SKIN AND MUCOUS MEMBRANE CONTACTS WITH BLOOD DURING SURGICAL PROCEDURES: RISK AND PREVENTION

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ABSTRACT

OBJECTIVE: To study the epidemiology and preventability of blood contact with skin and mucous membranes during surgical procedures.

DESIGN: Observers present at 1,382 surgical procedures recorded information about the procedure, the personnel present, and the contacts that occurred.

SETTING: Four US teaching hospitals during 1990.

PARTICIPANTS: Operating room personnel in five surgical specialties.

MAIN OUTCOME MEASURES: Numbers and circumstances of contact between the patient's blood (or other infective fluids) and surgical personnel's mucous membranes (mucous membrane contacts) or skin (skin contacts, excluding percutaneous injuries).

RESULTS: A total of 1,069 skin (including 620 hand, 258 body, and 172 face) and 32 mucous membrane (all affecting eyes) contacts were observed. Surgeons sustained most contacts (19% had ≥1 skin contact and 0.5% had ≥1 mucous membrane-eye contact). Hand contacts were 72% lower among surgeons who double gloved, and face contacts were prevented reliably by face shields. Mucous membrane-eye contacts were significantly less frequent in surgeons wearing eyeglasses and were absent in surgeons wearing goggles or face shields. Among surgeons, risk factors for skin contact depended on the area of contact: hand contacts were associated most closely with procedure duration (adjusted odds ratio [OR], 9.4; ≥4 versus <1 hour); body contacts (arms, legs, and torso) with estimated blood losses (adjusted OR, 8.4; ≥1,000 versus <100 mL); and face contacts, with orthopedic service (adjusted OR, 7.5 compared with general surgery).

CONCLUSION: Skin and mucous membrane contacts are preventable by appropriate barrier precautions, yet occur commonly during surgery. Surgeons who perform procedures similar to those included in this study should strongly consider double gloving, changing gloves routinely during surgery, or both (*Infect Control Hosp Epidemiol* 1995;16:703-711).

INTRODUCTION

Healthcare workers risk infection with bloodborne pathogens, including hepatitis B virus and human immunodeficiency virus (HIV), from blood contacts.[1] Contact by percutaneous injury has the highest risk of transmitting infection, but infection has been transmitted by contact with skin (especially nonintact skin) or mucous membranes.[2-4] Because infection with bloodborne pathogens cannot be assessed reliably by history and immediately avail-

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able laboratory testing, the Centers for Disease Control and Prevention (CDC) recommends barrier precautions to prevent contact between infective fluids and healthcare workers' skin and mucous membranes during care of all patients.[5]

A number of studies suggest that blood contacts are common during surgery.[6-11] We undertook a multicenter observational study to obtain detailed information on the frequency, circumstances, and preventability of blood contacts during surgical procedures. Our findings regarding percutaneous injuries have been presented previously.[12] This report presents our data on skin and mucous membrane contacts.

METHODS

Hospitals and Surgical Procedures Studied

Study methods have been presented previously.[12] In brief, this study was conducted from January through September 1990 at four hospitals: one innercity hospital and one suburban hospital each in the New York City and Chicago metropolitan areas. The study was approved by appropriate institutional review boards at participating hospitals. Procedures eligible for the study included those performed on adult inpatients on five surgical services. At all hospitals, a sample of general surgery (limited to abdominal procedures), gynecologic (not obstetric), and orthopedic cases were observed. In addition, at the two hospitals in the New York City metropolitan area, cardiac cases were observed; at the two hospitals in the Chicago metropolitan area, trauma cases were observed. Hand surgery, insertions of arterial and venous access devices, and procedures requiring no or a very small incision (eg, arthroscopy and laparoscopy) were not observed. From the pool of eligible procedures, procedures were chosen for observation by a random or systematic sampling method.[12] Except for six trauma cases that extended beyond the hours worked by study observers, entire surgical procedures were observed. Of 8,153 procedures eligible for the study, 1,362 (17%) were observed; observed procedures did not differ substantially from eligible procedures in service, shift, or duration.[12]

Definitions

Infective fluids were defined as blood, visibly bloody irrigation fluid, other body fluids requiring universal precautions (eg, pericardial, pleural, or peritoneal fluid), or bone fragments. Skin contacts were defined as contact, visible to the observer or reported by the worker, between blood or another infective fluid and the healthcare worker's skin, in the absence of percutaneous injury. When an observer saw blood on a worker's garment, the worker was asked, when feasible, to lift his or her garment to allow inspection of the skin; if this was not feasible, the worker's report of whether skin contact had occurred was accepted. Skin contacts were classified as affecting hands, body (arms, legs, or torso), face, neck, or feet. Mucous membrane contacts were defined as contact between blood or another infective fluid and a worker's conjunctival, nasal, or oral mucosa. Mucous membrane contacts were seen either by the observer or reported by a worker.

A person-procedure was defined as one healthcare worker present at a single procedure, ie, two person-procedures could be contributed by one worker at two different procedures, by two workers at one procedure each, or by two workers at the same procedure. A surgeon-procedure was defined as one surgeon present at a single procedure. Skin contact rates were calculated as the percent of person-procedures (or surgeon-procedures) with at least one skin contact; hand, body, face, and mucous membrane contact rates were calculated similarly.

Data Collection and Analysis

Surgical personnel were informed of the study in advance and asked to notify observers of the occurrence of blood contacts. Observations were performed by trained nurses or operating room technicians who had no other duties in the operating room and who were monitored by a cooperating physician investigator at each hospital. Observers identified themselves to the surgical team at the beginning of each procedure. Names of surgical personnel or patients were not recorded. For each procedure, observers recorded information about the procedure and surgical personnel present, including which, if any, barrier precautions (ie, single versus double gloves, cloth versus paper gowns) each person used. One or two surgical team members were identified as primary surgeons. Information on skin and mucous membrane contacts, including narrative descriptions of the incidents, also was recorded.

Data analysis was performed with Epi-Info software (Centers for Disease Control and Prevention, Atlanta, GA) and the Statistical Analysis System (SAS Institute, Inc, Cary, NC). Proportions were compared with the chi-squared or Fisher's Exact Test, and multivariate analysis was performed by logistic regression.

RESULTS

Descriptive Information

A total of 1,382 surgical procedures were observed. During these procedures, there were 1,069 skin contacts affecting hands (620 contacts, 58% of all skin contacts), face (172 contacts, 16%), arms (157 con-

TABLE 1
ACTIONS OR CIRCUMSTANCES ASSOCIATED WITH SKIN AND MUCOUS MEMBRANE CONTACTS

	Number (Percentage) of Contacts			
	Skin			Mucous Membrane
Actions	**Hand (N=620)**	**Body (N=258)**	**Face (N=172)**	**Eye (N=32)**
Suturing	80 (13)	2 (1)	4 (2)	3 (9)
Manipulating tissue	41 (7)	4 (2)	5 (3)	0
Placing an intravenous or arterial catheter	38 (6)	1 (<1)	0	0
Cutting	19 (3)	6 (2)	15 (9)	6 (19)
Retracting	15 (2)	0	1 (1)	0
Degloving	13 (2)	1 (<1)	0	0
Manipulating a wire or pin	12 (2)	0	1 (1)	1 (3)
Cauterizing	10 (2)	0	0	0
Clamping	10 (2)	0	0	0
Holding a bloody object	9 (1)	1 (<1)	0	0
Manipulating a blood vessel	9 (1)	8 (3)	20 (12)	6 (19)
Changing a suction receptacle	8 (1)	1 (<1)	1 (1)	0
Drilling or sawing bone	5 (1)	3 (1)	27 (16)	3 (9)
Counting sponges	5 (1)	6 (2)	0	0
Manipulating a prosthesis	4 (1)	0	9 (5)	2 (6)
Connecting or disconnecting tubing	4 (1)	1 (<1)	5 (3)	0
Irrigating	1 (<1)	17 (7)	38 (22)	3 (9)
Hammering	0	2 (1)	19 (11)	4 (12)
Other*	63 (10)	21 (8)	27 (16)	4 (12)
Unknown	270 (44)†	184 (71)†	0	0

* Actions associated with less than 10 total skin contacts (eg, dressing a wound, obtaining a blood specimen, passing an instrument) are grouped in the "other" category.
† Blood found under glove after removal; exact circumstances of contact uncertain.

tacts, 15%), legs (73 contacts, 7%), torso (28 contacts, 3%), feet (11 contacts, 1%), and neck (8 contacts, 1%). One or more skin contacts occurred during 585 procedures (42%). There were 33 mucous membrane contacts, all affecting eyes; one or more mucous membrane-eye contacts occurred during 28 surgical procedures (2%). The substances involved in the skin and mucous membrane contacts were blood (967 contacts, 88% of all contacts), bloody irrigation fluid (113 contacts, 10%), bone fragments (11 contacts, 1%), and other or not recorded (10 contacts, 1%).

The most common action observed in association with hand contact was glove perforation without percutaneous injury during suturing (80 contacts); however, many hand contacts were discovered when gloves were removed, and they could not be linked to a specific action or circumstance (Table 1). Similarly, most body contacts were discovered at gown removal. However, face and mucous membrane contacts most often were associated with actions likely to produce splatter, such as irrigating, drilling, sawing, and hammering (Table 1).

Skin and Mucous Membrane Contact Rates by Person-Procedure

Most skin and mucous membrane contacts affected surgeons (Table 2). Among surgeons, contact rates per person-procedure were 19% for skin and 0.5% for mucous membranes. Physicians' assistants had similar rates of contact, but the number of such individuals studied was small.

Skin Contact Rates Among Surgeons

The skin contact rate among surgeons did not vary significantly according to the surgeon's knowledge of the patient's HIV status: known or suspected negative, 345 of 1,954 (18%) versus known or suspected positive, 19 of 84 (23%; P=.3); among patients with unknown HIV status, the skin contact rate was 306 of 1,448 (21%). Although, in univariate analyses, the skin contact rate was significantly higher on the night (versus day) shift and during nonelective (versus elective) surgery, these variables were nonsignificant in multivariate analyses and are not presented further. During the course of the study, there was no

TABLE 2
FREQUENCY OF SKIN AND MUCOUS MEMBRANE CONTACTS BY WORKER CATEGORY

Workers	Number of Person-Procedures	Number (Percentage) of Person-Procedures With Contact: Skin	Mucous Membrane
Surgeons	3,514	679 (19)	17 (0.5)
Resident surgeon	2,138	406 (19)	11 (0.5)
Attending surgeon	1,376	273 (20)	6 (0.4)
Other workers	7,608	210 (3)	13 (0.2)
Circulating nurse	2,282	50 (2)	0 (0)
Scrub nurse/technician	2,079	38 (2)	5 (0.2)
Anesthesia	2,067	58 (3)	0 (0)
Medical student	575	25 (4)	3 (0.5)
Nonparticipating surgeon*	115	2 (2)	0 (0)
Physician's assistant	111	25 (23)	5 (4.5)
Other†	379	12 (3)	0 (0)

* Nonscrubbed resident or attending surgeons.
† Eg, perfusion, radiology, and laboratory technicians.

significant temporal trend in the skin contact rate among surgeons (20%, 19%, and 20% during the first 460 procedures, the middle 461 procedures, and the final 461 procedures, respectively; P=1.0, chi-squared test for trend).

For further analyses, skin contacts were categorized as affecting the hands, body (arms, legs, or torso), or face; neck and foot contacts (3% of all skin contacts) were excluded.

Among surgeons, skin contact rates were 12% for hand, 5% for body, and 4% for face (Table 3). Rates varied by service and procedure. To identify which of the 24 procedure categories listed in Table 3 had significantly higher hand contact rates, indicator variables for the procedures were evaluated by stepwise logistic regression and added to the resulting model if statistically significant; the eight procedures marked by an asterisk had significantly higher hand contact rates than did all unmarked procedures combined. Similar methods were used for body and face contacts (Table 3).

Among 491 hand contacts sustained by surgeons, 305 (62%) were due to a visible glove tear, 148 (30%) were discovered when gloves were removed and were attributed to nonvisible glove tears, 11 (2%) were due to blood penetrating the gown in the forearm area and dripping down into the glove, 19 (4%) occurred after the surgeon removed gloves at the end of the procedure, and 8 (2%) occurred during glove removal.

The hand contact rate was related significantly to estimated blood loss, procedure duration, surgeon characteristics, and hospital (Table 4). Additionally, the hand contact rate was significantly lower (relative risk [RR], 0.34; 95% confidence interval, 0.25 to 0.45) among surgeons using double (versus single) gloves. Double gloving was much more common on the orthopedic service, where 91.0% (815 of 896) of surgeons double gloved compared with 6.5% (165 of 2,557) on the other four services combined.

The body contact rate was influenced heavily by estimated blood loss and was reduced (RR, 0.46) by use of paper (versus cloth) gowns (Table 4).

The face contact rate was significantly lower among surgeons using face shields (Table 4). However, both the face contact rate and the use of face shields were highest on the orthopedic service (111 of 117 surgeons using face shields were orthopedists). Among orthopedists, face contact was noted in 0 of 111 face shield users and 74 of 799 (9%) nonusers (P=.002).

Logistic Regression Models of Hand, Body, and Face Contact

Logistic regression models were constructed to assess the independent importance of potential risk factors. Controlling for factors listed in the model (Table 5), hand contacts were related most strongly to procedure duration and were reduced significantly (OR, 0.28) by double gloving (Table 5). Body contacts were related highly to estimated blood loss and were reduced (OR, 0.27) by use of paper, compared with cloth, gowns.

The model for face contact excluded surgeons wearing face shields; because none of these surgeons

TABLE 3
FREQUENCY OF SKIN CONTACTS AMONG SURGEONS BY SERVICE, PROCEDURE, AND AREA OF CONTACT

Service/Procedure	Number of Surgeon-Procedures	Number (Percentage) of Surgeon-Procedures With Contact: Hand	Body	Face
All	3,514	418 (12)	191 (5)	135 (4)
Cardiac	353	66 (19)	14 (4)	20 (6)
Coronary artery bypass graft	262	54 (21)*	8 (3)	14 (5)‡
Other cardiac	91	12 (13)*	6 (7)†	6 (7)‡
General surgery	1,019	109 (11)	49 (5)	15 (1)
Intestinal procedures	369	62 (17)*	36 (10)†	5 (1)
Cholecystectomy	311	23 (7)	4 (1)	7 (2)
Appendectomy	84	1 (1)	1 (1)	0 (0)
Gastrectomy	62	7 (11)	1 (2)	1 (2)
Ventral herniorrhaphy	47	7 (15)*	0	1 (2)
Other general surgery	146	9 (6)	7 (5)	1 (1)
Gynecology	794	106 (13)	27 (3)	15 (2)
Abdominal hysterectomy	437	61 (14)*	14 (3)	13 (3)
Vaginal hysterectomy	122	20 (16)*	3 (2)	1 (1)
Salpingoophorectomy	82	10 (12)*	4 (5)	0 (0)
Ovarian cystectomy	37	5 (14)	1 (3)	0 (0)
Other gynecology	116	10 (9)	5 (4)	1 (1)
Orthopedics	910	47 (5)	30 (3)	74 (8)
Total hip replacement	217	12 (6)	5 (2)	26 (12)‡
Open reduction, internal fixation	216	14 (6)	15 (7)†	14 (6)‡
Total knee replacement	88	5 (6)	1 (1)	11 (13)‡
Repair hip fracture	63	3 (5)	4 (6)	6 (10)‡
Arthrotomy	58	2 (3)	0 (0)	1 (2)
Removal of hardware	32	0 (0)	1 (3)	2 (6)
Laminectomy	30	0 (0)	0 (0)	0 (0)
Debridement	17	2 (12)	0 (0)	0 (0)
Other orthopedic	189	9 (5)	4 (2)	14 (7)‡
Trauma	438	90 (21)	71 (16)	11 (3)
Abdominal	347	82 (24)*	59 (17)†	7 (2)
Other trauma	91	8 (9)	12 (13)†	4 (4)

* Significantly ($P<.05$) higher than all unmarked hand procedures combined.
† Significantly ($P<.05$) higher than all unmarked body procedures combined.
‡ Significantly ($P<.05$) higher than all unmarked face procedures combined.

had face contacts, it would not be possible to adjust for the effect of face shield in the model. Face contacts were not associated with procedure duration or estimated blood loss, but were associated strongly with orthopedic service (OR, 7.5). When the variable for orthopedic service was replaced with variables coding for individual orthopedic procedures, the following results were obtained (general surgery is the reference category): total hip replacement, OR, 12.5, $P<.001$; repair hip fracture, OR, 12.1, $P<.001$; total knee replacement, OR, 11.2, $P<.001$; removal of hardware, OR, 7.8, $P=.01$; other orthopedic, OR, 6.4, $P<.001$; open reduction and internal fixation, OR = 5.8, $P<.001$; and arthrotomy, OR, 1.7, $P=.6$ (variables for laminectomy and debridement were not included because no face contacts were observed during these procedures).

To assess observer-specific confounding, variables coding for the 20 individual observers were introduced into the models in a forward stepwise manner if statistically significant. The addition of these variables produced changes in the odds ratios for the hospitals, but minimal changes (<10%) in other odds ratios, and therefore they were not included in the models presented in Table 5.

TABLE 4
POTENTIAL RISK FACTORS FOR SKIN CONTACTS AMONG SURGEONS BY AREA OF CONTACT

Factor	Number of Surgeon-Procedures	Number (Percentage) of Surgeon-Procedures With Contact		
		Hand	Body	Face
Estimated blood loss (mL)				
0-99*	1,184	92 (8)	19 (2)	45 (4)
100-299	1,060	97 (9)	38 (4)†	32 (3)
300-499	592	95 (16)†	38 (6)†	26 (4)
500-999	433	78 (18)†	50 (12)†	20 (5)
≥1,000	245	56 (23)†	46 (19)†	12 (5)
Procedure duration (hours)				
0-0.9*	637	26 (4)	24 (4)	18 (3)
1-1.9	1,362	114 (8)†	56 (4)	37 (3)
2-2.9	869	110 (13)†	51 (6)	45 (5)†
3-3.9	375	78 (21)†	27 (7)†	17 (5)
≥4	271	90 (33)†	33 (12)†	18 (7)†
Surgeon				
Assistant*	1,738	128 (7)	79 (5)	62 (4)
Primary	1,776	290 (16)†	112 (6)	73 (4)
Level of training				
Resident, years 1-3*	835	68 (8)	33 (4)	19 (2)
Resident, years ≥4	1,170	187 (16)†	76 (6)†	51 (4)†
Attending	1,376	158 (11)†	79 (6)	58 (4)†
Glove use				
Single gloves*	2,473	356 (14)	—	—
Double gloves	974	47 (5)†	—	—
Gown type				
Cloth*	1,323	—	109 (8)	—
Paper	2,143	—	81 (4)†	—
Face shields				
Not used*	3,397	—	—	135 (4)
Used	117	—	—	0 (0)†
Hospital				
A	762	152 (20)†	50 (7)†	31 (4)
B*	974	55 (6)	4 (<1)	47 (5)
C	862	138 (16)†	65 (8)†	19 (2)†
D	916	73 (8)	72 (8)†	38 (4)

* Reference category.
† $P<.05$ compared with reference category.

Mucous Membrane-Eye Contacts Among Surgeons

Mucous membrane-eye contacts occurred among 15 (1.3%) of 1,166 surgeons using no facial protection other than a surgical mask; the rate was significantly lower among those using eyeglasses (2 of 1,930 [0.1%], $P<.001$) or face shield or goggles (0 of 418, $P=.03$); the rate among those using eyeglasses was not significantly different from the rate among those using a face shield or goggles ($P=1.0$).

The mucous membrane-eye contact rate was highest on the gynecology and orthopedic services; excluding surgeons who used face shields, goggles, or eyeglasses, the contact rate was 1.9% (8 of 414) for gynecology and 2.3% (5 of 211) for orthopedics.

DISCUSSION

In this study conducted at two inner-city and two suburban US teaching hospitals, skin contact occurred during 42% of surgical procedures, and mucous membrane-eye contact occurred during 2% of procedures. Among surgeons, 19% had skin con-

TABLE 5
LOGISTIC REGRESSION MODELS OF BLOOD-SKIN CONTACT BY AREA OF CONTACT

	Odds Ratios		
Factor	**Hand**	**Body**	**Face**
Estimated blood loss (mL)			
0-99	Ref	Ref*	Ref
100-299	1.1	2.0†	1.2
300-499	1.7†	3.5†	1.6
500-999	1.4	5.2†	2.0†
≥1,000	1.6	8.4†	2.7†
Procedure duration (hours) range			
0-0.9	Ref	Ref	Ref
1-1.9	2.1†	1.1	1.1
2-2.9	3.6†	1.9†	1.7
3-3.9	5.3†	1.8	1.9
≥4	9.4†	2.4†	2.5†
Surgeon			
Assistant	Ref	Ref	Ref
Primary	2.2†	1.6†	1.3
Level of training			
Resident, years 1-3	Ref	Ref	Ref
Resident, years ≥4	1.5†	1.3	1.3
Attending	Ref	Ref	Ref
Glove use			
Single	Ref	—‡	—
Double	0.28†	—	—
Gown			
Cloth	—	Ref	—
Paper gown	—	0.27†	—
Service			
Cardiac	1.2	1.6	2.7†
General surgery	Ref	Ref	Ref
Gynecology	1.4†	0.6†	1.3
Orthopedic	1.3	0.7	7.5†
Trauma	2.2†	2.5†	1.9
Hospital			
A	3.6†	3.7†	0.8
B	Ref	Ref	Ref
C	2.4†	2.1	0.4†
D	2.2†	16.0†	0.8

* Abbreviation: Ref denotes reference category (odds ratio=1.0). Because of exclusions and missing data, the models are based on 3,315 (hand), 3,326 (body), and 3,266 (face) surgeon-procedures.
† $P<.05$ compared with reference category.
‡ Not included in model.

tact and 0.5% had mucous membrane-eye contact. These figures are in the range noted by most previous studies, in which blood contact occurred during 6.4% to 50% of procedures[7-11] and among 19% of surgeons.[9] In a study among obstetric personnel, blood or amniotic fluid contacts occurred during 39% of vaginal deliveries and 50% of caesarian sections.[13] Our results for orthopedic surgeons (mucous membrane-eye contacts, 0.5%; skin contacts, 15%) were similar to the rates determined from a self-administered questionnaire completed by 3,420 orthopedic surgeons (mucous membrane contacts, 1.2%; skin contacts, 16%).[14]

Studies that combine skin contacts from several body areas, possibly also including mucous membrane contacts and percutaneous injuries, may fail to disclose important features of the epidemiology of blood contacts. In our study, risk factors for skin contact among surgeons depended on the area of contact: hand contacts were associated most closely with procedure duration, body contacts with estimated blood loss, and face contacts with orthopedic procedures.

Hands were the most frequent area of contact. The adjusted OR of 0.28 for double gloving means that surgeons wearing two pairs of gloves had 72% fewer hand contacts than those wearing one pair. Reductions in blood-hand contact among double- versus single-gloved surgeons have been reported to occur during pelvic surgery (2% versus 38%)[15] and among surgical personnel in two multispecialty studies conducted at a single institution (1.2% versus 11.5%[16] and 7% versus 51%[17]). A number of studies have shown lower perforation rates for the inner glove of double-gloved personnel compared with the one glove of single-gloved personnel or the outer glove of double-gloved personnel.[18-25] In a recent study, perforation was found in 31% of single gloves, 8.8% of inner gloves from double-gloved personnel, and 1.2% of inner gloves from triple-gloved personnel.[26] In one study, double gloving produced subjective impairment of dexterity.[24] However, another study showed no measurable reduction in two-point discrimination or ability to tie surgical knots among 17 surgeons,[27] and a third reported that 88% of 130 double-gloved surgeons rated tactile sense as satisfactory.[17]

Glove perforations or hand contacts have been found to increase as duration of glove use increased,[17,19,20,22,26] which is consistent with our findings. Some glove perforations will be too small to be noticed; 30% of hand contacts among surgeons in our study were attributed to nonvisible glove perforations. Therefore, routine changing of gloves at fixed intervals during prolonged operations may be necessary to maintain the barrier between surgeons' hands and patients' blood and tissues.

The body (arm, leg, and torso) was the second most frequent area of skin contact. The strong association with estimated blood loss suggests that blood-resistant gowns should be used during procedures where blood loss is expected to be high. Our data did not permit a detailed assessment of the protection afforded by different gown types. Because of recent improvements in both paper and cloth gowns, and because of the diversity of types available, trials of specific gowns under conditions of use are needed to assess the level of protection afforded.

Face contacts, particularly frequent during certain orthopedic procedures, were prevented reliably by face shields. These contacts were not significantly higher in primary versus assistant surgeons, suggesting that facial protection would be needed by all surgeons present at procedures that generate splatter of potentially infectious materials.

A relatively small number of mucous membrane-eye contacts were recorded during the study; because contacts of this type were probably more difficult for the observers to see, they may have been underestimated. However, our data suggest that face shields or goggles prevented, and eyeglasses substantially reduced, such contacts.

Strengths of this study include that data were collected prospectively during surgical procedures, that four hospitals were studied (including two each in inner-city and suburban areas), and that the influence of multiple factors on contact rates were studied and controlled for in multivariate models. The use of trained observers without other responsibilities in the operating room increases the accuracy of data collection, but may change the behavior of surgical personnel. Another limitation is the inability to assess whether any of the observed contacts transmitted infection. Although the hospitals where this study was performed were not necessarily representative of all hospitals in the United States, they probably were similar to many teaching institutions in or near large metropolitan areas.

Surgical workers, especially surgeons, should strongly consider double gloving, performing routine glove changes during surgical procedures similar to those included in our study, or both; using reinforced or impermeable gowns for procedures anticipated to involve high blood loss; and using face shields for many orthopedic procedures. (These suggestions are the opinions of the authors and do not constitute official CDC recommendations.) Besides protective efficacy, factors to be considered in the decision to increase barrier precautions include the prevalence of bloodborne infection in patients, the risk of infection per blood contact, possible adverse effects of the precautions on patient care, increased costs, and increased waste generated by increased use of disposable items.

REFERENCES

1. Robert LM, Bell DM. HIV transmission in the health care setting: risks to health care workers and patients. *Infect Dis Clin North Am* 1994;8:319-329.
2. Bell DM. Human immunodeficiency virus transmission in health care settings: risk and risk reduction. *Am J Med* 1991;91(suppl 3B):294S-300S.
3. Centers for Disease Control. Update: human immunodeficiency virus infections in health-care workers exposed to blood of infected patients. *MMWR* 1987;36:285-289.
4. Centers for Disease Control and Prevention. Human immunodeficiency virus transmission in household settings—United States. *MMWR* 1994;43:347,353-356.

5. Centers for Disease Control. Recommendations for prevention of HIV transmission in health-care settings. *MMWR* 1987;36(suppl 2S):1S-8S.
6. Hussain SA, Latid ABA, Choudhary AAAA. Risk of surgeons: a survey of accidental injuries during operations. *Br J Surg* 1988;75:314-316.
7. Gerberding JL, Littell C, Tarkington A, Brown A, Schecter WP. Risk of exposure of surgical personnel to patients' blood during surgery at San Francisco General Hospital. *N Engl J Med* 1990;322:1788-1793.
8. Quebbeman EJ, Telford GL, Hubbard S, et al. Risk of blood contamination and injury to operating room personnel. *Ann Surg* 1991;214:614-620.
9. Panlilio AL, Foy DR, Edwards JR, et al. Blood contacts during surgical procedures. *JAMA* 1991;265(12):1533-1537.
10. Popejoy SL, Fry DE. Blood contact and exposure in the operating room. *Surg Gynecol Obstet* 1991;172:480-483.
11. White MC, Lynch P. Blood contact and exposures among operating room personnel: a multicenter study. *Am J Infect Control* 1993;21:243-248.
12. Tokars JI, Bell DM, Marcus R, et al. Percutaneous injuries during surgical procedures. *JAMA* 1992;267:2899-2904.
13. Panlilio AL, Welch BA, Bell DM, et al. Blood and amniotic fluid contact sustained by obstetric personnel during deliveries. *Am J Obstet Gynecol* 1992;167:703-708.
14. Tokars JI, Chamberland ME, Schable CA, et al. A survey of occupational blood contact and HIV infection among orthopedic surgeons. *JAMA* 1992;268(4):489-494.
15. Cohn GM, Seifer DB. Blood exposure in single versus double gloving during pelvic surgery. *Am J Obstet Gynecol* 1990;162:715-717.
16. Telford GL, Quebbeman EJ. Assessing the risk of blood exposure in the operating room. *Am J Infect Control* 1993;21:351-356.
17. Quebbeman EJ, Telford GJ, Wadsworth K, Hubbard S, Goodman H, Gottlieb MS. Double gloving: protecting surgeons from blood contamination in the operating room. *Arch Surg* 1992;127:213-217.
18. Matta H, Thompson AM, Rainey JB. Does wearing two pairs of gloves protect operating theatre staff from skin contamination? *Br Med J* 1988;297:597-598.
19. McLeod GG. Needlestick injuries at operations for trauma. *J Bone Joint Surg Br* 1989;71-B(3):489-491.
20. Cole RP, Gault DT. Glove perforation during plastic surgery. *Br J Plast Surg* 1989;42:481-483.
21. Dodds RDA, Barker SGE, Morgan NH, Donaldson DR, Thomas MH. Self protection in surgery: the use of double gloves. *Br J Surg* 1990;77:219-220.
22. Gani JS, Anseline PF, Bissett RL. Efficacy of double versus single gloving in protecting the operating team. *Aust N Z J Surg* 1990;60:171-175.
23. Bennett B, Duff P. The effect of double gloving on frequency of glove perforations. *Obstet Gynecol* 1991;78:1019-1022.
24. Doyle PM, Alvi S, Johanson R. The effectiveness of double gloving in obstetrics and gynaecology. *Br J Obstet Gynaecol* 1992;99:83-84.
25. Chapman S, Duff P. Frequency of glove perforations and subsequent blood contact in association with selected obstetric surgical procedures. *Am J Obstet Gynecol* 1993;168:1354-1357.
26. Rose DA, Ramiro NZ, Perlman JL, Schecter WP, Gerberding JL. Two gloves or not two gloves? Intraoperative glove utilization at San Francisco General Hospital. *Infect Control Hosp Epidemiol* 1994;15:(4,suppl)P37.
27. Webb JM, Pentlow BD. Double gloving and surgical technique. *Ann R Coll Surg Engl* 1993;75:291-292.

Microbe Names—Are You Keeping Up?

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In a recent article in *Infectious Disease Alert,* Dr. Stan Deresinski highlighted some of the changes in nomenclature, taxonomy, and classification of pathogenic organisms. By now, most know that enterococci are no longer Group D streptococci and that the former *Neisseria catarrhalis* briefly was known as *Branhamella catarrhalis* and now has become *Moraxella catarrhalis.* Other pathogenic organisms, he notes, that recently have changed names include *Mycobacterium mucogenicum* (formerly *Mycobacterium chelonae*-like organism or MCLO); *Prevotella melaninogenica* (formerly *Bacteroides melaninogenicus*); *Burkholderia cepacia* (formerly *Pseudomonas cepacia*); *Chrysobacterium meningosepticum* (formerly *Flavobacterium meningosepticum*); and *Stenotrophomonas maltophilia* (formerly *Xanthomonas maltophilia*). Dr. Deresinski points out that although these changes may drive us crazy, they may help to maintain our value as knowledge brokers.

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