

Pearson's product-moment correlation indicated that there was no significant relationship between sex, head circumference, birth weight, and size of anterior fontanel and the total amount of transilluminated light. Table 2 shows ranges, means, and standard deviations of the length, width, and total size of the anterior fontanel. These compare with results of Popich and Smith (1972, p. 750). The relationship of the type of delivery to the amount of total transilluminated light could not be evaluated.

The results indicated that there might be a
developing trend in relation to the infant's age in hours at time tested and the amount of total transilluminated light observed. The trend indicates an increase of transilluminated light up to 37 hours with a slight downward trend thereafter (Figure 2). This suggests that: (1) perhaps the initial transillumination examination should be delayed until after the thirty-seventh hour of age to obtain maximal readings; and (2) more infants need to be studied to validate this trend, as only 13 of the 47 infants were examined after 37 hours of age in this study.

Characteristics of two individual infants bear special mention because of implications for future research. Specific information about each infant appears in Table 4. The first infant, a girl, was delivered by Caesarian section. Total transilluminated light measured 46 millimeters, thus placing the infant above the second standard deviation. This infant was reported to have more mucous, a poor sucking reflex, and was a slower feeder. The male infant delivered with the aid of forceps had a total transilluminated light of 42 millimeters, also placing him above the second standard deviation. This infant was also reported to be a poor feeder.

The only apparent similarities between these two cases are an increase in the total transilluminated light above the second standard deviation limitations and the
Fig. 2. Means and standard deviations in millimeters of total transilluminated light in relation to age in hours at the time of transillumination.
TABLE 4
Comparison of Two Infants Who Scored above the Second Standard Deviation

<table>
<thead>
<tr>
<th>Case no.</th>
<th>EGA in weeks</th>
<th>Type of delivery</th>
<th>Sex</th>
<th>Apgar score</th>
<th>Birth weight in grams</th>
<th>Head circumference in centimeters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>39</td>
<td>Primary, C/section, (double footling), breech</td>
<td>female</td>
<td>8; 9</td>
<td>3090</td>
<td>33.4</td>
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<tr>
<td>2</td>
<td>40</td>
<td>Forceps, vertex</td>
<td>male</td>
<td>9; 9</td>
<td>3402</td>
<td>34.2</td>
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</table>

<table>
<thead>
<tr>
<th>Case no.</th>
<th>Hours of age at transillumination</th>
<th>Coronal suture</th>
<th>Sagittal suture</th>
<th>Lambdoidal suture</th>
<th>No of total transilluminated light</th>
<th>Standard deviation position</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>57</td>
<td>Overriding</td>
<td>Overriding</td>
<td>Overriding</td>
<td>46</td>
<td>Above second S.D.</td>
</tr>
<tr>
<td>2</td>
<td>29</td>
<td>Adjacent</td>
<td>Adjacent</td>
<td>Overriding</td>
<td>42</td>
<td>Above second S.D.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Case no.</th>
<th>Deviations from normal at birth</th>
<th>Abnormalities from physical exam</th>
<th>Nurses' observations of infants</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cord about neck x 1</td>
<td>None reported</td>
<td>Mucous trapped x 3, moderate to large amount secretions, initial poor suck, slow eater</td>
</tr>
<tr>
<td>2</td>
<td>Short cord (34 cm)</td>
<td>None reported</td>
<td>Poor feeder, ? Hyperactive gag reflex</td>
</tr>
</tbody>
</table>


initially poor feeding patterns recorded by the nurses caring for the infants. It is recommended that additional research be conducted with particular attention to those infants who score above the second standard deviation in the total amount of transilluminated light observed in order to determine what characteristics these infants have in common and to evaluate how they might differ from infants who score in the first and second standard deviation groups. It is further suggested that these infants should be closely followed for a minimum period of 1 year to determine if indeed they are developing normally according to physical and neurological guidelines. Deviations from normal would necessitate long-term follow-through studies of these children.

A problem in data collection involved the small darkened closet in which the procedure was conducted. There was enough room for only the baby, its crib, and the investigator. The examiner could not move freely about all sides of the crib. This may have influenced the measurements taken as the examiner viewed the infant's skull from only one angle. This was especially noticed when the infant's head was moved forward to obtain the occipital midline measurement. This limitation is not unusual, for many newborn areas are not equipped with a suitable room for the procedure. Perhaps this is one of the greatest
barriers to routine transillumination procedures.

In this setting it was necessary to test infants soon after feedings. Although the problem did not occur, there was concern on the part of the investigator as to the possibility of an infant's regurgitating and aspirating while tied in the infant seat in a darkened room with a single examiner who could not immediately observe what was happening. Another participant holding the infant securely would make it possible for the head to be more effectively stabilized and the measurements more rapidly determined. Infant testing between feedings might decrease the chances of regurgitation and aspiration.

Still another problem centered around the water soluble ink pens used to mark the rim of transilluminated light on each infant's skull. Although the pens used were labeled as being water soluble and nontoxic, the examiner had difficulty in washing the marks off after the procedure was finished. The possibility of danger to the infant from the ink markings as well as parental distress should be considered if further research is initiated in this area.

Parental reaction to subjecting their infants to this procedure needs to be considered. On many occasions mothers decided against permitting the procedure. It did not seem to matter whether it was the mother's first or fifth infant. The investigator observed that the mothers
already exhibited a strong protective behavior towards the safety of their newborns. Additionally, the aspect of marking the infant's head with ink was observed to make mothers more anxious and tense, resulting in the decision that their particular infants be excluded from the study.

Recommendations for future research in the area of cranial transillumination should first include an increase in the sample size, especially evaluation of infants after 37 hours of age. Second, the study should be replicated to validate the findings obtained. Special interest should be devoted to ascertaining if the use of millimeter units in recording the amounts of transilluminated light is a more accurate method for evaluating normal ranges of light not only in each specific region of the skull but in the accumulated total amount of light observed in individual cases. Third, the variable of the type of delivery should be included to determine if forceps delivered infants transilluminate more light than spontaneously delivered infants. Findings in this specific area could have implications as to the normal ranges of transilluminated light to be expected in infants who are delivered by both methods.

Perhaps routine screening of all newborn infants should be delayed until further investigation has evaluated this population. This investigator suggests that the equipment developed by Sjögren and Engsner (1972, p. 427) might be a valuable tool in further research endeavors.
APPENDIX A
DATA COLLECTION SHEET

Name of Hospital: ______________________
Maternal Name: ________________________ LMP: ___ EDC: ___
Maternal Hospital Number: ________
Race of Mother: ____________
Race of Father: ____________
Maternal History of: diabetes ___
pre-diabetes ___
gestational diabetes ___

Type of Delivery:
1. Vaginal _____
   a) Vertex _____
      (1) Spontaneous _____
      (2) Forceps _____
   b) Breech _____
      (1) Spontaneous _____
      (2) Partial extraction _____
      (3) Complete extraction _____
      (4) Forceps _____
2. C/Section _____
   a) Reason For: ______________________________
   b) Vertex _____
   c) Breech _____
   d) Forceps _____
3. Vacuum Extractor _____
   a) Used _____
   b) Not Used _____

Infant Hospital Number: ________
Birth Date and Time: ________
Testing Date and Time: ________ @ ________ ____ hours of age
Birth Weight:
1. _____ pounds _____ ounces
2. _____ grams
Sex:
1. _____ Male
2. _____ Female
Head Circumference
1. _____ cms.
Anterior fontanel size:
1. _____ length (A-P dimension)
2. _____ width (Transverse dimension)
Cranial Suture Lines:
1. Coronal ___ open ___ adjacent ___ overriding
2. Sagittal ___ open ___ adjacent ___ overriding
3. Lambdoidal ___ open ___ adjacent ___ overriding

Transillumination Measurements:
1. Anterior fontanel ___ mm
2. Frontal midline ___ mm
3. Left biparietal ___ mm
4. Right biparietal ___ mm
5. Occipital midline ___ mm
6. Description of any abnormal findings:
DATA COLLECTION SHEET

Clinical estimation of gestational age (according to Dubowitz):

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<thead>
<tr>
<th>I. Neurological criteria</th>
<th>II. External criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Criterion</strong></td>
<td><strong>Score</strong></td>
</tr>
<tr>
<td>Posture</td>
<td></td>
</tr>
<tr>
<td>Square window</td>
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</tr>
<tr>
<td>Dorsiflexion of foot</td>
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<tr>
<td>Arm recoil</td>
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<td>Leg recoil</td>
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</tr>
<tr>
<td>Popliteal angle</td>
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</tr>
<tr>
<td>Heel to ear</td>
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<tr>
<td>Scarf sign</td>
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</tr>
<tr>
<td>Head lag</td>
<td></td>
</tr>
<tr>
<td>Ventral suspension</td>
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<td></td>
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<tr>
<td><strong>Total</strong></td>
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</table>

Total of Column I
Total of Column II
Combined Total Score

Estimated gestational age as read from graph:
___ weeks
APPENDIX B

CONSENT FOR PARTICIPATION IN INVESTIGATIONAL STUDY

I. INFORMATION

Cranial transillumination is a procedure which may accompany the first physical examinations carried out on a newborn baby. It involves having the infant in a totally darkened room. A flashlight with a rubber adaptor is then moved over several parts of the infant's skull to see how much of a rim of light is observed around the outside edge of the rubber adaptor. During the procedure several markings to show the width of this outside rim of light will be made on your baby's head. These markings will be made with a water soluble ink marker. During the procedure your infant will remain in a nursery crib. After the procedure is finished, the lights will be turned on and the widths of the rims of light noted earlier will be measured.

This procedure is being done to help determine what the "normal range" is for neurologically (nervous system) intact full-term infants.

The procedure will not involve the use of any drugs, injections, or other invasive actions which would subject your baby to discomfort or risk.

Benefits include a more detailed examination before your baby leaves the hospital. Any signs of abnormal findings will be referred to your baby's doctor so that he can again check your baby before his (or her) discharge from the hospital.

There is no alternative method suitable for use on normal babies: X-ray examination is, of course, recommended only when there is evidence suggesting brain abnormality.

If there are any questions, they will be answered. Participation in this study can be terminated at any time by withdrawing consent.
II. CONSENT

I have read the foregoing and my questions have been answered. I consent to this examination on my baby.

________________________________________
Signature of Parent

Date ____________  Witness ______________
REFERENCES


**VITA**

<table>
<thead>
<tr>
<th>Name</th>
<th>Sharon Marie Jones</th>
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<tr>
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</tr>
<tr>
<td>High School</td>
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<td>College</td>
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<td>University</td>
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<tr>
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<td>University of Utah Salt Lake City, Utah 1972-1974</td>
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<tr>
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<tr>
<td>Professional Positions</td>
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<td>Staff Nurse Valley West Hospital Salt Lake City, Utah 1972-1974</td>
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