

**Capt Susan Marie Perry, CRNA, MSN,  
USAF, NC**

San Antonio, Texas

**W. Patrick Monaghan, SBB, CLS, PhD**

Bethesda, Maryland

# THE PREVALENCE OF VISIBLE AND/OR OCCULT BLOOD ON ANESTHESIA AND MONITORING EQUIPMENT

*The Occupational Safety and Health Administration (OSHA) and the Centers for Disease Control and Prevention (CDC) have attempted to stop the spread of blood-borne pathogens by issuing several recommendations and regulations. However, unless healthcare workers comply with these standards, they are not effective. In the anesthesia care environment, the anesthetist is responsible for ensuring that the equipment is clean, and disinfected, before use. We studied the prevalence of visible and occult blood on 6 types of anesthesia and monitoring equipment identified as ready for use in 28 operating suites, in 2 facilities.*

*The sample consisted of 336 observations of the 6 types of equipment. The equipment was inspected for visible blood and then tested for occult blood using a 3-stage phenolphthalein test. Of the 336 observations, 110 (32.7%), were positive for occult blood with only 6 showing visible blood. The presence of blood on this equipment may be in direct violation of the OSHA Blood-borne Pathogen Standard and the infection control guidelines of the American Association of Nurse Anesthetists. Furthermore, the presence of blood on this equipment may increase the risk for nosocomial and occupational exposure to viral and bacterial pathogens. Recommendations were made to decrease the risks from this contamination by redesigning equipment, increasing the use of disposable equipment, and ensuring compliance with effective infection control practices.*

**Keywords:** Anesthesia, anesthesia equipment, contamination, decontamination, occult blood.

## Introduction

**T**he problem of cross-infection is ubiquitous. As early as 1859, medical experts were entreating their colleagues, as well as their patients, to use asepsis to guard against the spread of disease.<sup>1</sup> With the advent of the human immunodeficiency virus (HIV) epidemic, there is renewed interest in, and emphasis on, preventing the spread of blood-borne pathogens.

This new interest spawned regulations and new guidelines from the Centers for Disease Control and Prevention (CDC), the Association for Professionals in Infection control (APIC), the Occupational Safety and Health Administration (OSHA), the American Society of Anesthesiologists, and the American Association of Nurse Anesthetists.<sup>2-8</sup> These policies and regulations include procedures for cleaning and disinfecting anesthesia equipment; however, regulations are not effective unless they are put into practice. Therefore, to ensure these regulations are followed, the consistent cleaning and decontamination of anesthesia equipment should be assessed routinely for compliance.

In following the recommended procedures for cleaning and disinfecting anesthesia equipment, there are 2 benefits to be realized. First, is the prevention of nosocomial infections among patients, and second, is the reduction of the risk of blood-borne pathogen exposure among healthcare workers, including anesthesia staff.

Although anesthesia staff generally take precautions when they know a patient has a particular infectious disease, many may not always take precautions with patients not known to be infected with these diseases.<sup>9,10</sup> According to OSHA and the CDC, healthcare

workers must assume that there is the potential for all patients to be infected with a blood-borne pathogen such as HIV or hepatitis B virus (HBV). This is the basis for universal precautions and governs the way contaminated equipment must be disinfected. Due to the lag time between the contracting of HIV or the hepatitis B virus (HBV) and the onset of symptoms, the patient may be contagious and unaware of his or her disease status. Therefore, reducing the exposure to all blood or body fluids is the only reliable means of effectively reducing the risk of contracting a blood-borne disease.<sup>2,6,11</sup>

The purpose of the present study was to determine the prevalence of visible and/or occult blood on anesthesia equipment and monitoring equipment identified as ready for use. The presence of blood would indicate that the equipment was not cleaned and/or disinfected adequately.

## Materials and methods

Data for the study were collected from 2 hospitals in the mid-Atlantic region. Each institutional review board was given a copy of the research proposal. However, they both ruled that as no human or animal subjects were involved, their approval was not necessary. One hospital was a military medical treatment facility, and the other was a civilian facility. Twenty-eight operative suites were used for the study, allowing for a total of 336 samples. The equipment tested consisted of ventilator control knobs and switches, flow meter knobs on the anesthesia machine, dials on the volatile agent vaporizers, electrocardiograph cables, pulse oximeter probes (inner and outer surfaces), and noninvasive blood pressure cuffs (inner and outer surfaces).

Before the first case of the day, a

visual inspection was made of the identified samples of anesthesia equipment in each operative suite to determine whether any blood was visible on the test equipment. All study equipment was wiped with a 70% isopropyl alcohol swab, and each swab was placed into a plastic interlocking bag labeled with the equipment type, the operating room from which it was obtained, the facility where it was obtained, and the study group it represented.

On the first day at each facility, the equipment was reinspected for visible blood at the conclusion of the operative procedure and tested again for occult blood. This procedure was accomplished before any attempt to clean the equipment. The purpose was to identify equipment contaminated during the procedure. On the second day of data collection, the equipment was reinspected and tested immediately before the beginning of the second case, after the staff had completed cleaning the equipment.

Swabs from the samples were tested for occult blood using a modified 3-stage phenolphthalein blood indicator test (Phenolphthalien Test Kit, Cluefinders, Inc, Tampa, Fla). The phenolphthalein test works on the principle of oxidation-reduction. When a sample containing hemoglobin is present, the phenolphthalein reagent on the sample will be oxidized due to peroxidase activity. When hydrogen peroxide is added, the blood will be broken down, the oxygen transferred to the phenolphthalein reagent, thereby oxidizing the phenolphthalein and causing the color to change to pink. The results were recorded as to the presence or absence of visible blood and/or occult blood on the equipment.

The sensitivity of the 3-stage phenolphthalein blood indicator test was evaluated by examining the results of serial dilutions. These results showed the sensitivity of the modified 3-stage phenolphthalein blood indicator test to be 1:10,000 at 60 seconds.<sup>12</sup> Reliability was verified further by using a bloodstain control card, supplied by the (Cluefinders) kit manufacturer. When tested with a sample of the researcher's blood, the color change was noted within 5 seconds. To rule out a false positive result, the reagents were tested by exposing them to clean alcohol swabs. It was noted that after placing the reagents on clean 70% alcohol swabs, a pink color could be observed faintly at the end of approximately 2 minutes. For this reason, the swabs were read for color change within 60 seconds of placing the reagents. Any color change occurring after this time would be disregarded.

All results were recorded as positive or negative for visible or occult blood. The collected data were analyzed, and percentages were computed based on the

number of positive results. The standard error of a proportion of rates of occurrence was calculated to determine the significance ( $P < .01$ ).

## Results

A total of 336 pieces of anesthesia equipment were sampled. This included 180 samples taken before the first case of the day, 78 samples taken immediately following the first case of the day, and 78 taken immediately before the second case of the day. Of these samples, a total of 110 (32.7%) were positive for blood when tested with the phenolphthalein blood indicator test.

Before the first case of the day, 64 (35.5%) of the 180 samples were found to be positive for occult blood. Only 1 specimen was positive for visible blood. Immediately after the first case of the day, occult blood was present on 23 (29.5%) of the 78 samples. Visible blood was found on 2 pieces of equipment in this sample group. Before the second case of the day, occult blood was present on 23 of the 78 samples (29.5%), with 3 positive for visible blood. Analysis by facility showed that 27.4%, or 56 of the 204 samples taken from facility number 1 were positive, and 40.9%, or 54 of the 132 samples taken from facility number 2 were positive. All equipment displaying visible blood was present at facility 2. These results are noted by facility and equipment type in Tables 1 through 3.

Of all anesthesia equipment surfaces tested, 32.7% were positive for blood contamination. These results

**Table 1. Prevalence of blood on anesthesia equipment and monitoring equipment at facility 1 (n = 204)**

Equipment surfaces	Sample total	Visible blood	Occult positive	Percentage positive
Ventilator controls	34	0	8	23.5
Flow meter knobs	34	0	14	41.2
Vaporizer controls	34	0	7	20.6
Electrocardiograph monitor cables	34	0	18	52.9
Pulse oximeter probes	34	0	6	17.6
Blood pressure cuffs	34	0	3	8.8
<b>Total</b>	<b>204</b>	<b>0</b>	<b>56</b>	<b>27.4%</b>

indicate that anesthesia and monitoring equipment is being contaminated with blood, and that this equipment is not being adequately cleaned and/or disinfected adequately before it is used for another patient. The results of this study are similar to those reported by Hall<sup>13</sup> in 1994. Hall examined 19 surfaces using the phenolphthalein blood indicator test and found that 33% of the surfaces were positive for blood.

Neither facility observed in the present study had written guidelines for specifically cleaning or disinfecting this equipment between cases. When asked about the cleaning practices, staff members responsible for cleaning at each facility reported that they "looked at the equipment and cleaned it if it was dirty." The responsibility for cleaning the room was different at each facility. At facility 1, the operating room nurses and technicians were responsible for cleaning the operating room, and at facility 2, the cleaning was shared by the housekeeping and operating room staff members.

In addition to the occult blood that was found during the testing, the alcohol swabs also picked up dust and dirt from the equipment tested before the first case of the day. This indicates that the equipment had not been cleaned enough to remove even surface dust.

Visibly inspecting the equipment for blood is not a reliable means for determining which equipment requires decontamination. In the present study, only 6 of the 336 samples were positive for visible blood,

**Table 2. Prevalence of blood on anesthesia equipment and monitoring equipment at facility 2 (n = 132)**

Equipment surfaces	Sample total	Visible blood	Occult positive	Percentage positive
Ventilator controls	22	0	6	27.3
Flow meter knobs	22	0	5	22.7
Vaporizer controls	22	0	8	36.4
Electrocardiograph monitor cables	22	4	14	81.8
Pulse oximeter probes	22	1	4	22.7
Blood pressure cuffs	22	1	11	54.5
<b>Total</b>	<b>132</b>	<b>6</b>	<b>48</b>	<b>40.9%</b>

while testing revealed that 110 were contaminated with blood. The dark surfaces of the anesthesia ventilator and vaporizer controls, the blood pressure cuff surfaces, and the pulse oximeter probes make the presence of blood difficult to observe with the naked eye. The electrocardiograph (ECG) cables that were positive for blood in 64.3% of samples (36/56) are difficult to clean due to the length and design of the cables and the cable housing. In addition, the surfaces of the anesthesia machine are not designed for easy cleaning.<sup>13</sup>

The study facilities used different brands of anesthesia machines. The percentage positive by machine type is given in Table 3. There were differences between machine types. The machines are designed differently; however, they were also at different facilities and, therefore, possibly cleaned differently. No conclusions are made about the machine type.

### Discussion

The results of the present study demonstrate that the anesthesia equipment at each facility was not in compliance with OSHA standards, or with the infection control guidelines of the American Association of Nurse Anesthetists, or American Society of Anesthesiologists. These standards state that all surfaces contaminated with blood or other potentially infectious materials be cleaned and decontaminated with

**Table 3. Prevalence of blood on anesthesia equipment and monitoring equipment, total (both facilities)**

Equipment surfaces*	Percentage (no.) positive	Percentage positive by anesthesia machine type <sup>†</sup>	
		Ohmeda	Narcomed
Ventilator controls	25.0 (14)	23	27
Flow meter knobs	33.9 (19)	40	22
Vaporizer controls	26.8 (15)	20	36
Electrocardiograph monitor cables	64.3 (36)	NA	NA
Pulse oximeter probes	19.6 (11)	NA	NA
Blood pressure cuffs	26.8 (15)	NA	NA

\* Number of samples for each type of equipment = 56.

† Ohmeda, Datex-Ohmeda, Helsinki, Finland; Narcomed, Dräger Medical Inc, Telford, Pa.

NA indicates not applicable.

sodium hypochlorite solution immediately after contamination. In addition, the Standards for Nurse Anesthesia Practice (1989), adopted in 1990, state: "The Certified Registered Nurse Anesthetist shall check the readiness, availability, cleanliness and working condition of all equipment to be utilized in the administration of the anesthesia care." This statement clearly places the responsibility for ensuring a that clean and disinfected equipment be used in the provision of anesthesia services.<sup>6-8</sup>

Although it was beyond the scope of the study to demonstrate the potential for infection from the blood found to be present on the equipment, the potential for acquiring a blood-borne pathogen infection, such as hepatitis B, is increased by the mere presence of blood.<sup>2</sup>

The surfaces of the anesthesia machine tested probably were contaminated by the hands or gloves of anesthesia personnel. By observing the practices of the anesthesia staff, it is easy to track the probable mode of contamination. Immediately after intubation, while still wearing the gloves used for the intubation, (and sometimes the same gloves used to start an intravenous or central lines), the anesthesia providers usually turn on the ventilator and adjust the flow meter and vaporizer dials. After removing the gloves at a later time, anesthetists then touch those same dials throughout the surgery, placing themselves, and the patients they touch, at risk for contracting a blood-borne disease.

To avoid this contamination, and reduce the risk to the patients and themselves, the anesthesia providers should either remove the gloves immediately after intubation or use a double glove technique during intubation. This technique requires that the anesthetist don 2 pairs of gloves. After intubation, 1 pair of gloves is removed before adjusting the anesthesia machine dials. The second pair of gloves also protects the provider from any contamination on equipment that was not adequately cleaned or disinfected after the previous case.

After intubation, the placement of oral or nasal gastric tubes, esophageal temperature probes, and/or oral airways may serve to contaminate the gloves or hands of the anesthetists and, subsequently, the equipment they touch. Therefore, regardless of glove technique, equipment always should be cleaned and disinfected between cases.

The OSHA standards and the infection control policies of medical facilities require that hands be washed immediately after removing gloves or as soon as possible thereafter.<sup>5</sup> However, in the actual operating room, there is no means for washing hands after removing

gloves. This may result in hands contaminated with blood or other infectious materials contaminating other surfaces, including charts, intravenous lines, and equipment. This could be corrected by the placement of a foam cleanser or disinfecting hand towellettes at each anesthesia station.

The surfaces of the anesthesia equipment should be redesigned to allow for easy identification of the presence of blood and for reliable disinfection. This would mean using a lighter color on knobs and dials and altering the surface to eliminate knurls and indentations. The current design of the machines is such that cleaning cannot be ensured easily, even if an attempt is made to disinfect the machine surfaces. To remove blood from the gnarled surfaces and indentations on the knobs would require a thorough wiping technique.

Blood pressure cuffs should be disposable or changed and disinfected between each case. The outer surface of the cuff was where the majority of the occult blood was noted, again pointing to the hands of the staff as the means of contamination. The ECG cables had the highest percentage of positive results, both in the present study and the study reported by Hall in 1994.<sup>13</sup> The ECG cables usually are dropped on the operating room floor after the procedure, and the operating room floor may be contaminated with blood. In addition, the operative site for many patients permits blood to drip down onto the cables. The cables are handled by the anesthesia and surgical staff members during placement and disconnection.

The ECG monitors are perhaps the piece of equipment in the present study most likely to cause patient contamination. They are placed on the patient's body and may be in close proximity to surgical wounds. The ECG monitors and cables ideally should be disposable, and changed between patients, or taken with the patient to the recovery area, and submitted to high-level decontamination before reuse.

Pulse oximeter probes also are easily contaminated with blood. They frequently are moved to various sites by the anesthesia or surgical staff and may be contaminated by hands or gloves. Usually placed on the patient's hand, they are easily contaminated by blood from intravenous or arterial punctures. Disposable pulse oximeter probes are available, but at times, these disposable units are reused in an effort to decrease cost. Pulse oximeters should be disposable, or disinfected between cases.

Each anesthesia department is required to prepare and maintain an infection control policy for its department.<sup>6,7</sup> These policies should include specific instructions for cleaning anesthesia and monitoring equipment between cases and at the end of each day. A

specific anesthesia team member should be tasked with this duty and quality control instituted by the anesthesia staff members themselves to ensure compliance.

The argument against these recommendations will no doubt be the additional cost of purchasing appropriate disposable equipment. An additional argument may be the few extra minutes required between cases for adequate cleaning. Although not demonstrated in the present study, the cost of additional supplies and equipment may pay for itself by a decrease in nosocomial and occupational infections. The risk of blood-borne disease to patients and staff could be decreased dramatically by adequately cleaning and disinfecting the equipment.

Although anesthesia providers have been shown to be at a higher risk than other healthcare personnel for contracting a blood-borne pathogen, several studies have demonstrated the anesthesia provider's lack of compliance with OSHA and infection control guidelines.<sup>10,11</sup> Infection control education should be designed specifically for anesthesia staff and targeted toward the learning style and values of these practitioners to improve their general attitudes toward, and improve compliance with, infection control standards. Effective adaptation of these infection control standards may significantly reduce the high incidence of nosocomial infections presently reported in medical facilities.

## REFERENCES

1. Nightingale F. *Notes on Nursing: What It Is and What It Is Not*. London, England: Harrison and Sons; 1859.
2. Centers for Disease Control and Prevention. Recommendations for prevention of HIV transmission in health-care settings. *MMWR Morb Mortal Wkly Rep*. 1987;36:35-185.
3. Centers for Disease Control. Update: universal precautions for prevention of transmission of human immunodeficiency virus, hepatitis B virus, and other blood-borne pathogens in health-care settings. *MMWR Morb Mortal Wkly Rep*. 1985;37:377-382, 387-388.
4. Rutala WA. APIC guideline for selection and use of disinfectants. *AJIC Am J Infect Control*. 1996;24:312-342.

5. Dorsch JA, Dorsch SE. *Understanding Anesthesia Equipment: Construction, Care and Complications*. 2nd ed. Baltimore, Md: Williams & Wilkins; 1984:430-438.
6. U.S. Department of Labor, Occupational Safety and Health Administration. Occupational exposure to bloodborne pathogens; final rule. C.F.R. Part 1910.1030. 56 *Federal Register*. 64004 (1991): 56:64004-64182.
7. American Society of Anesthesiologists. Prevention of nosocomial infections in patients. *Recommendations for Infection Control for the Practice of Anesthesiology*. 1998. Available at: <http://www.asahq.org/ProfInfo/Infection/01Disinfection.html>.
8. American Association of Nurse Anesthetists. Infection control guide. In: *Professional Practice Manual for the Certified Registered Nurse Anesthetist*. Park Ridge, Ill: American Association of Nurse Anesthetists; 1993.
9. O'Donnell NG, Asbury AJ. Perceived risks and preventative measures adopted by anaesthetists: a postal survey. *Anaesthesia*. 1992; 47:923-928.
10. Tait AR, Tuttle DB. Preventing perioperative transmission of infection: a survey of anesthesiology practice. *Anesth Analg*. 1995;80:764-769.
11. Telford GL, Quebbeman EQ. Assessing the risk of blood exposure in the operating room. *AJIC Am J Infect Control*. 1993;6:351-356.
12. Phillips RA, Monaghan WP. The incidence of visible and occult blood on laryngoscope blades and handles. *AANA Journal*. 1997;65:241-246.
13. Hall JR. Blood contamination of anesthesia equipment and monitoring equipment. *Anesth Analg*. 1994;78:1136-1139.

## AUTHORS

Capt Susan Marie Perry, CRNA, MSN, USAF, NC, is a staff nurse anesthetist at Wilford Hall Medical Center, Lackland Air Force Base, San Antonio, Texas. She completed this research while a graduate student at the Graduate School of Nursing, Uniformed Services University of the Health Sciences, Bethesda, Md.

W. Patrick Monaghan, SBB, CLS, PhD, is a professor at the Uniformed Services University of the Health Sciences in the Graduate School of Nursing.

## ACKNOWLEDGMENT

We wish to thank the members of the thesis committee, Maura S. McAuliffe, CRNA, PhD, FAAN; Eugene Levine, PhD; and Virginia K. Saba, RN, EdD, FAAN, for their support during the preparation of the thesis. Also, we thank Barbara A. Goldrick, RN, MPH, PhD, CIC, for her assistance with editing the article prior to submission for publication.

This work was supported by the Uniformed Services University of the Health Sciences Protocol No. TO6143-01. The opinions or assertions contained herein are the private opinions of the authors and are not to be construed as official or reflecting the views of the Department of Defense or the Uniformed Services University of the Health Sciences.