Objective: To identify the presence of residual blood and organic matter on "clean" stethoscopes in maternal-infant units.

Design: In this retrospective, nonexperimental study, stethoscopes were tested using qualitative measurements.

Setting: Using a nonprobability sampling technique, 11 acute care hospitals in a three-state area of the southwestern United States were studied.

Participants: All stethoscopes found on the maternal-infant units were included, for a total sample size of 97.

Instruments: A hand-held 10-power lens was used to visually rank the amount of organic buildup, and the phenolphthalein test was used to detect residual blood on the stethoscope.

Results: Of 97 clean infant stethoscopes, 80% of labor and delivery and 72% of nursery stethoscopes had organic buildup on the diaphragm. Both areas had similar rates of organic buildup, $\chi^2 (1, N = 97) = 1.00, p = ns$. Nursery areas did have significantly lower rates of residual blood than stethoscopes from labor and delivery, $\chi^2 (1, N = 97) = 9.89, p = .002$. Seventy-six percent of labor and delivery stethoscopes were positive for blood, as compared to 46% of nursery stethoscopes.

Conclusions: Traditional methods for cleaning stethoscopes used in labor and delivery and nursery areas are ineffective in removing blood and other body fluids from the stethoscope.

Since the 1980s, health care personnel have become more aware of the inherent risk of disease transmission caused by blood-borne pathogens. In response to this threat of transmission, the Centers for Disease Control and Prevention (CDC) issued recommendations that all health care personnel take precautions to avoid direct contact with blood and body fluids (1987). All body fluids are now considered potentially contaminated with pathogens, and standard precautions are observed with all patients, regardless of their health status. In maternal-infant areas, stethoscopes used on newborns come in direct contact with blood and other body fluids on a daily basis. In addition, because of the tenacious nature of this admixture (i.e., vernix, amniotic fluid, meconium, and blood), routine cleaning procedures may prove ineffective in removing blood and body fluids. If this mixture remains on the stethoscope despite cleaning, a special environmental hazard could exist. Because of the theoretical transmission of viral pathogens, health care workers in maternal-infant areas must again consider equipment contamination and evaluate the presence of blood and other body fluid contaminants that may remain despite cleaning.

In the current study, the cleanliness of stethoscopes used on newborns in the delivery and nursery areas was investigated. In a naturalistic setting, a nonexperimental, two-group, post-test design was implemented to determine the presence of organic buildup and residual blood on stethoscopes in maternal-infant areas.

Theoretical Framework

The theory of germ transference was used to underscore the importance of environmental effects on the spread of infection. Historically, nursing has sought to manipulate the environment by preventing or decreasing exposure to infectious
Because of the tenacious nature of the mixture of vernix, amniotic fluid, meconium, and blood, routine cleaning procedures of stethoscopes may prove ineffective in the removal of blood and body fluids.

Materials as a method for improving the health of the individual. The link between equipment contamination, subsequent cleaning methods, and pathogens found in blood and other body fluids was used as the basis for assessing contamination in maternal-infant areas.

Research Questions
The following research questions are addressed by the current study:

1. What is the incidence of organic buildup on the diaphragms of the stethoscopes?
2. What is the incidence of residual blood on the diaphragms of the stethoscopes?
3. What is the relation between organic buildup on stethoscopes and the incidence of residual blood?
4. What are the differences between the labor and delivery and nursery areas in rates and proportions of organic buildup and residual blood?

Threats to Validity
Three threats were identified that could have affected the external, internal, or construct validity of the study or its statistical conclusion. Methodologic controls were built into the study to minimize these limiting effects. Identified threats include the Hawthorne effect, instrumentation, and construct validity. To minimize the Hawthorne effect, nurse managers were asked not change their cleaning practices until after data were collected. To minimize threats of instrumentation and construct validity, sensitivity and specificity trials were conducted each day before data collection.

Review of the Literature
Not until the mid-19th century did scientists begin to connect environmental influences with health. Previously, contagion was thought to spread through the air. No connection was made until the 1850s regarding hand-to-hand contact and subsequent spread of infection. Health care professionals now understand the association between direct contact and transfer of organisms and perform measures to decrease the spread of infection. Unfortunately, not all such measures are completely effective. Hospital equipment remains a common source of iatrogenic infection in the hospitalized patient (Fereres, 1988). Newborns are particularly susceptible to iatrogenic infection because of their loss of skin integrity related to postmaturity, an immature immune system, and increased permeable skin related to poor keratinization (Donowitz, 1993).

Since the 1970s, stethoscopes have been studied for bacterial contamination. From these studies it is known that stethoscopes harbor bacterial pathogens and are a significant source in the spread of methicillin-resistant strains of Staphylococcus (Boo, Wong, & Khoo, 1989; Breathnach, Jenkins, & Pedler, 1992; Garner & Rimland, 1982; Gerken, Cavanagh, & Winner, 1972; Jones, Hoerle, & Riekse, 1993; Smith, Mathewson, Ulert, Scerpella, & Ericsson, 1996; Widmer, Pfaller, & Wenzel, 1991; Wright, Orr, & Porter, 1995).

Some of these studies also showed that simple cleaning with a germicidal significantly decreases the bacterial load (Boo et al., 1989; Breathnach et al., 1992; Garner & Rimland, 1982; Gerken et al., 1972; Wright et al., 1995). However, these authors sampled stethoscopes from areas in the hospital where direct contact with blood and body fluids did not occur routinely. From the literature, it is clear that the removal of organic material before disinfection is essential. Organic material can inactivate the effect of the disinfectant (Hoffman, 1987; Rutala, 1993; Simmons, 1983).

Guidelines for cleaning equipment are somewhat vague. Cleaning is defined as the physical removal of organic material or soil (Rutala & Weber, 1993). Disinfection is defined as the elimination of pathogenic microorganisms, except endospores (Rutala & Weber, 1993). It also renders an object noninfectious (Hoffman, 1987). Cleaning is intended to physically remove virulent materials rather than to kill or destroy them as in the case of disinfection. Interestingly, for proper disinfection, Hoffman (1987) recommends soaking instruments in a germicidal for a minimum of 10 minutes, provided they are scrupulously clean.

Because of the concern over exposure to blood and body fluids, researchers have begun to assess equipment contamination in a new light and have found disturbing results. Studies are beginning to surface that demonstrate equipment contaminated with blood. Beaumont (1987) sampled nonporous surfaces of an autopsy suite and found residual blood on a variety of environmental surfaces that did not come in contact with cadavers. In a study on residual blood in the central sterile area of the hospital, Kennedy and Gwaltney (1988) found that 60% of instruments considered “clean but not sterile” had residual blood contaminants, and 15% of gloved hands of workers were also contaminated with residual blood. In 1990, Forseter, Joline, and Wormser sampled 102
tourniquets and found that 30% tested positive for blood, even though no blood was apparent. When the staff were queried, 86% stated that they reused tourniquets without cleaning them between uses on different patients. In summary, blood has been found on equipment or environmental surfaces in areas where blood and other body fluids are prevalent.

Because of such research results showing the positive growth of pathogenic flora, the need for removal of organic material from equipment prior to disinfection, and the presence of residual blood on surfaces previously thought clean, health care professionals must realize that stethoscopes exposed to blood and body fluids may pose a threat of cross-contamination.

Methods

Sample
A nonprobability convenience sample was obtained. Because the accessible population of stethoscopes in each hospital was small (3–20), multiple sites were included. Steps were taken to decrease the chance of biased selection by increasing the geographic area and the urban/metropolitan differences within each geographic area. All stethoscopes used for newborn assessment on the unit the day of data collection were sampled. A minimum sample size of 87 was necessary to obtain a priori levels of power (0.80, \( p = .05 \)), and a calculated effect size, \( (w) = 0.30 \), which were based on Cohen's \((1988)\) sample size tables for chi-square analyses. The final sample consisted of 97 stethoscopes from 11 different hospitals in the southwestern United States.

Instruments
The instrument used to visualize the organic buildup was a 10-power hand lens. Stethoscopes were inspected visually, and rank ordered as to the amount of buildup seen. The categories included none, mild, or gross amount of buildup present. Descriptive criteria for each category of organic buildup are presented in Table 1. To verify that the white-to-yellowish matter seen on stethoscopes with the hand lens or the unaided eye was organic, drops of hydrogen peroxide (H\(_2\)O\(_2\)) were applied to those stethoscopes. This produced bubbles, indicating that the matter was indeed organic.

The instrument used to indicate the presence of residual blood was a catalytic chemical test called the phenolphthalein test. Catalytic tests for blood are based on the premise that hemoglobin exhibits a peroxidase-like activity. Hemoglobin catalyzes or "speeds up" oxidation when hydrogen peroxide is added to the sample, and its color changes almost immediately.

Before each day's data collection, sensitivity and specificity tests were conducted to ensure that the test solution provided reliable and valid results. To rule out false-positive results, all materials and items coming in contact with stethoscopes or stethoscope parts were tested. They included latex gloves, cotton swabs, metal parts in stethoscopes, used stethoscopes from medical areas, new unused stethoscopes, various diaphragm

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**TABLE 1.**

Criteria for Categorizing the Amount of Organic Buildup Seen on Stethoscopes

<table>
<thead>
<tr>
<th>No buildup seen (1)</th>
<th>Mild amount seen (2)</th>
<th>Gross amount seen (3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No organic buildup seen in crevices, edges, or disc of the diaphragm, and no discoloration seen on the diaphragm disc with aid of 10-power magnifying hand lens.</td>
<td>Organic buildup seen in crevices, edges, or disc of the diaphragm with the aid of 10-power magnifying hand lens.</td>
<td>Organic buildup and/or discoloration seen on diaphragm disc without the aid of the 10-power magnifying hand lens (i.e., seen with the human eye).</td>
</tr>
</tbody>
</table>

Discoloration may be seen on diaphragm with aid of 10-power magnifying hand lens.
TABLE 2. Description and Coding of Phenolphthalein Residual Blood Test

<table>
<thead>
<tr>
<th>Negative (0)</th>
<th>Positive (1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No pink shading on the cotton swab within 45 seconds after the application of phenolphthalein and hydrogen peroxide ($H_2O_2$).</td>
<td>Any shade of pink color on the cotton swab obtained less than 45 seconds after the application of phenolphthalein and hydrogen peroxide ($H_2O_2$).</td>
</tr>
</tbody>
</table>

discs, and the distilled water used during sampling. Ger-
icides at each institution also were tested. They in-
cluded alcohol pads, hypochlorite solutions, Sparquat (Spartan Chemical Company, Inc., Maumee, OH), Lysol (National Laboratories L & F Products, Montvale, NJ), Septisol (Steris Corporation, St. Louis, MO), TOR (Hun-
tington Laboratories Canada, LTD., Bramalea, Ontario, Canada), and Wex-cide (Wexford Labs, Inc., Kirkwood, MO). No false-positive results were obtained from the materials or germicidal. To rule out false-negative re-

Results

Description of the Sample

The sample consisted of 97 “clean” stethoscopes collected from 11 hospital sites. Of the 97 stethoscopes tested, 51 were from labor and delivery (L&D) areas. Forty-six stethoscopes were collected from nurseries where their stethoscopes were not used in L&D areas. A variety of stethoscope brands and styles was inspected. Stethoscope brands included BMS (Omron HealthCare Inc., Schaumburg, IL); Littman (3M Company, Hewlett-Packard, Palo Alto, CA); Sprague-Rappaport, a type of design; and others.

Characteristics of the Setting

Five hospitals were in urban areas, and six in a large metropolitan area. Haupt and Kane (1991) define metropolitan as a large concentration of population, usually an area of 100,000 or more people. The median number of deliveries at each institution was 850 per year, with a range of 150 deliveries per year at the smallest hospital to 1,850 deliveries per year at the largest hospi-
tal. Five hospitals had labor, delivery, and recovery (LDR) units, and six hospitals had labor, delivery, recov-
er, and postpartum (LDRP) units. Three hospitals did not have a nursery, but the remaining eight hospitals had a separate nursery unit.

Of the 11 hospitals sampled, most ($n = 9$) cleaned their stethoscopes by wiping them with alcohol pads. Two institutions sprayed a gluteraldehyde germicide on the stethoscope, then wiped it with a washcloth.

Analysis of Study Question #1

Of the 97 stethoscopes tested for the presence of organic buildup, 24% had no visible organic buildup on the diaphragm disc ($n = 23$), 54% had mild amounts of organic buildup ($n = 52$), and 23% had gross amounts of buildup that could be seen with the unaided eye ($n = 22$) (see Figures 1 and 2). Because any amount of organic material left on an instrument is unacceptable, the cate-
gories “mild” and “gross amount” were collapsed into one category and subsequent analyses were done with “buildup present,” and “buildup absent.”

The sample was then divided between LDR/LDRP units ($n = 51$) and nursery units ($n = 46$). Frequency analysis showed that 80% of L&D stethoscopes had organic buildup ($n = 41$), and 72% of stethoscopes from newborn nursery had buildup ($n = 33$).
FIGURE 1.
Photograph of the diaphragm side of a neonatal stethoscope showing the dark outer metal ring (approximately seven eighths inch in diameter), and the light fibrous disc. Organic material is white in the photograph and is concentrated in the groove between the outer metal ring and disk. This stethoscope was considered clean and ready for use.

Analysis of Study Question #2
Of the 97 stethoscopes tested for residual blood, 62% were positive for detectable amounts of blood ($n = 60$). When analyzed by group, 76% of L&D stethoscopes ($n = 39$) had residual blood on them, and 46% of stethoscopes ($n = 21$) in the newborn nursery areas were positive for residual blood.

Analysis of Study Question #3
To determine the association of organic buildup with residual blood, a contingency table was constructed and the chi-square test for independence was computed. As Table 3 shows, there was a significant association between organic buildup and residual blood.

Surprisingly, nursery areas were just as likely to have organic contaminant on their stethoscopes as labor and delivery or labor, delivery, recovery, and postpartum areas.

Analysis of Study Question #4
Do stethoscopes in the L&D area have more organic buildup and blood on them than those in the nursery? Because stethoscopes used in LDR/LDRP come in direct contact with newborn infants covered in vernix, amniotic fluid, blood, and meconium, one would expect that the rates for organic buildup and residual blood would be higher in this area than in the nursery. Yet analysis revealed that no difference was found in the rates of organic buildup between L&D and nursery areas (see Table 4). Nursery areas are just as likely to have organic buildup on their stethoscopes as are L&D areas.

However, there was a difference in the rate of residual blood between the two areas tested (see Table 5).

TABLE 3.  
Association Between Residual Blood and Organic Buildup

<table>
<thead>
<tr>
<th>Amount of Buildup</th>
<th>Presence of Blood</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Negative</td>
<td>Positive</td>
<td>Total</td>
</tr>
<tr>
<td>Absent</td>
<td>14</td>
<td>9</td>
<td>23</td>
</tr>
<tr>
<td>Present</td>
<td>23</td>
<td>51</td>
<td>74</td>
</tr>
<tr>
<td>Total</td>
<td>37</td>
<td>60</td>
<td>97</td>
</tr>
</tbody>
</table>

Note. $\chi^2 (df = 1, N = 97) = 6.5989, p = .010$. Odds ratio = 3.64.

TABLE 4.  
Differences Between Two Maternal-Infant Areas and Organic Buildup

<table>
<thead>
<tr>
<th>Maternal-Infant Area</th>
<th>Buildup</th>
<th>Labor &amp; Delivery</th>
<th>Nursery</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Absent</td>
<td>10</td>
<td>13</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Present</td>
<td>41</td>
<td>33</td>
<td>74</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>51</td>
<td>46</td>
<td>97</td>
<td></td>
</tr>
</tbody>
</table>

Note. $\chi^2 (df = 1, N = 97) = 1.001, p = ns.$
TABLE 5.
Differences Between Two Maternal-Infant Areas and Residual Blood

<table>
<thead>
<tr>
<th>Maternal-Infant Area</th>
<th>Labor &amp; Delivery</th>
<th>Nursery</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative</td>
<td>12</td>
<td>25</td>
<td>37</td>
</tr>
<tr>
<td>Positive</td>
<td>39</td>
<td>21</td>
<td>60</td>
</tr>
<tr>
<td>Total</td>
<td>51</td>
<td>46</td>
<td>97</td>
</tr>
</tbody>
</table>


Stethoscopes in the L&D area were almost four times as likely to have residual blood on them as stethoscopes used in nursery areas.

Discussion

Although there are numerous studies in the literature investigating bacterial contamination of stethoscopes, no previous studies relating to blood and body fluid contamination of stethoscopes were found. This study documented that 72–80% of stethoscopes used in maternal-infant areas are contaminated with organic matter and 46–76% of stethoscopes still have residual blood on them despite routine cleaning. Nursery areas were just as likely to have organic buildup on the stethoscope, but were less likely to have blood on them. A reason for this might be that infants transferred to the nursery have been dried off and most of the blood has been removed, whereas vernix still remains on their skin.

The significant association between organic buildup and residual blood indicates the presence of organic buildup increases the likelihood of finding residual blood. The strength of the relationship, as measured by the odds ratio, indicates that there is 3 1/2 times more likelihood that blood will be on the stethoscope if buildup is present. Intuitively, this relationship is easily understood. The tenacious nature of vernix and other body fluids that remain on the stethoscope after routine cleaning also makes it difficult to remove blood from the diaphragm disc and crevices.

Even stethoscopes with no detectable amounts of organic buildup had residual blood on them. It is interesting to note that of the 23 stethoscopes that looked clean through a hand lens, 9 tested positive for residual blood.

Limitations of the Study

Because this study used a nonexperimental design, selection bias may have occurred and may affect the generalizability of the results. Therefore, results must be tempered with the knowledge that this sample of stethoscopes may be different than stethoscopes found in other hospitals. In addition, the age of the stethoscopes and the amount of use could not be determined. These factors could affect the amount of residual buildup.

Implications for Nursing

From these results, it appears that wiping with alcohol pads or spraying with germicides and wiping with washcloths are not effective methods for cleaning stethoscopes habitually exposed to gross amounts of blood, amniotic fluid, vernix, and other body fluids. Therefore, recommended changes in cleaning practices include the following:

1. Physical removal of all organic matter is necessary before disinfection. Maternal-infant nurses must pay meticulous attention to cleaning the surface and the crevices of stethoscopes to eliminate organic matter associated with delivery. Possible methods for removal of organic matter include use of brushes to get into crevices or taking them apart and cleaning (which can be laborious and time consuming).

2. After organic matter is removed, disinfection can begin because stethoscopes are potentially contaminated with virulent organisms. Agency-approved disinfectant such as alcohols, hypochlorites, gluteraldehydes, or phenolics are effective agents. However, the length of time the stethoscope has to be in contact with the disinfectant must be established.

3. If organic matter remains despite the application of disinfectants, the stethoscope should be considered contaminated because organic material inactivates disinfectants.

4. Visual inspection of the stethoscope for organic material is not sufficient grounds for determining if blood is present on the stethoscope. Several stethoscopes looked clean yet were positive for residual blood. Therefore, meticulous attention

Because of a variety of factors (i.e., frequency of exposure, type of body fluids, and stethoscope design), traditional methods for cleaning stethoscopes used in maternal-infant areas are ineffective.
circumstances. The frequency of exposure and type of stethoscopes also come in direct contact with blood, from an infected infant to others is theoretically possible. Body fluids can transmit lethal organisms given the right conditions and current cleaning methods have been shown to be ineffective, future studies may concentrate on replication and/or interventions to address this problem. Possibilities include development and testing of (a) cleaning techniques, (b) stethoscope designs, and (c) disposable stethoscope coverlets.

Another topic for future research could involve determining the effect an enriched medium such as blood, amniotic fluid, and meconium, plus a moisture retaining medium (vernix caseosa) has on the length of time pathogens such as human immunodeficiency virus (HIV), hepatitis B virus (HBV), or hepatitis C virus (HCV) survive on environmental surfaces. We know that inorganic surfaces do not facilitate cell life—however, what effect does this medium have on the length of survival of pathogenic organisms?

One study does not provide sufficient evidence to support a change in practice; other studies must replicate these results. Although sampling was done in a wide geographic area and the hospitals came from urban and metropolitan areas to decrease the chance of bias, replicating using probability sampling techniques could provide further evidence of the need to change practice.

The results of this study raise questions as to the possibility of blood contamination on other pieces of equipment commonly used in the maternal-infant area. Any equipment that is reusable (e.g., transducers, internal electrode leg plates, etc.) should be suspected of blood contamination. Research extending the focus to other equipment is needed.

Since residual blood was found on several stethoscopes even when no buildup was visibly present, evaluation of stethoscopes in other areas such as emergency departments and emergency response vehicles, where stethoscopes also come in direct contact with blood, might warrant further investigation.

In conclusion, the potential cross-contamination from an infected infant to others is theoretically possible. Body fluids can transmit lethal organisms given the right circumstances. The frequency of exposure and type of body fluids coming in contact with the stethoscope, coupled with the design, make it difficult for residual matter and blood to be removed effectively. Reevaluation of this common piece of equipment has shown that problems with cleanliness exist. Changes in cleaning practices, development of new stethoscope designs, introduction of disposable coverlets, or the creation of new assessment techniques may be needed to deal effectively with this problem.

REFERENCES


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