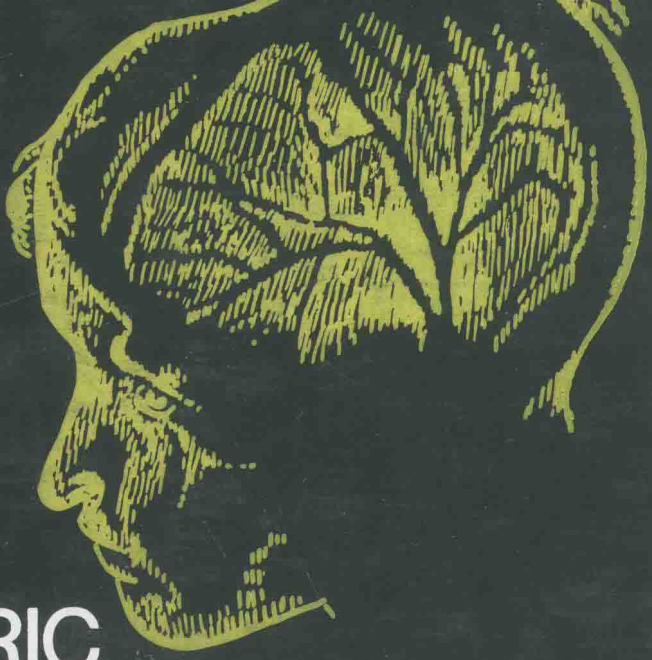

PEDIATRIC TRANSILLUMINATION

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Pediatric Transillumination

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To Paula, Elaine, and Richard
and
To Jane, Matt, Liz, Brian, and Tim

Foreword

ANYONE WHO HAS experienced the quantum leap in the power of imaging brought about by computerized tomography and ultrasonography in recent years might agree to call this the age of noninvasive diagnostics. Indeed, even more powerful (and technically more demanding) methods, such as positron emission tomography and nuclear magnetic resonance, will make us leap again. Against this background of "modern" advances stands the renewed interest in the diagnostic use of transillumination with visible light. The present volume summarizes what has been learned about the clinical use of transillumination, predominantly in newborn infants.

This book will have been most useful if it stimulates refinement and further application of transillumination as a means of rapid, noninvasive, inexpensive bedside evaluation and clinical enlightenment.

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Preface

TRANSILLUMINATION has been applied to clinical medicine for over 150 years. However, the more recent growth in the techniques of transillumination has paralleled that of neonatology owing to its many uses in the newborn. Its use in clinical practice has become widespread in nurseries because of its reliability, noninvasiveness, and minimal expense. It has been applied to several organs and anatomical regions and is considered by many to have become a first-line diagnostic tool.

It is the purpose of this volume to acquaint the reader with the scientific principles of transillumination and its use in the practice of pediatrics. We have divided the book into three sections.

Part I deals with the basics of transillumination. Chapter 1 describes the history of transillumination in medicine, reviewing the major developments since Richard Bright's first description. Chapter 2 presents the principles of transillumination, including the nature of light, its interaction with matter, and its filtration. Chapter 3 summarizes equipment and principles of measurement, including available light sources and light meters.

Part II is devoted to clinical transillumination. Chapter 4 describes the general techniques of pediatric transillumination. This is followed by a regional atlas which reviews normal and abnormal findings in the transillumination of the head and neck (chapter 5), chest (chapter 6), abdomen and spine (chapter 7), and extremities and blood vessels (chapter 8). We have included a section of color reproductions to illustrate some of the more striking diagnoses which we have encountered using transillumination under optimal lighting conditions.

Part III contains a further description of some physical aspects of light and its measurement, and defines related terminology. Addition-

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Part I

BASICS OF TRANSILLUMINATION

1

History of Transillumination

R. C. Banagale, M.D.

Be not the first to lay the old aside, nor yet the last by whom the new are try'd.
—Alexander Pope

TRANSILLUMINATION, the passage of light rays through the tissues and cavities of the body, was first introduced as a viable diagnostic aid in the early nineteenth century. Crude utilization of various sources of light, including that of candles and, in some instances, direct sunlight, enabled the examiner to determine gross abnormalities in shape, substance, and relative density of an organ, tumor, or other object of his study.

Over the course of the next one hundred fifty years tremendous advances were made in the techniques of transillumination. Candlelight was supplanted by fiberoptic transilluminators, and the techniques used to detect gross irregularities were categorically refined to provide not only specific diagnostic comprehension, but also versatile therapeutic assistance.

APPLICATION AND CLINICAL EXPERIENCE

Transillumination of the Head

Transillumination of the head (Fig 1-1) was first described in 1831 by Richard Bright:

James Cardinal, aged 29, was admitted into Guy's Hospital under the care of Sir Astley Cooper, December 1st, 1824. . . . [H]is head was at least twice the size which his spare body would lead us to expect. . . . If a candle was held

behind his head, or the sun happened to be behind it, the cranium appeared semi-transparent.

It was not until 1910, however, that what Bright recorded as an observation would first be used to pursue specific medical information. In that year Strasburger recorded the performance of cranial transillumination on a 3-month-old hydrocephalic infant, using a lamp positioned behind the baby's head. Von Bokay, in 1913, reported his utilization of basically the same technique on 15 children with a diagnosis of chronic hydrocephalus internus. He published his further experiences in a systematic use of transillumination in 1915, 1923, and 1932.

The introduction of ventriculography in 1921 by Dandy as a more precise procedure in locating the exact site and character of an obstruction in a hydrocephalic patient briefly encroached on the burgeoning popularity of transillumination as a beneficial tool. However, in 1950 Hamby and his associates presented seven cases of hydranencephaly and reemphasized the value of cranial transillumination as the single simplest and most valuable aid in diagnosis. They described their experience relative to one of the hydranencephalic children:

> The head was held in the beam of a strong light in a darkened room. A remarkable picture was seen. . . . The entire cranium glowed with an orange-red light like an illuminated Japanese lantern. When the beam was directed against the occiput and the eyelids were held open, the glow was transmitted clearly through the pupils. . . . Opacities could be seen representing the major cranial buttresses, the large scalp veins and the superior longitudinal sinus.

Alexander and associates (1956), feeling that the value of cranial transillumination was being somewhat neglected by neurologists and pediatricians, published an article which described a contrivance by which more precise transillumination would be possible. They devised a table apparatus upon which an infant could be placed with his head over an opening, illuminated from below by a 100-watt bulb. A 2-inch-thick foam rubber pad around the opening was shaped so as to fit the patient's head and, at the same time, prevent the escape of light around it. As an added feature, the apparatus was capable of taking both black and white and color photographs of the transilluminated head. This device is described in better detail by Taylor and his co-workers in a later report (Taylor et al., 1956).

In 1958 Horner and colleagues presented a very simple modification of cranial transillumination during the Sixty-Eighth Annual Meeting of the American Pediatric Society, which Horner restated in a later publication (1962). He described the use of a standard two-cell flashlight with a narrow cuff of opaque sponge rubber surrounding the illuminating surface. In a darkened room the cuff is pressed against the cra-

Fig 1–1.—Artist's interpretation of Richard Bright's observation of the transillumination of the head of James Cardinal, 1831. (Drawing by Lewis Sadler.)

nial vault allowing the foam rubber to conform to the contours of the skull surface. The extent of the rim of light around the rubber cone is observed.

Dodge, who participated in the discussion of Horner's 1958 presentation, also published with Porter his experience utilizing basically the same technique (1961). In addition, numerous other works demonstrating the value of cranial transillumination in cranial and intracranial pathology were published (Calliauw, 1962; Shurtleff, 1964; Lehman et al., 1970; Rozovski et al., 1971; Nixon et al., 1974; and Haller, 1981). These dealt with hydrocephalus of varied etiology, subdural hygroma, hydranencephaly, subdural effusion, cystic disease of the brain, porencephaly, scalp edema, subdural hematoma, and the observation of increased transillumination in severely malnourished infants.

The detracting aspect common to all methods of transillumination up to this point was the need for a completely dark room. Lack of provision for this within the hospital unit, coupled with the difficulty of

holding a squirming infant or moving an acutely ill newborn, necessitated technological refinements.

One form these refinements took was that of a Pulsed Transilluminator* for cranial transillumination, which was first introduced by Hayden et al. in 1975. The pulsed transilluminator contains a gallium arsenide infrared emitting diode and a silicon photodetector diode. The light emitter and detector are built into one hand-held unit which can be firmly placed on the infant's head. A meter is calibrated to read the transmitted infrared intensity in optical density units per centimeter (OD/cm).

In the same year, Cheldelin and his colleagues (1975) reported the use of the Chun Gun,† named in honor of Dr. Ray Chun of the University of Wisconsin Medical School, who was instrumental in its development. Using the Chun Gun with a standardized light source and absorbing filters, they reported normal values for cranial transillumination.

In 1976, Swick et al. reported transillumination values for premature infants, also with the use of the Chun Gun. The procedure was done in a totally darkened room and calipers were used to measure the extent of transillumination. They found, with increasing gestational age, a progressive increase in transillumination over three sites: the anterior fontanelle, the frontotemporal fossa, and the parieto-occipital eminence.

In 1977, Vyhmeister and associates reported their experience with the use of a Chun Gun that had been fitted with a flexible plastic disk‡ to simplify the measurement of transillumination. They pointed out the impracticality of completely darkening the room and performed the procedure in controlled, subdued light. An important difference between their findings and those of Swick is the observation of a progressive increase in transillumination with increasing gestational age only in the occipital region.

The use of high-intensity transillumination in detecting a growing skull fracture in an 8-month-old female infant was reported by Kuhns et al. (1977). Further experience with the use of a fiberoptic device‖ and a cadmium sulfide light meter§ in detecting neonatal intracranial hemorrhage was reported by Donn and associates (1979).

During the course of the development of transilluminating instru-

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‡Audio-Visual Department, Loma Linda, CA.
‖Omni-Source Med General, Inc., Minneapolis, MN.
§TLM 2, Radiation Measurements, Inc., Middleton, WI.

ments and techniques, many attempts have been made to record permanently the findings on transillumination devices. The apparatus for photography and transillumination of the head devised by Taylor and his colleagues (1956) is no longer practical with the present-day set-up in the neonatal intensive care unit. In 1961, Cambern and associates described their technique of cranial transillumination photography; however, their experience was before the availability of high-speed color film. In 1966, Shurtleff and associates described transillumination photography using a 200-watt second strobe, triggered by a photocell, as fill light with a blue filter bounced from ceiling or wall.

Martin and co-workers (1977) described a technique of transillumination photography in the radiographic rooms using 35-mm film that can be processed in an automatic x-ray processor.

Transillumination of the Chest

A very early attempt to apply transillumination to the tissues of the chest was made by the Scottish physician, Sir James Simpson, in 1869. Fostered by the development of the electric incandescent light, Simpson examined the famous Siamese twins, Eng and Chang, conjoined by a band of tissue from sternum to sternum. Simpson wrote:

> You are well aware that various attempts have been made of late years, by electric and other strong lights, to make portions of the body more or less translucent. By placing a powerful light behind the connecting band in Eng and Chang, I tried to make its thinner portions transparent, with a view of possibly tracing its contents better than by touch; but I failed entirely in getting any advantage from this mode of examination.

One of the first applications of transillumination as a diagnostic tool in diseases involving the chest was reported by Cutler in 1929 when he reported on the value of transillumination in the diagnosis and interpretation of pathologic conditions in the breast:

> Transillumination is of special value in those cases of bleeding nipple in which no tumor can be palpated. In these cases, in which localization of the lesion has heretofore been difficult or impossible, transillumination usually enables localization of the lesion and thereby directly indicates the site for operative removal.

The value of transillumination in the diagnosis of chest abnormalities in infants did not receive wide attention until 1975 when experience was reported by Kuhns and colleagues. A high-intensity transilluminator, the Mini-Light Portable Illuminator,* was utilized successfully in

*Med General, Minneapolis, MN.