OCCUPATIONAL BLOOD EXPOSURE IN THE OPERATING ROOM

Introduction

This literature review presents an overview of occupational blood exposure in the operating room (OR). Rather than providing an in-depth analysis of the multitude of factors affecting blood exposure in the OR, the purpose is to provide a broad overview of the more current literature in order to facilitate a discussion on ways to advance the field of occupational blood exposure prevention in the OR setting. Topics covered in this review include the following: Definition of the OR, epidemiology of OR exposures, systems approaches to blood exposure reduction (e.g. Standard Precautions and safety climate), and OR-specific approaches to blood exposure reduction (e.g., use of blunt-tipped needles and double gloving). The review ends with a series of questions designed to facilitate discussion of ways to continue to reduce occupational blood exposure in the OR.

The Operating Room

Occupational blood exposure is influenced by numerous factors including setting, environmental factors, staffing levels and characteristics, type of procedure, devices and equipment, and patient characteristics. The OR is a healthcare setting where surgical procedures are performed, and "is controlled geographically, environmentally, and bacteriologically" (Lewis *et al.* 2004, page 378). Surgery can be either planned (elective) or unplanned (emergency). The surgical setting is affected by factors such as procedure complexity, the potential for complications, and the patient's health status (Lewis *et al.* 2004). Surgery may be performed on an inpatient or outpatient basis. Inpatient surgery is performed on patients who have been admitted to the hospital for greater than 24 hours, and is often performed in a designated hospital operating room. Outpatient surgery, also known as same-day or ambulatory surgery, can be performed in the hospital operating room, or in other settings such as emergency departments, specialty clinics, doctors' offices, freestanding surgical clinics, and hospital-based outpatient surgical units (Lewis *et al.* 2004).

While the number and type of surgical staff vary by procedure, the core surgical team consists of the following members: Surgeon, surgical assistant, perioperative nurse, nurse first assistant, surgical technician, and anesthesia care provider. In a teaching setting, surgeries are often attended by various types of students. Each member plays a different and defined role during surgery and thus experiences different levels of risk for blood exposure. Unless otherwise noted, discussions of blood exposure prevention in this review apply to each member of the surgical team.

The unique characteristics of each surgical setting, and arguably, each procedure, affect healthcare workers' risk for blood exposure; however, there are certain common characteristics of the OR environment that increase exposure risk. The Johns Hopkins' report, "Infection Prevention: Guidelines for Healthcare Facilities with Limited Resources" notes:

> *The operating room has special characteristics that increase the chance of accidents. For example, staff often use and pass sharp instruments without looking or letting the other person know what they're doing. The workplace is confined and the ability to see what is going on in the operative field for some members of the team (scrub nurse or assistant) may be poor. There is, moreover, the need for speed and the added stress of anxiety, fatigue, frustration, and occasionally even anger. Finally, there is the fact that exposure to blood often occurs without the person's knowledge, usually not until the gloves are removed at the end of the procedure, which prolongs the duration of exposure. The fact that fingers are frequently the site of minor scratches and cuts further increases the risk of infection with bloodborne pathogens.* (Tietjen et al. 2003, chapter 7, page 3)

Epidemiology of OR Exposures

The 2003 data from the Exposure Prevention Information Network (EPINet) show that in the hospital setting, the highest proportion of percutaneous injuries occurred in the OR, with over 30 percent of all reported hospital sharps injuries occurring in this setting. For nonpercutaneous exposure (e.g. nonintact skin, mucocutaneous), ORs had the second highest rates of exposure, at 16.5 percent of the total (Perry *et al.* 2006). Data collected between 1995 and 2001 from the National Surveillance System for Health Care Workers (NaSH) show that the OR had the second highest number of hospital-based blood exposure events, representing 25 percent of all exposures (CDC 2004). Data collected between 1998 and 2002 from the Duke Health and Safety Surveillance System (DHSSS) show that surgical-OR technical staff sustained the highest rate of percutaneous exposures and the third highest rate of mucocutaneous or skin exposure of all hospital staff (Dement *et al.* 2004). The DHSSS data show that, "exposure rates for surgical-operating room technicians were nearly eight times the average rate for all occupational groups combined" (Dement *et al.* 2004, page 642).

A literature review published in 1997 noted that blood exposure events occur in 6.4 to 24 percent of surgical procedures, and that scrub nurses had the highest rate of percutaneous injuries and operating surgeons had the second highest injury rate (Cardo and Bell 1997). An OR observational study published in 1998 found that attending and resident surgeons had the highest frequency of percutaneous and mucocutaneous exposures, accounting for over 50 percent of all exposures in the OR setting (Jagger *et al.* 1998). It should be noted that these studies were conducted prior to the passage of the 2001 Needlestick Safety and Prevention Act and OSHA's revised Bloodborne Pathogens Standards.

The literature consistently shows that in the OR, the highest proportion of percutaneous injuries are from suture needles (Jaffray and Flint 2003,Berguer and Heller 2004, Perry *et al.* 2006). Other sources of OR exposure include scalpels, hypodermic needles, stylets, scissors, wire sutures, orthopedic equipment (drill bits, screws, pins, saws), needle point cautery tips, skin hooks, towel clips, and forceps (Davis 2001,Tietjen *et al.* 2003). It should be noted that the type of device affects the injury severity, and that scalpels are

more likely to cause severe injury than suture needles (Jagger *et al.* 1998). Injury severity indicates depth of wound and amount of bleeding, with more severe injuries representing a greater risk for exposure and pathogen transmission.

The literature shows different trends as to which specific types of procedures present the most risk for blood exposure. In general, procedures involving high blood volume, poor visibility, and greater length of time are more likely to result in exposure. Examples include cardiac, obstetric, and orthopedic surgeries.

Systems Approaches to Reducing OR Exposures

As noted previously, blood exposure events are related to a combination of factors including the healthcare worker, the environment, and the patient. Thus, instead of focusing on a specific risk factor, some of the most successful measures to reduce blood exposure risk take a systems-level approach, addressing multiple risk factors concurrently. While these systems-level approaches are not specific to the OR, their application can be used to reduce blood exposure risk in this setting. This section presents two main systems-level blood exposure prevention measures— Standard Precautions and safety climate.

Standard Precautions

According to the CDC, "Standard Precautions are designed to reduce the risk of transmission of microorganisms from both recognized and unrecognized sources of infection in hospitals" (CDC 1996). Standard Precautions recognize that transmission can occur from patient to provider and from provider to patient and apply to all patients and providers, *regardless of their disease* status. A brief description of the key elements of the Standard Precautions is outlined below:

Handwashing: Describes when handwashing needs to occur and using what types of agents (plain soap or antimicrobial agents).

Gloves: Describes when gloves need to be worn and changed.

Mask, eye protection, face shield: Describes when to implement face and eye protection.

Patient care equipment: Describes how to handle contaminated or potentially contaminated equipment.

Environmental control: Describes procedures for the care, cleaning, and disinfecting of surfaces.

Linen: Describes the handling of contaminated or potentially contaminated linens.

Occupational health and bloodborne pathogens: Describes the use and handling of sharps and PPE.

Patient placement: Describes appropriate locations for patients.

Standard Precautions have been operationalized through several legislative and regulatory mechanisms. In 2001, Congress passed the Needlestick Safety and Prevention Act. This act mandated that OSHA revise and strengthen the Bloodborne Pathogens Standard (BPS), which outlines specific actions employers are required to take to protect workers from occupational blood exposure. Key elements of the BPS include the following:

- An exposure control plan, including an annual review and incorporation of technological advances designed to reduce exposure risk.
- Input from nonmanagerial employees regarding the selection of safety devices.
- Maintenance of an active log for documenting sharps injuries in addition to other occupational illnesses or injuries. The log must include the device brand and type, incident location, and incident description.
- Implementation of safety devices in the healthcare setting.
- A definition of the terms, "sharps with engineered sharps injury protection" and "needleless systems," which had not been previously defined (OSHA 2001).

Standard Precautions and the BPS serve as the cornerstone of occupational blood exposure prevention in all healthcare settings, including the OR. Beekmann and Henderson note, "thoughtful adherence to universal or standard precautions remains the primary means of preventing occupational exposures and thus reducing occupational risk of acquiring infection with bloodborne pathogens" (Beekmann and Henderson 2005, page 332). These standards hold employers and workers accountable for implementing strategies to reduce or prevent contact with blood; however, research shows that healthcare agencies do not consistently implement or follow the guidelines (McCoy *et al.* 2001). From October 2004 through September 2005, OSHA issued the highest number of citations for violation of the BPS than any other citation category. Of 2,152 OSHA citations, 43 percent were due to BPS violations (OSHA 2005). The most common violations were lack of a written exposure control plan, not using sharps safety devices, inadequate training, and not keeping an exposure log.

A study by Beekmann, Vlahov, and Koziol et. al., found a temporal relationship between the implementation of Standard Precautions and a reduction in percutaneous injuries (Beekmann *et al.* 1994). Despite the proven protective benefits of Standard Precautions, several studies have shown that they are not consistently implemented among healthcare workers. A survey of physicians, nurses, and medical technologists published in 2003 found that many healthcare workers do not follow Standard Precautions. Approximately one-third reported not wearing gloves during an invasive procedure, 30 to 71 percent would recap a needle after use, and 46 to 68 percent did not always wash their hands after patient care. Among those reporting that they never recap needles, physicians had the lowest compliance with not recapping and nurses had the highest compliance (Doebbeling *et al.* 2003). Consistent with other studies, in an observational study of OR personnel during surgery, a 1996 study found that no eye protection was used in 24 percent of the observations. The study also showed that double gloves were worn by only

28 percent of workers observed who were expected to double glove, and that the passage of sharp instruments or devices between members of the surgical team was not announced in 91 percent of the procedures observed (Akduman *et al.* 1999).

Reasons for noncompliance with Standard Precautions include interference with patient care, unanticipated need for implementation of precautions, and high job demands (Ferguson *et al.* 2004). Thus, while Standard Precautions serve as a foundation for the prevention of blood exposure, research shows that they are not always implemented. Many of the surveillance systems in place can track rates and causes of blood exposure and can distinguish exposures that occur in the OR and/or among surgical staff. However, little or no research has been published since the enactment of the BPS that focuses specifically on the effect of implementation of Standard Precautions in the OR.

Safety Climate

Safety climate has been defined as, "the perception that employees have in common about the safety of their work environment" (Zohar 1980). This section provides a summary of the relationship between hospital safety climate and occupational blood exposure. When possible, examples specific to the OR are provided.

Safety climate includes several factors including, "management decision making, organizational safety norms and expectations, and safety practices and procedures" (Gershon *et al.* 2000). Related elements include communication among employees and between employees and management, educational programs and opportunities, systematic review of exposure data, the workers' perceived risk of exposure, job demands, the level of involvement of a safety committee and/or infection control officers, and the availability and use of personal protective equipment (PPE) and safety devices. Safety climate represents the organizational culture related to all factors that affect blood exposure risk.

Research shows a strong relationship between a safety climate that fosters prevention of blood exposures and a reduction in blood exposure events. Table 1 below summarizes the findings of several studies examining the relationship between safety climate and blood exposure.

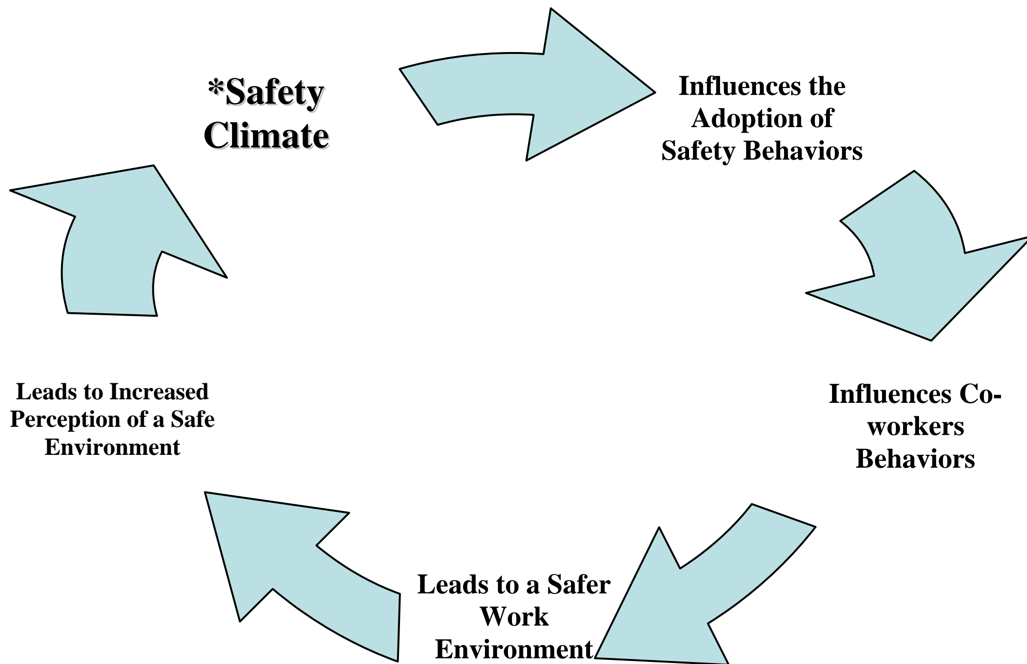
Table 1: Summary of studies on safety climate and blood exposure

Measure of Safety Climate	Effect on Blood Exposure
Study: Vaughn, McCoy, Beekmann et al., 2004 (Vaughn *et al.* 2004)	
Population: Healthcare workers at all non-Federal Iowa general hospitals	
• Infection control personnel hours per FTE • Standard Precaution education • Provision of PPE • Use of needleless intravenous (IV) systems • Management support of safety • Use of "blood and body fluid precaution" patient category • Increased job demands	• Adherence with Standard Precautions increased with the following: High infection control personnel hours per FTE, increased frequency of Standard Precaution education, increased provision of PPE, use of needleless systems, and increased management support • Adherence with Standard Precautions decreased with use of "blood and body fluid precaution" category for patients and increased job demands.
Study: Eagan, Sepkowitz, and Zuccotti, 2004 (Sohn *et al.* 2004)	
Population: NaSH data from a 427-bed tertiary care hospital in Manhattan	
• Organizational implementation of safety-engineered devices to facilitate needle-safe IV delivery, blood collection, IV insertion, and injections	• Mean annual incidence of percutaneous injuries were reduced by over 50 percent • Percutaneous injury rates were reduced for the following activities: Manipulating patients or sharps, collisions or contacts with sharps, disposal-related injuries, catheter insertions, and use of hollow-bore needles.
Study: Gershon, Karkashian, Grosch et. al., 2000 (Gershon *et al.* 2000)	
Population: 789 employees of a large, urban research medical center	
• Management support • Absence of barriers to safe work practices • PPE and safety device availability • Positive staff communication • Worksite cleanliness • Safety-related feedback Also: Demographics, reported compliance with safety practices, exposure incidents	• Workers reported high levels of compliance (greater than 80 percent) for waste disposal, sharps disposal, wearing gloves. Low compliance levels (less than 45 percent) were reported for recapping contaminated needles, wearing disposable face masks, and wearing protective eye coverings. • Adherence to safe work practices was associated with clean work environment, managerial support, absence of job hindrances, being female, and younger age • Reduced exposure incidents were associated with high senior management support, high levels of safety feedback, and training.
Study: White and Lynch, 1997 (White & Lynch 1997)	
Population: OR staff from one university and two community hospitals	
• Development and implementation of hospital-based blood exposure prevention plans following hospital personnel analysis of that hospital's blood exposure surveillance data • Prevention plans were unique to each hospital, but included some of the following activities: Letter sent to hospital staff, encouragement of double gloving, use of leg coverings in surgeries with high blood loss, development of a cart stocked with PPE, development of "no touch" methods for instrument passage	• For all hospitals combined, blood contact rates decreased from 12.3 percent to 7 percent in the year following the implementation of the prevention plans.

In addition to the specific studies described above, numerous other studies have consistently described a relationship between improved safety climate and a reduction in blood exposure events (Holodnick and Barkauskas 2000, Beekmann *et al.* 2001, McCoy *et al.* 2001,Clarke *et al.* 2002, Rivers *et al.* 2003, Lymer *et al.* 2004, Stone *et al.* 2004, Beekmann and Henderson 2005). The Association of Perioperative Registered Nurses

says, “health care organizations and their employees are responsible for actively participating in strategies to reduce percutaneous injuries. The employing facility should provide an environment that reduces the risk of percutaneous injury from contaminated sharp devices. A well-developed safety program and support from management sends a clear message to employees about the organization’s commitment to preventing injuries and keeping employees safe” (AORN 2005, page 201).

Gershon, Karkashian, and Grosch, et al. (2000) developed the model below to explain the relationship between safety climate and worker behavior:



Several public and private institutions and researchers have developed tools for improving safety climate in the hospital setting. Worth mentioning is the CDC’s “Workbook for Designing, Implementing, and Evaluating a Sharps Injury Prevention Program.” This workbook provides step-by-step guidance on how to design and implement a successful sharps injury prevention program. The tools are based on a model of continuous quality improvement and have two main components: (1) organizational steps for developing and implementing a sharps injury prevention program, and (2) operational processes for implementing a site-specific plan. The workbook provides extensive background information on occupational blood exposure and factors influencing risk reduction. It also includes tools that sites can use to guide the development of specific activities and programs (CDC 2004).

The majority of research on the influence of safety climate with regard to occupational blood exposure is not specific to the OR setting. However, factors such as high blood exposure rates, use of sharps, and the presence of blood make the OR a critical environment for maximizing the safety climate. Given the dramatic impact of a positive

safety climate on reducing blood exposure rates in other settings, a systematic analysis of the relationship between safety climate and blood exposure in the OR is warranted.

OR-specific Blood Exposure Prevention Activities

In addition to systems-level approaches to reducing the risk of blood exposure in the OR, three OR-specific practices have been effective at reducing risk: (1) Use of blunt suture needles, (2) double gloving, and (3) neutral or safe zones. A description of each of these practices and their effect on blood exposure is provided below.

Blunt Suture Needles

Because suture needles are involved in the majority of OR percutaneous injuries, the use of blunt needles has been proposed as a way to reduce exposure risk. Blunt needles are curved suture needles with a relatively blunt tip, with several levels of bluntness. According to Tietjen, Bossemeyer, and McIntosh, 2003 (Tietjen *et al.* 2003), "minimally blunt needles can be used for closure of all layers from fascia to skin. Intermediate blunt needles require some additional conscious effort to close fascia, but are safer to use. Very blunt needles are seldom used except when operating deep in the pelvis where the needle absolutely must be retrieved with the fingers" (chapter 7, page 6). Research shows that use of blunt suture needles results in a reduction in percutaneous injuries. A literature review presented by Berguer and Heller, 2004, notes that in prospective, randomized trials, use of blunt suture needles has been associated with substantial reductions in percutaneous injuries during surgery (Berguer and Heller 2004). For example, one study reported a seven-fold reduction in sharps injuries. A 1997 CDC study based on observations of gynecologic surgeries examined the use of blunt suture needles to reduce blood exposure. The study observed 1,464 surgeries using both conventional and blunt needles. Of 61 injuries involving suture needles, 92 percent involved conventional curved needles, 8 percent involved straight needles, and zero involved blunt needles. A logistic regression model found that, "the estimated odds of a PI with a curved suture needle were reduced by 87% when 50% of the suture needles used during the procedure were blunt" (CDC 1997, page 2).

Double Gloving

AORN notes, "glove failure represents a significant risk of exposure to bloodborne pathogens for perioperative personnel. Such failures are more likely to occur during procedures where shearing of glove material is likely and contact with sharp-edged items is common" (Allen 2004). Perforation rates of 40 to greater than 60 percent have been reported for some surgical procedures (Hentz *et al.* 2001). Hentz, Stephanides, and Boraldi et. al. 2001 note that often, glove perforations are not noticed until after the surgical procedure is completed (Hentz *et al.* 2001). Double gloving has been proposed as a way to reduce rates of perforation. In addition, even when perforations occur in double gloving, the amount of blood on the sharp is reduced as it passes through the glove layers, reducing the level of exposure (Jaffray and Flint 2003). Several studies have shown a reduction in percutaneous injuries when double gloving is implemented. Laine and Aarnio, 2001 tested single and double glove integrity over 885 operations. Results showed that there were glove perforations in 18.3 percent of the 885 procedures. Frequency of glove perforations increased with increased duration of surgery. Of 88

perforations observed in double gloving, only 6.8 percent perforated the inner glove (Laine and Aarnio 2001). Aarnio and Laine, 2001 present a study of glove perforation rates in vascular surgery. In a study of 73 operations testing 100 single gloves and 100 double gloves, there were three perforations in the double gloves and 12 in the single gloves (Aarnio and Laine 2001).

Consistent with other research, Berguer and Heller, 2004 note, "there is a widespread perception that double gloving reduces hand sensitivity and dexterity. . . . Subjective evaluations comparing surgeon comfort, sensitivity and dexterity with single and double gloves indicated subjective impairment on all parameters" (Berguer & Heller 2004). However, when double gloving is implemented, surgeons adjust to their use. A study by Patterson, Novak, and Makinnon, et al. 1998 reported that a period of 1 to 120 days is needed to adjust to double gloving, with most cases needing 2 days. Given the dramatic effect of double gloving on blood exposure rates, addressing the concerns of surgical staff regarding the effect on performance seems prudent.

Neutral or Safe Zone

A neutral zone, also called a safe zone, is defined as, "a previously agreed on location on the field where sharps are placed from which the surgeon or scrub nurse can retrieve them. So hand-to-hand passing of sharps is limited" (Stringer *et al.* 2002). Results from a prospective study of the effect of a neutral zone on injury rates found that percutaneous injuries, glove tears, and contaminations occurred less often in surgeries with a neutral zone than in surgeries without a neutral zone. The effect was minimal in operations involving less than 100ml of blood loss and was most pronounced in operations involving greater than100ml of blood loss (Stringer *et al.* 2002). Both the American College of Surgeons and the Association of Perioperative Registered Nurses recommend the use of a neutral zone during surgery. Use of a neutral zone is not widely accepted, and some surgeons report that they do not like diverting their eyes from the surgical field when the neutral zone is used (Stringer *et al.* 2002).

Conclusions

The OR represents one of the highest risk environments in the hospital setting for occupational blood exposure. Numerous factors place surgical staff at risk for exposure. While considerable research has been conducted on the effect of systems-level approaches to the prevention of blood exposure, the effect of these approaches in the OR has not been adequately studied. In addition, ways to adapt these systems-level approaches to the unique OR environment should be explored. There are several safety practices specific to the OR setting: Blunt needles, double gloving, and the neutral zone. While research has shown that each of these practices results in a reduction of blood exposure in the OR, they are not always followed or implemented. An analysis of barriers to their use should be explored.

Questions for the Workshop

- How can the Safety Climate approach to reducing occupational blood exposure be applied to the OR? What additional research is needed? What approach should be taken to promote improved Safety Climate to reduce OR blood exposure?
- What approach should be taken to improve compliance with Standard Precautions in the OR? What additional research is needed?
- How can OR blood exposure interventions encompass the diversity of staffing types and levels in the OR, given that the sources and risk of exposure vary among these groups?
- Younger personnel are more likely to implement safety measures than older personnel. What are the implications of this finding in the OR setting?
- What are the barriers to OR-specific risk reduction practices and how can they be addressed?

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