

Procedural Hazards of Neonatal Ultrasonography

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Abstract: Neonatal ultrasonography entails potential procedural hazards to the newborn infant. When performing ultrasound studies, the examiner may inadvertently move the endotracheal tube or may facilitate the spread of infection from one baby to another. The examiner should also be aware that the pressure of applying the transducer to the scalp is transmitted to the central nervous system and that the baby may become hypothermic during the procedure. Precautions include minimizing head and neck movement and application of pressure on the fontanel, using prewarmed coupling gel, which is removed after scanning, careful handwashing, and wiping the transducer with 70% isopropyl alcohol or 2% alkalized glutaraldehyde between studies. **Indexing Words:** Ultrasound · Neonatal · Cranial · Hazards

No deleterious effects from diagnostic ultrasound have yet been documented in human beings. Recently, Bergman¹ has called attention to biologic effects of ultrasound as reported in animals or in vitro, but those biologic effects may be unrelated to what occurs in vivo at the intensities used for pulsed, diagnostic ultrasound.²⁻⁵

Potential hazards to the newborn unrelated to the ultrasound per se arise from performing the examination on the unstable, fragile infant who is very susceptible to environmental stresses. Ultrasonography performed at the bedside is a tremendous aid in the diagnosis of many neonatal conditions. Although newborns are thought to be minimally disturbed by the ultrasound examination, significant environmental and mechanical stresses may result from performance of the study. This report discusses potential hazards of the procedures involved with neonatal sonography.

ENDOTRACHEAL TUBE MOTION

Endotracheal tubes move cephalad with extension and caudad with flexion of the head and neck.^{6,7}

When obtaining cranial ultrasonograms, sonographers may change the head position and thereby move the endotracheal tube. We have observed two intubated children on assisted ventilation in whom the transcutaneous PO₂ value fell during cranial sonography while the neck was being flexed. When the neck was again extended by raising the chin, the PO₂ rose to its prior level. The tip of the endotracheal tube was just above the carina with the chin up but passed into the right main bronchus when the neck was flexed.

In one case, we placed the ultrasound transducer over the subxiphoid area and obtained a transverse scan of both hemidiaphragms. Normally, with inspiration, the curvature of both hemidiaphragms decreases.⁸ In this case, however, with the neck flexed, only the right hemidiaphragm moved passively during assisted ventilation. Only the right lung was being ventilated because the endotracheal tube was pushed into the right main bronchus when the neck was flexed. Both hemidiaphragms moved normally with an occasional spontaneous breath, excluding the possibility of hemidiaphragmatic paralysis. With the neck extended, both hemidiaphragms were seen to move normally on real-time ultrasound. The endotracheal tube was now in the trachea, allowing both lungs to be ventilated. A chest radiograph confirmed the low position of the endotracheal tube at the carina with the neck extended. The ultrasonographer should be wary of displac-

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ing the endotracheal tube by moving the head and neck when performing cranial sonography. Sonography of the hemidiaphragms may confirm tube movement.

INTRACRANIAL PRESSURE

The open fontanel is an acoustic window for imaging the neonatal brain. Intracranial pressure has also been measured at the anterior fontanel.^{9,10} Good correlation exists between intracranial pressure measured at the anterior fontanel with a cutaneous sensing device and intracranial pressure measured by direct ventricular or lumbar manometry.¹⁰

We have occasionally observed the onset of bradycardia after placement of the ultrasound transducer on the anterior fontanel. Might such compression of the neonatal head stimulate the parasympathetic nervous system just as fetal head compression causes subsequent early-type fetal heart rate decelerations?¹¹ We investigated intracranial pressure changes caused by application of an ultrasound transducer to the anterior fontanel.

Five newborn infants (birth weights between 840 and 3300 g and gestational ages between 26 and 40 weeks) who required lumbar punctures for evaluation of possible meningitis had the opening pressure of the cerebrospinal fluid (CSF) measured by attachment of a manometer to the hub of the spinal needle. The infants were in a lateral decubitus position and flexed along the spine for the puncture but were allowed to straighten while remaining on their sides after the needle was in proper position. The CSF pressure was measured only when the babies were quiet. Immediately after stabilization of the pressure, a rotating head-type real-time ultrasound transducer with a small curved surface (ATL, Bellevue, CA) was lightly applied to the anterior fontanel exactly as is done for sonography by one of us (MD) who is experienced in performing cranial sonography and was

unaware of the manometer readings. Changes in CSF pressures were recorded. As shown in Table 1, the mean increase in CSF pressure after application of the transducer was 3.3 cm of water, a statistically significant increase ($P < 0.01$) by a two-tailed Student's *t*-test. Transmitted pressures conceivably may vary with differently shaped transducer faces. The clinical significance and physiologic implication of a change of this magnitude are not known but it is possible that cerebral perfusion pressure may be jeopardized in the stressed preterm infant experiencing an incremental rise in intracranial pressure. We are usually not aware of the pressure being applied to the head while scanning but should use the minimal pressure needed to maintain adequate transducer-skin contact for acceptable images.

TRANSMISSION OF INFECTION

Newborn infants in intensive care nurseries are at high risk for infection because of immature defense systems, mucosal and epithelial disruption, and the frequent necessity for invasive monitoring and therapy. Transfer of pathogens to infants from inanimate objects and inadequately washed hands has been documented on several occasions and strongly suspected on many others.¹²⁻¹⁶ Since many infants may require frequent ultrasonography, the same ultrasound transducer head may contact multiple infants within a few hours and thus facilitate transmission of pathogens under favorable conditions. Plastic surfaces, such as the transducer head, may harbor significant quantities of bacteria in moist crevices for several hours in the absence of exogenous nutrition and much longer if such nutrition is available. Recent evidence also suggests that cytomegalovirus may survive on similar plastic surfaces for several hours¹⁷; it is probable that other viruses can survive in a similar manner. To assess whether pathogens may also survive in ultrasonic coupling

TABLE 1
Response of Cerebrospinal Fluid Pressure to Transducer Placement

Patient	Weight (kg)	Opening CSF pressure (cm H ₂ O)	CSF pressure after applying transducer (cm H ₂ O)	Change in pressure (cm H ₂ O)
1	0.84	6.0	8.0	2.0
2	3.0	11.0	14.0	3.0
3	2.2	5.8	9.2	3.4
4	1.8	7.5	11.2	3.7
5	2.0	6.8	11.2	4.4
Mean ± SD		7.4 ± 2.1	10.7 ± 2.3	3.3 ± 0.4*

* $P < 0.01$, two-tailed Student's *t*-test.

gel (Aquasonic 100, Parker Laboratories, Inc., Orange, NJ), two sets of quadruplicate aerobically vented 10-ml tubes of coupling gel were inoculated with standard bacteriologic loops of coagulase-positive *Staphylococcus aureus* (American Type Culture Collection numbers 25923 and 29213) and incubated at 37°C. No visual evidence of bacterial growth in the gel was noted at 1, 2, 4, 8, 12, or 48 h after inoculation. Trypticase soy broth was inoculated with samples of this previously inoculated gel obtained at the same intervals and inspected for growth after 24 h of incubation at 37°C. Visible growth in trypticase soy broth confirmed that both strains of staphylococci survived in the gel for up to 2 h.

The survival of potential pathogens on plastic and in coupling gel stresses the importance of cleaning the transducer head between patients. Heat sterilization would destroy the casing and ruin the piezoelectric properties of the crystal, rendering it useless. Wiping the transducer thoroughly with 70% isopropyl alcohol or 2% alkalized glutaraldehyde between patient examinations will dramatically reduce the number of organisms present on the surface. Ultrasound personnel should also be aware of and adhere to isolation and hand-washing techniques. One may have carefully washed his hands only to contaminate them once again by touching equipment that has not been cleaned since it was used on the previous patient.

THERMAL STRESS

Thermal regulation is critical in the newborn. Excessive heat gain or heat loss will stress the limited metabolic reserves of the infant and increase mortality and morbidity.^{18,19} The head represents approximately 21% of the total body surface area and as such is a significant site of heat loss in the premature infant.²⁰ It has been suggested that neonates wear small caps to limit heat loss through the scalp.²¹

Bedside sonography permits the infant to remain within an incubator or under a radiant warmer and maintain thermal stability. The limited energy reserves of the neonate can then be expended for muscular activity or growth rather than maintenance of body temperature.

Diagnostic pulsed ultrasound does not significantly heat or cool target tissues.^{2,5} However, the coupling gel that is applied to the scalp could possibly affect thermal regulation. We undertook a simple experiment to study the thermal properties of ultrasonic coupling gel.

Two standard mercury laboratory thermome-

ters were placed under a radiant warmer at room temperature. Both were equidistant (90.0 cm) from the overhead heat source. Both registered identical temperatures. The bulb of one thermometer was then covered completely with a generous layer of aqueous coupling gel (9.8 g, Aquasonic 100, Parker Laboratories Inc., Orange, NJ), which had been stored at room temperature for more than 1 week. The radiant warmer was then set to its highest heat output, and the temperatures of both thermometers were recorded at 1-min intervals during a 10-min heating cycle and a subsequent 10-min cooling cycle after the heat source was extinguished. These data, summarized in Figure 1, show the slow warming and cooling rates of the gel.

The same container of gel used earlier was warmed in a water bath overnight to 37°C as confirmed by a thermometer placed within the gel. Two standard mercury laboratory thermometers were again placed under a radiant warmer adjusted to maintain constant temperature readings of 37°C. Prewarmed gel (9.7 g) was removed from the bath and immediately layered over one thermometer bulb. Changes in temperature readings are depicted in Figure 2. Despite the prewarming of the gel, the temperature reading in the thermometer within the small sample of gel dropped 6.0°C in 30 s and 7.6°C in 60 s. Further cooling occurred at a much slower rate, although the temperature remained well above room temperature (23.8°C at 3 m from the warmer). A parallel study was performed with prewarmed gel and thermometers in infant incubators in 37°C with and without fully humidified atmospheres. These studies (Fig. 3) also revealed rapid initial temperature declines but the slopes were less steep (especially in the fully humidified atmosphere) and temperature plateaus occurred at higher temperatures than under the radiant warmer. This suggests that the gel cooled at least partially by evaporation. In all cases, the plateau temperature with prewarmed gel was 4–6°C warmer than room temperature. Prewarming the gel therefore resulted in a higher temperature than unwarmed gel after 10 min, even under a radiant warmer at maximal heat output. Although imperfect, prewarming the coupling gel should decrease neonatal heat loss during sonography. Gel should be removed promptly from the scalp at the conclusion of the study.

OTHER ENVIRONMENTAL CONCERNS

It is often necessary to darken the nursery to visualize the ultrasound image optimally as it appears on the screen. Although most patients in a

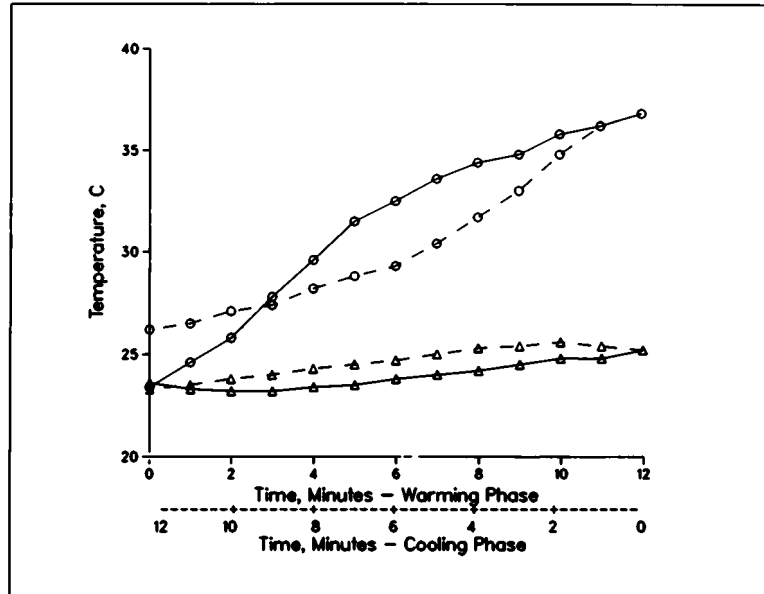


FIGURE 1. Temperature changes recorded by a thermometer whose bulb was covered with coupling gel stored at room temperature (Δ) and thermometer with uncovered bulb (\circ) during 12 min of warming (—) under radiant warmer at maximal heat output and subsequent 12 min of cooling (----) after the warmer was extinguished.

neonatal intensive care unit are adequately monitored for the detection of apnea and bradycardia, subtle changes in skin color, respiratory effort, or perfusion are more difficult to see in dim lighting. Patient alarms or electrode leads may be disconnected temporarily during the performance of an ultrasonogram to gain better access to the patient or to silence an overly sensitive alarm. When lights are also dimmed, this could delay the detection of cyanosis, apnea, or bradycardia. One must re-

member to reactivate the alarms on completion of the procedure.

SUMMARY

Neonatal sonography is generally considered safe at the intensities used for diagnosis. The ability to perform the study in the nursery at the bedside minimizes the environmental stresses on the baby.

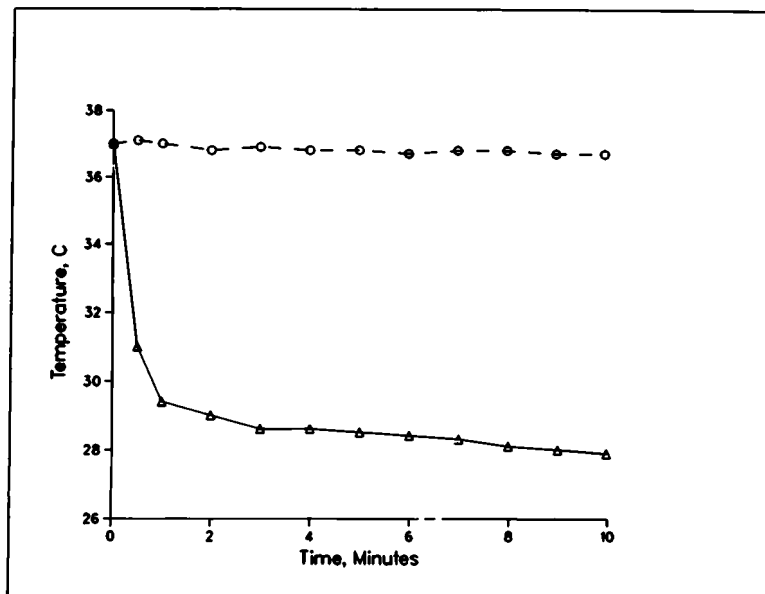


FIGURE 2. Temperature changes recorded by parallel thermometers pre-equilibrated at 37°C under a radiant warmer with (Δ) and without (\circ) application of coupling gel prewarmed to 37°C to thermometer bulb.

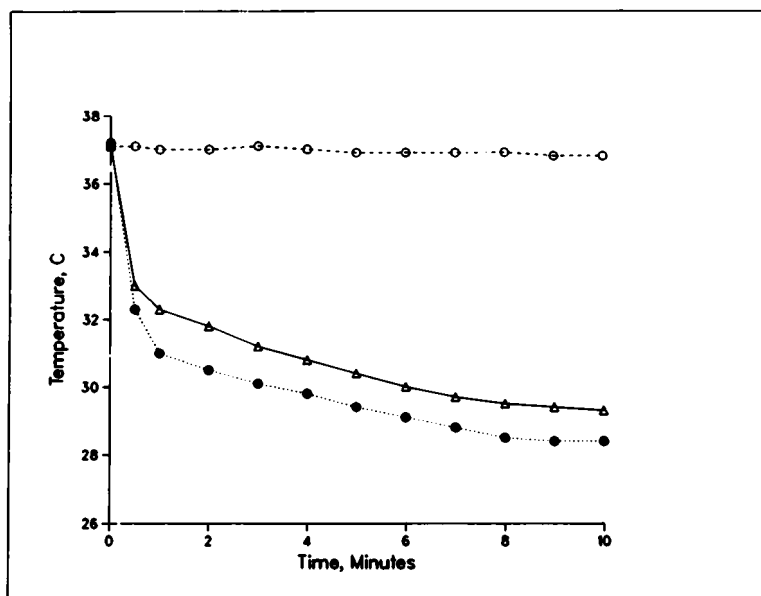


FIGURE 3. Temperature changes recorded by thermometers preequilibrated at 37°C within an infant incubator with ambient humidity (●) and >90% humidity (▲) after application of gel prewarmed to 37°C to thermometer bulbs. Temperature changes recorded by parallel thermometers without coupling gel (○) were nearly identical at both humidities; therefore, only one curve is shown for both.

However, the examination is not completely without stress to the infant.

The sonographer does invade the environment of the preterm infant and should be aware of the potential problems that we have cited. These hazards may be obvious to many, and we do not wish to discourage the use of diagnostic ultrasound in the neonatal nursery. The sonographer, being more aware of potential environmental stresses to the neonate, will be able to reduce their occurrence.

Simple precautions include minimizing head and neck movement that might move the endotracheal tube position, minimizing the pressure of applying the transducer on the fontanel, using prewarmed coupling gel and removing it after scanning to reduce evaporative heat loss through the scalp, careful handwashing, and wiping of the transducer with 70% isopropyl alcohol or 2% alkalized glutaraldehyde between studies to kill bacteria and viruses that can survive on hands, plastic surfaces, and in coupling gel.

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