# Hand Washing & Infectious Disease Transmission in the Anesthesia Work Area

**"The patient in the next bed is highly infectious. Thank God for these curtains"**

**Chuck Biddle CRNA, PhD**

# Hospital acquired infections ( HAI )

## A national patient safety issue

- >35 million patients admitted to US hospitals yearly
- 5-10% of these acquire a nosocomial infection
- Nearly 100K of these patients will die as a result
- Cost of treating these infections ~ $4.5-5.7 billion

Provonost. NEJM. 2006;355:2725
Maki. Mayo Clin Proc. 2006;2006;81:1159
Horan. Am J Infect Control. 2008;36:309
Klevens. Public Health Rep. 2007;122:160

# Nosocomial Infections

- **Most often target the urinary tract, surgical wounds, blood & respiratory tract**
- **Common causes: *Staphylococci, Enterococci, E coli, Listeria*, and *Pseudomonas aeruginosa, mrsa vancomycin resistant enterococcus, c difficile***
- **Transfer of microorganisms from the hands of healthcare workers is the main route of infection**

# 99,000 Die Yearly From Preventable Hospital Infections*

Approximately 99,000 Americans die each year from preventable, hospital-acquired infections.

Central-line-associated bloodstream infections account for 1/3 or more of all related deaths.

*DeNoon, D. "99,000 Die Yearly From Preventable Hospital Infections" *WebMD. 5/27/10*

# Estimating Health Care-Associated Infections and Deaths in U.S. Hospitals

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## SYNOPSIS

**Objective.** The purpose of this study was to provide a national estimate of the number of healthcare-associated infections (HAI) and deaths in United States hospitals.

**Methods.** No single source of nationally representative data on HAIs is currently available. The authors used a multi-step approach and three data sources. The main source of data was the National Nosocomial Infections Surveillance (NNIS) system, data from 1990–2002, conducted by the Centers for Disease Control and Prevention. Data from the National Hospital Discharge Survey (for 2002) and the American Hospital Association Survey (for 2000) were used to supplement NNIS data. The percentage of patients with an HAI whose death was determined to be caused or associated with the HAI from NNIS data was used to estimate the number of deaths.

**Results.** In 2002, the estimated number of HAIs in U.S. hospitals, adjusted to include federal facilities, was approximately 1.7 million: 33,269 HAIs among newborns in high-risk nurseries, 19,059 among newborns in well-baby nurseries, 417,946 among adults and children in ICUs, and 1,266,851 among adults and children outside of ICUs. The estimated deaths associated with HAIs in U.S. hospitals were 98,987: of these, 35,967 were for pneumonia, 30,665 for bloodstream infections, 13,088 for urinary tract infections, 8,205 for surgical site infections, and 11,062 for infections of other sites.

**Conclusion.** HAIs in hospitals are a significant cause of morbidity and mortality in the United States. The method described for estimating the number of HAIs makes the best use of existing data at the national level.

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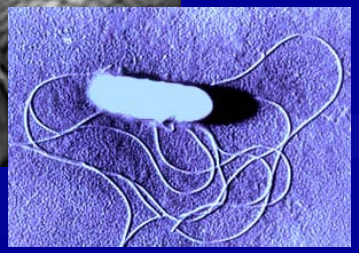
- $1.7 \times 10^6$ HAIs
- 33 K among NICU
- 20 K in newborn nurseries
- 417 K in ICUs
- $1.3 \times 10^6$ outside the ICU
- Deaths → 98,987

Public Health Reports. March/April 2007


01/15/08

**June 6, 1944: Landing marines ashore**
**D-Day, Normandy Beach, France**



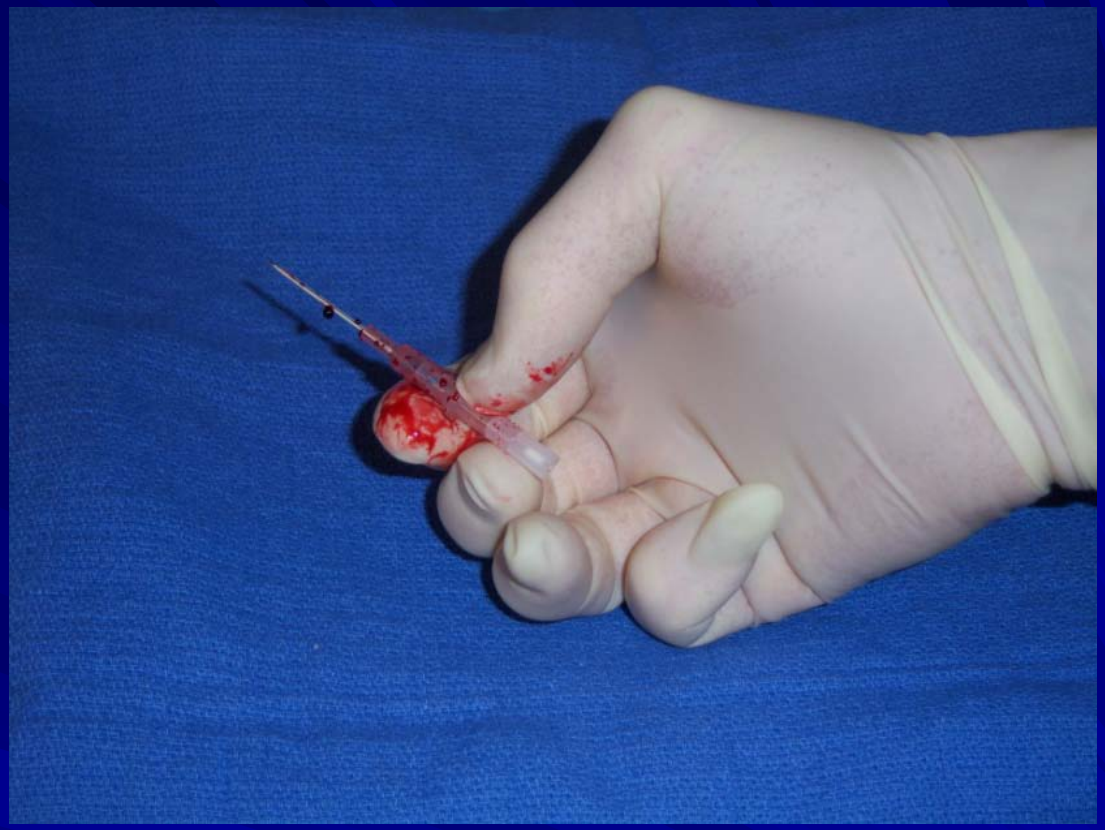
20% maternal mortality
Childbed (puerperal) fever
~1% mortality at home!

1847

Viennese obstetrician Semmelweiss
Blamed problem on doctors not washing hands
Enforced Dr. & nurse hand washing
Rate fell to ~1%

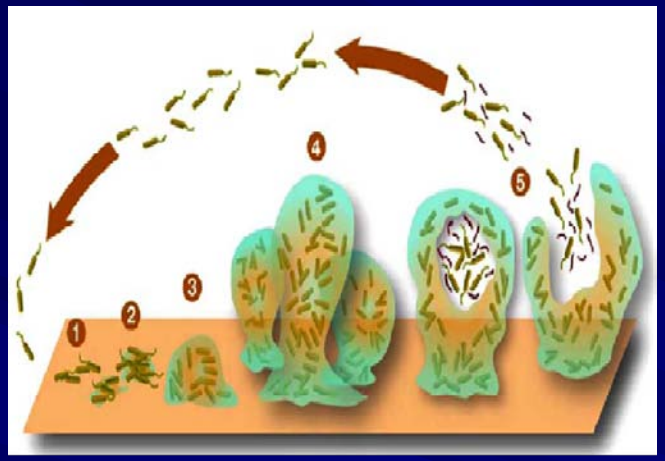
Semmelweiss was harshly criticized
Branded a lunatic—Drs. killing patients!?
Fired!

Failed genius
20 years later Lister's plea more persuasive
30 years later Koch & Pasteur provided the science

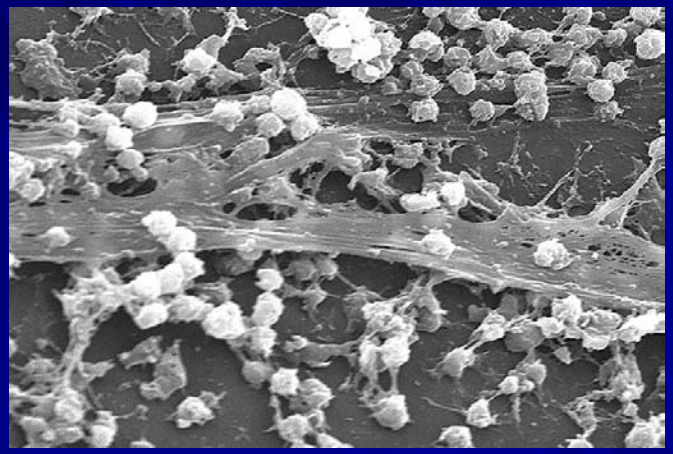


- Formal guidelines for hand washing in hospitals not published until a 1975 release by the CDC
- Current studies show health care workers average < 50% compliance with hand hygiene guidelines

# Biofilms




Staph aureus 2835x



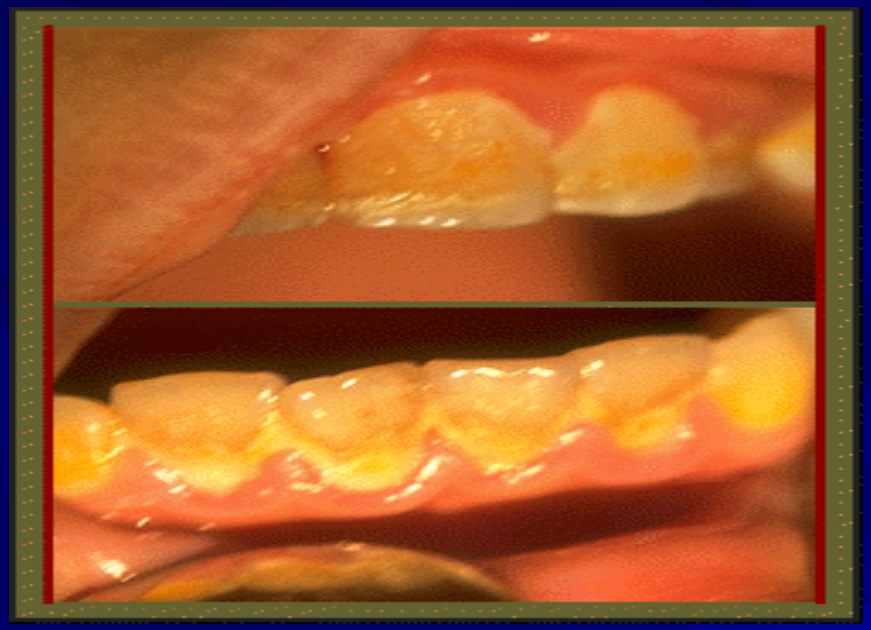
**Thin layer of organisms adherent to a surface**

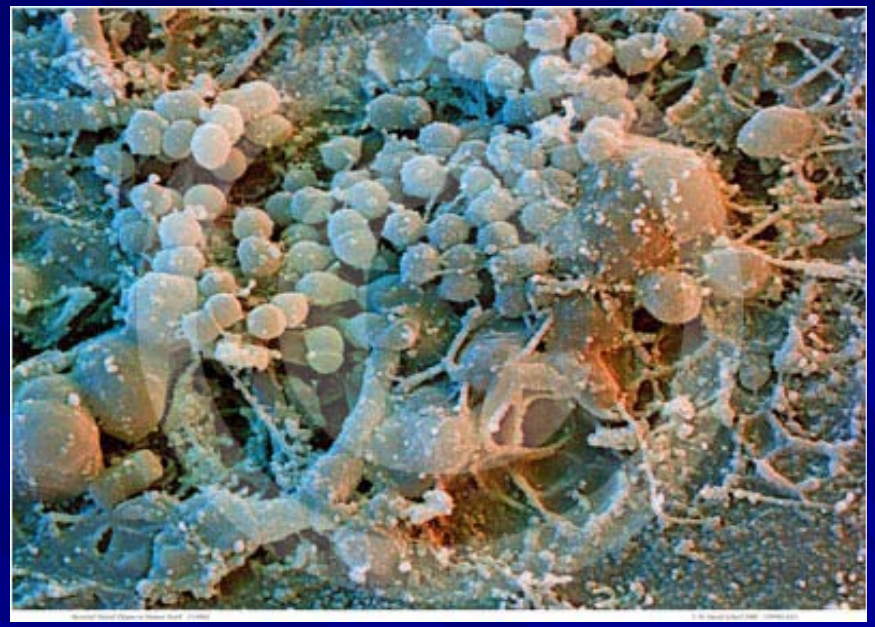
**Provides a fortress against environmental stressors**

**Organisms + secreted polymers = biofilm**

**Resist immunologic, phagocytotic, chemical and physical forces**
**Often many different communal species**
**Biofilm highly resistant to antibiotics**

# Examples of biofilm disease

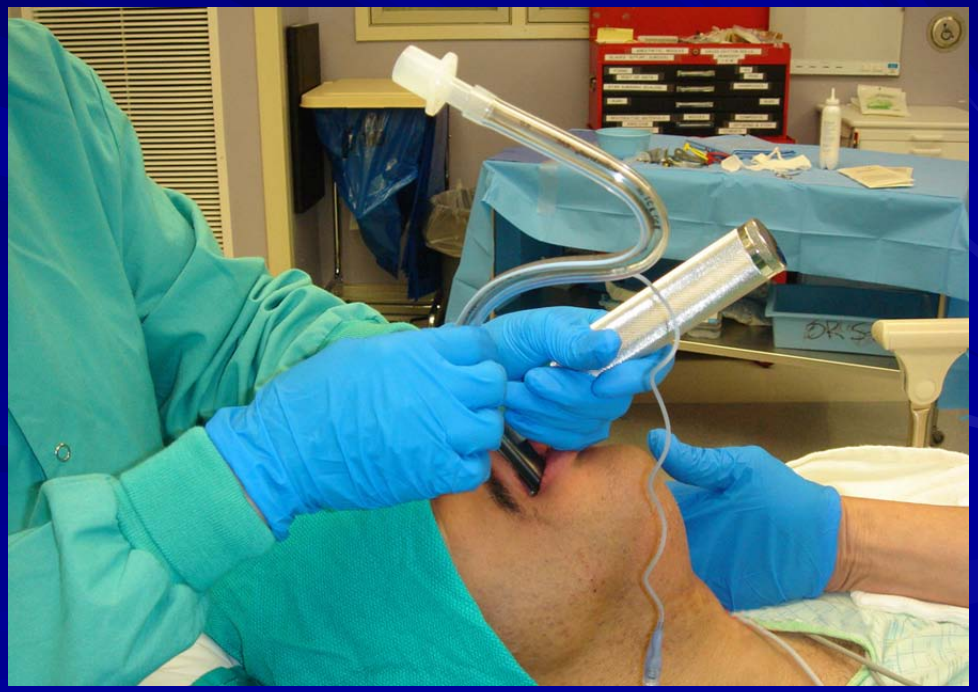


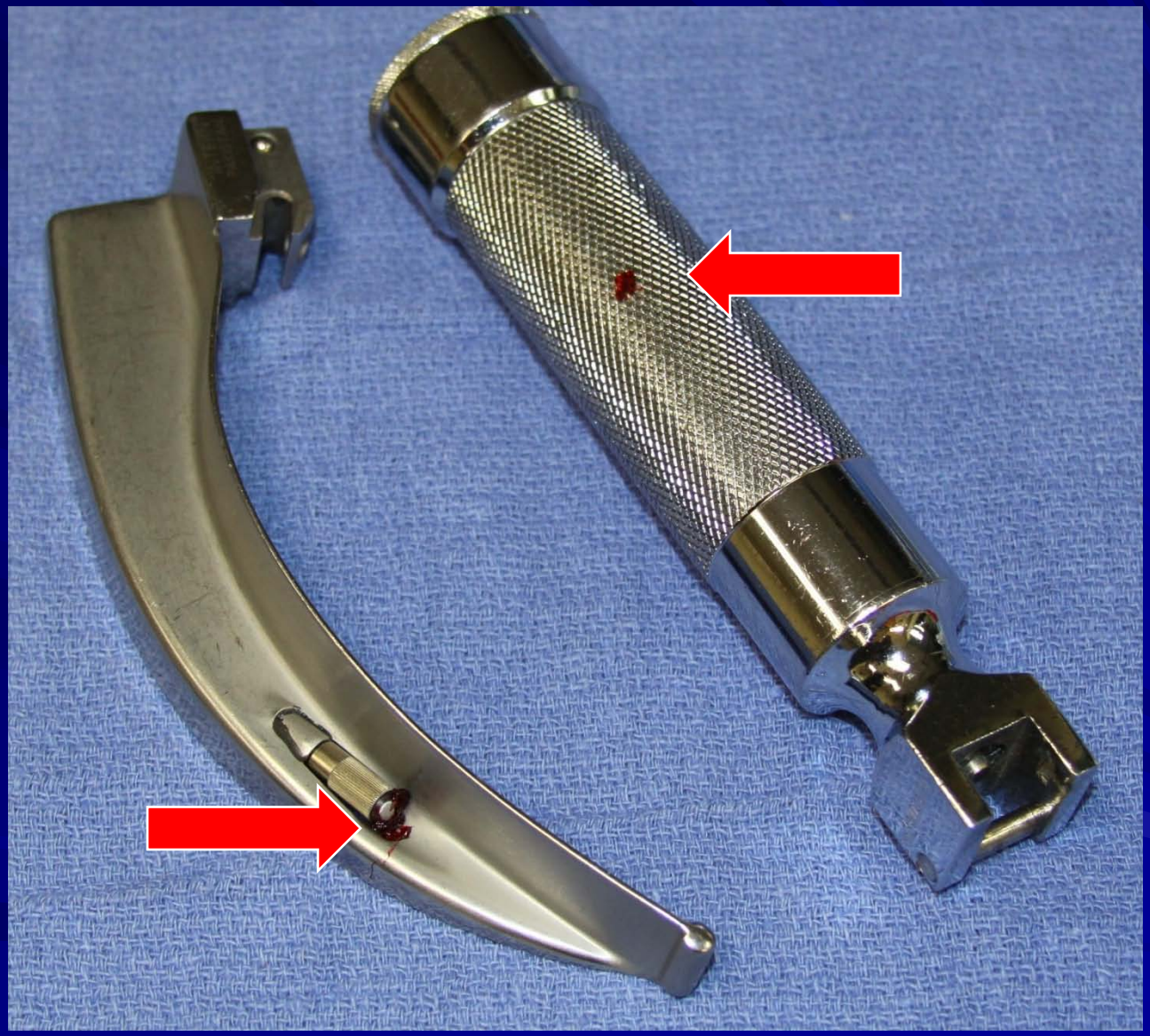


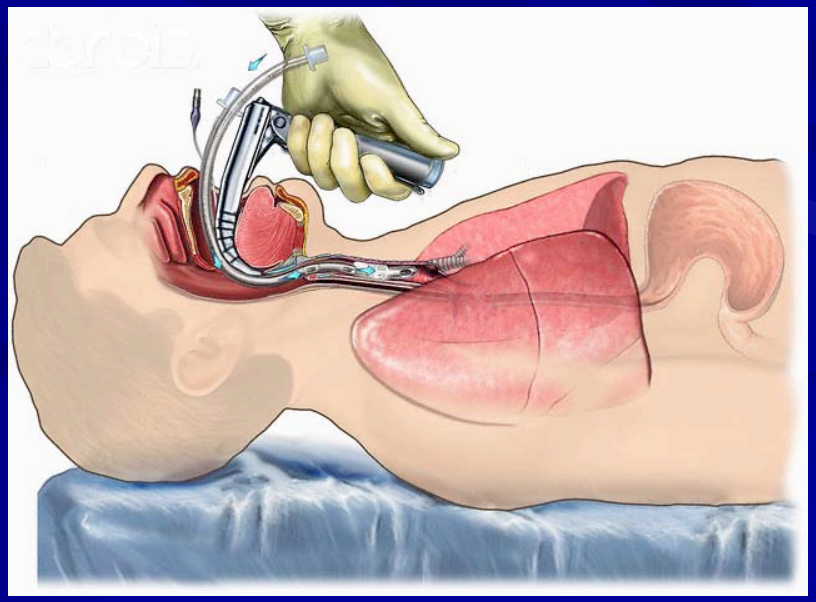
**Pneumonia**
**Dental plaque**
**Cystic fibrosis**
**Infected knee prosthesis**
**Cardiac valvular infections**
**Infected pace-wires, intravenous catheters**


NARKOMED


LATEX FREE

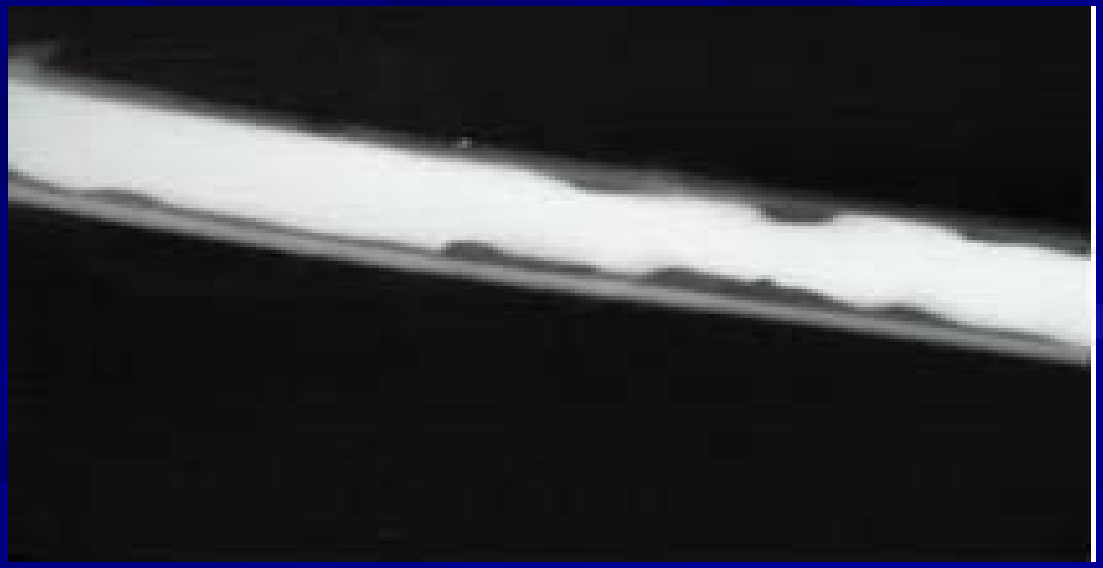




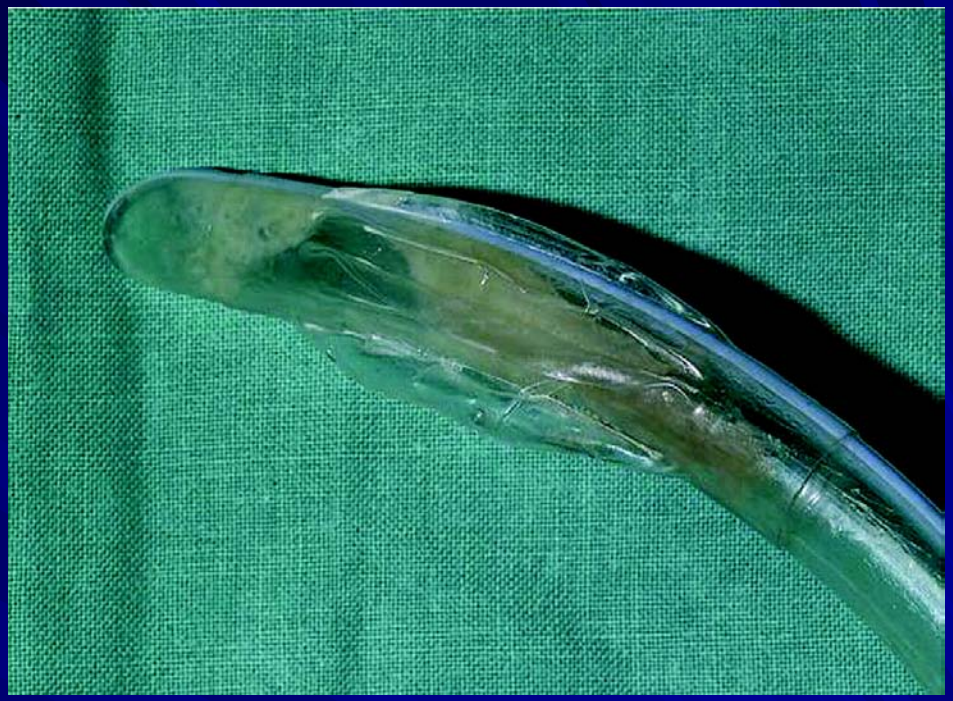


# Tracheal tube biofilms

- ETTs covered with biofilms inside & out within hours
- The longer *in situ*, the greater the risk of VAP
- Colonization/innoculation often from oral flora



Eur Respir J. 1999;13:546 Otolar Head Neck Surg. 2004;130:407

**SEM of multispecies biofilm aggregate on the lumenal surface of an ETT. The uvula-shaped aggregates have a rubbery texture and routinely break off and are aspirated into patients' lungs.**

INSTITUTE OF PHYSICS PUBLISHING

Nanotechnology **16** (2005) 2346–2353

# The bactericidal effect of silver nanoparticles

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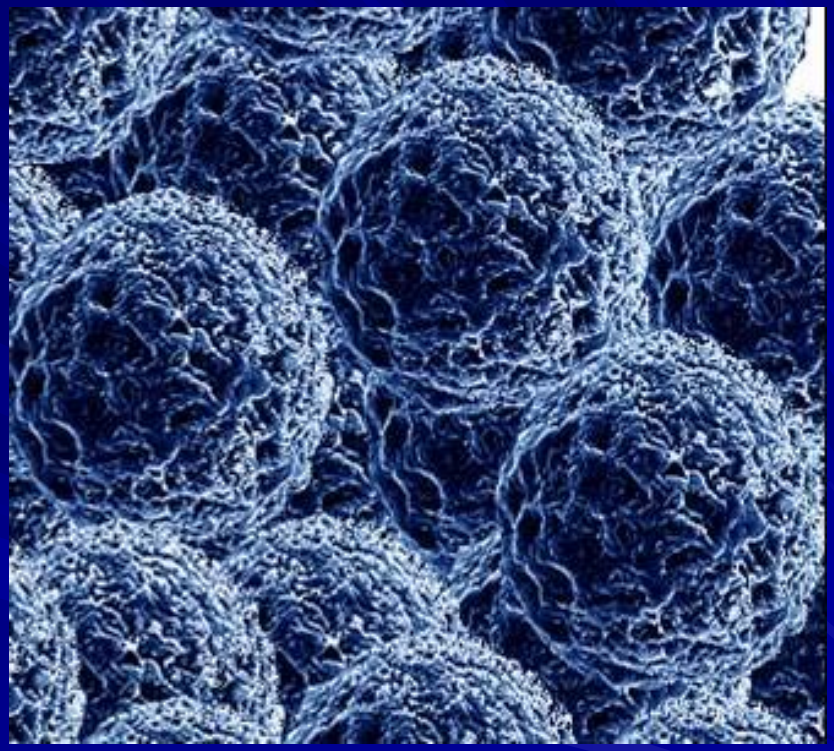
**Abstract**
Nanotechnology is expected to open new avenues to fight and prevent disease using atomic scale tailoring of materials. Among the most promising nanomaterials with antibacterial properties are metallic nanoparticles, which exhibit increased chemical activity due to their large surface to volume ratios and crystallographic surface structure. The study of bactericidal nanomaterials is particularly timely considering the recent increase of new resistant strains of bacteria to the most potent antibiotics. This has promoted research in the well known activity of silver ions and silver-based compounds, including silver nanoparticles. The present work studies the effect of silver nanoparticles in the range of 1–100 nm on Gram-negative bacteria using high angle annular dark field (HAADF) scanning transmission electron microscopy (STEM). Our results indicate that the bactericidal properties of the nanoparticles are size dependent, since the only nanoparticles that present a direct interaction with the bacteria preferentially have a diameter of ~1–10 nm.



# Silver-Coated Endotracheal Tubes and Incidence of Ventilator-Associated Pneumonia

## The NASCENT Randomized Trial

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**Context** Ventilator-associated pneumonia (VAP) causes substantial morbidity. A silver-coated endotracheal tube has been designed to reduce VAP incidence by preventing bacterial colonization and biofilm formation.

**Objective** To determine whether a silver-coated endotracheal tube would reduce the incidence of microbiologically confirmed VAP.

**Design, Setting, and Participants** Prospective, randomized, single-blind, controlled study conducted in 54 centers in North America. A total of 5[illegible] adult patients (≥18 years) were screened between 2002 and 2006. A total of 2003 patients expected to require mechanical ventilation for 24 hours or longer were randomized.

**Intervention** Patients were assigned to undergo intubation with 1 of 2 high-volume, low-pressure endotracheal tubes, similar except for a silver coating on the experimental tube.

**Main Outcome Measures** Primary outcome was VAP incidence based on quantitative bronchoalveolar lavage fluid culture with $10^3$ colony-forming units/mL or greater in patients intubated for 24 hours or longer. Other outcomes were VAP incidence in all intubated patients, time to VAP onset, length of intubation and duration of intensive care unit and hospital stay, mortality, and adverse events.

**Results** Among patients intubated for 24 hours or longer, rates of microbiologically confirmed VAP were 4.8% (26/[illegible] patients; 95% confidence interval [CI], 3.2%-6.6%) in the group receiving the silver-coated tube and 7.0% (46/[illegible]; 95% CI, 5.1%-9.1%) ($P = .03$) in the group receiving the uncoated tube (all intubated patients, 3.8% [26/[illegible]; 95% CI, 2.7%-4.2%] and 5.8% [46/[illegible]; 95% CI, 4.4%-7.5%] [$P = .04$], with a relative risk reduction of 34.9% [95% CI, 3.6%-49.0%; all intubated patients, 34.3% [95% CI, 1.2%-49.9%]). The silver-coated endotracheal tube was associated with delayed occurrence of VAP ($P = .006$). No statistically significant between-group differences were observed in durations of intubation, intensive care unit stay, and hospital stay, mortality, and frequency and severity of adverse events.

**Conclusion** Patients receiving a silver-coated endotracheal tube had a statistically significant reduction in the incidence of VAP and delayed time to VAP occurrence compared with those receiving a similar, uncoated tube.

**Trial Registration** clinicaltrials.gov Identifier: NCT00[illegible]

JAMA, 2008;300(7):805 www.jama.com

Ventilator-associated pneumonia (VAP) is associated with high morbidity, including increased length of hospital stay, health care costs, and infection with multidrug-resistant pathogens.[1-4] The condition usually occurs within 10 days after endotracheal intubation.[5-7] Reported rates vary by case mix, case definition, diagnostic procedures, and method of surveillance.[8] Conservative estimates of incidence range from 9%[9] to 18%[10] in large databases of mechanically ventilated patients and decreased substantially when the definition was changed from adjudicated radiographic, clinical, and bronchoscopic criteria[11] to rigorous microbiological criteria.[12]

For editorial comment see p 842.

The etiology of VAP is likely related to colonization of the aerodigestive tract with pathogenic bacteria and to aspiration of contaminated secretions.[1,7] Prevention strategies often focus on modifiable risk factors for colonization and aspiration[13-16] and can successfully reduce

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JAMA. 2008;300:805

# RCT, 54 centers, 2003 adults

**S-C ETT → 4.8% VAE**
**Reg ETT → 7.5% VAE**

## Silver

- Broad spectrum antibiosis
- Reduces bacterial adhesion
- Blocks biofilm formation
- Nontoxic

KOHLER

**Hand bacterial counts: $5 \times 10^3 – 5 \times 10^6$ units / $cm^2$**

**Hair, groin and underarm areas are higher**

**Skin crevices are bacterial respites**

**Fingernails harbor enormous #**

**Jewelry & watches → worse**


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**US Center for Disease Control, 2008**
**Morbidity & Mortality Weekly Report**
**WWW.CDC.GOV**

# Effect of Antiseptic Handwashing vs Alcohol Sanitizer on Health Care–Associated Infections in Neonatal Intensive Care Units

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**Background:** The Centers for Disease Control and Prevention, Atlanta, Ga, recommend use of waterless alcohol hand products in lieu of traditional handwashing for patient care, but there are few data demonstrating the impact of this recommendation on health care–associated infections.

**Objective:** To compare the effect of 2 hand hygiene regimens on infection rates and skin condition and microbial counts of nurses' hands in neonatal intensive care units.

**Design, Setting, and Participants:** Clinical trial using a crossover design in 2 neonatal intensive care units in Manhattan, NY, from March 1, 2001, to January 31, 2003, including 2932 neonatal hospital admissions (51 760 patient days) and 119 nurse participants.

**Intervention:** Two hand hygiene products were tested: a traditional antiseptic handwash and an alcohol hand sanitizer. Each product was used for 11 consecutive months in each neonatal intensive care unit in random order.

**Results:** After adjusting for study site, birth weight, surgery, and follow-up time, there were no significant differences in neonatal infections between the 2 products; odds ratios for alcohol compared with handwashing were 0.98 (95% confidence interval [CI], 0.77-1.25) for any infection, 0.99 (95% CI, 0.77-1.33) for bloodstream infections, 1.61 (95% CI, 0.57-5.54) for pneumonia, 1.78 (95% CI, 0.94-3.37) for skin and soft tissue infections, and 1.26 (95% CI, 0.42-3.76) for central nervous system infections. The skin condition of participating nurses was significantly improved during the alcohol phase ($P = .02$ and $P = .049$ for observer and self-assessments, respectively), but there were no significant differences in mean microbial counts on nurses' hands (3.21 and 3.11 $\log_{10}$ colony-forming units for handwashing and alcohol, respectively; $P = .38$).

**Conclusions:** Infection rates and microbial counts on nurses' hands were equivalent during handwashing and alcohol phases, and nurses' skin condition was improved using alcohol. However, assessing the impact on infection rates of a single intervention is challenging because of multiple contributory factors such as patient risk, unit design, and staff behavior. Other practices such as frequency and quality of hand hygiene are likely to be as important as product in reducing risk of cross-transmission.

*Arch Pediatr Adolesc Med. 2005;159:377-383*

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THE RECENTLY PUBLISHED Centers for Disease Control and Prevention "Guideline for Hand Hygiene in Healthcare Settings"[1] represents a major change in hand hygiene. The guideline recommends using alcohol-based hand sanitizers rather than traditional handwashing for patient encounters and washing with soap and water only when hands are physically soiled. There are, however, few data regarding the potential impact of these products on risk of health care–associated infection (HAI), particularly in high-risk neonatal units. Hence, the purpose of this study was to compare the impact of 2 hand hygiene products (alcohol hand sanitizer or traditional antiseptic handwash) on HAI rates among the neonates in 2 neonatal intensive care units (NICUs) and the skin condition and microbial counts of the hands of participating nurses.

## METHODS

### STUDY DESIGN

This clinical trial used a sequential crossover design in which each hand hygiene product was used by each study NICU in random order for 11 consecutive months.

### PARTICIPANTS AND SETTING

The study was conducted in 2 NICUs in Manhattan that are part of the New York Presby-

**Arch Pediatr Adols Med 2005;159:377-383**

# Why we don’t wash our hands

- Patient care distracts us
- Male gender
- Forgetfulness
- Hand irritation
- Wearing gloves
- Hands don’t look dirty
- Takes too long / don’t have time
- Feelings of overwork or understaffing
- Lack of well-placed facilities (soap or sink)
- Lack of knowledge of guidelines

# Will you wash your hands?

- Washing hands saves lives, and reduces the overall cost of healthcare
- As anesthesia providers we hold patients' lives in our hands every time we enter the OR

***Shouldn't those hands be clean?***

# Hand Washing and Use of Gloves While Managing Patients Receiving Mechanical Ventilation in the ICU*

*Mohamad Khatib, PhD; Chassan Jamaleddine, MD, FCCP; Afif Abdallah, RN; and Youssef Ibrahim, RN*

**Study objective:** To evaluate the effectiveness of warning labels permanently attached to mechanical ventilators in improving the practice of hand washing and use of gloves by respiratory care practitioners (RCPs) in the ICU.
**Design:** The study consisted of two 4-week periods. Daily observations of hand washing and use of gloves by RCPs were made over four 1-h observation periods. Prior to the first 4-week period, the importance of hand washing and use of gloves was presented to all staff. At the end of the first period, "Wash Hands Use Gloves" labels were permanently placed on all ventilators in the ICU. The RCPs were not aware they were being observed for hand washing and use of gloves in either period.
**Measurements and results:** The total number of encounters between the RCPs and patients as well as the rates of hand washing and use of gloves were obtained during the study. The rates of hand washing and use of gloves were significantly higher during the second period when labels were attached to the ventilators, as compared to the rates during the first period: hand washing, 92% vs 46% ($p < 0.05$); use of gloves, 92% vs 43% ($p < 0.05$), respectively. During the first period, the rates of pre-encounter hand washing (78%, 48%, 27%, and 29% in weeks 1 through 4, respectively) and the use of gloves (56%, 37%, 32%, and 45% in weeks 1 through 4, respectively) were primarily declining. This was not observed during the second period of the study (94%, 88%, 95%, and 92% in weeks 1 through 4, respectively) for the rates of pre-encounter hand washing and the use of gloves.
**Conclusions:** Simple measures such as the placement of warning labels on mechanical ventilators can significantly improve hand washing and use of gloves by RCPs in the ICU.
*(CHEST 1999; 116:172–175)*

**Key words:** gloves; hand washing; ICU; mechanical ventilators
**Abbreviation:** RCP = respiratory care practitioner

Patients receiving mechanical ventilation in the ICU are at high risk of getting a hospital-acquired infection or ventilator-associated pneumonia. These patients are frequently subjected to invasive therapy, such as tracheal suctioning, bronchodilation, and manipulation of the ventilator or endotracheal tube. Therefore, the likelihood of contamination and cross-infection is increased. Pathogens causing nosocomial pneumonia, such as Gram-negative bacilli and *Staphylococcus aureus*, are ubiquitous in hospitals, especially in ICUs.[1]

The transmission of these microorganisms to patients frequently occurs via the hands of health-care workers that become contaminated or transiently colonized with the microorganisms.[2] These infections are a major cause of mortality and morbidity, as well as of prolongation of hospitalization and increases in hospitalization costs.[3] Thus, prevention of hospital-acquired infections has become an important aspect of intensive-care practice.

An effective hand-washing technique is the cornerstone of effective infection control and remains unchallenged as the most effective means of preventing hospital-acquired infections. The practice of hand washing is well known to reduce the spread of infection, yet the compliance of health-care professionals, including those in the high-risk area of intensive care, is usually unsatisfactory and occasionally very poor.[4]

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Manuscript received October 27, 1998; accepted January 26, 1999.
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**Wash Hands!**
**Use Gloves!**

**With labels :**

**Handwashing 92% vs 46%**

**Gloves 92% vs 43%**

**Chest. 1999;116:172**


YOUR HANDS CAN BE DANGEROUS.
WASH THEM WITH SOAP AND WATER TO KEEP BACTERIA AT BAY.
CEVS


Your 5 moments for
HAND HYGIENE
1 BEFORE PATIENT CONTACT
2 BEFORE ASEPTIC TASK
3 AFTER BODY FLUID EXPOSURE RISK
4 AFTER PATIENT CONTACT
5 AFTER CONTACT WITH PATIENT SURROUNDINGS

# Promoting alcohol hand rubs improves hand hygiene habits in the ICU

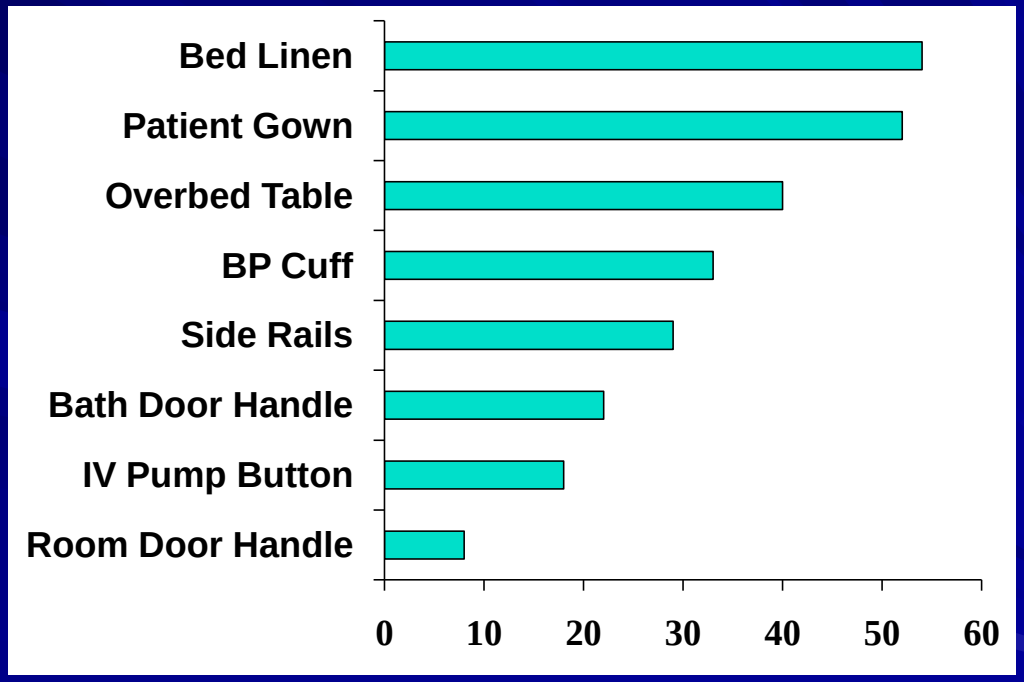
When alcohol hand rub dispensers are near each patient's bed, we clean our hands significantly more often than when only sinks are available


Arch Intern Med. 2000;160:1017-1021

# Cleaning hands with alcohol-based hand-rubs compared to soap and water

- takes less time to use
- more accessible than sinks
- less skin irritation and dryness
- *more effective* in reducing the number of bacteria
- has led to improved hand hygiene practices

# % of surfaces contaminated with pathogenic bacteria




J Hosp Infect. 2006;65:50

# Hand-cleansing during PACU care

9/2003

Anesthesiology 2003; 99:519–20

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## *A Study of Hand Hygiene in the Postanesthesia Care Unit—It's about Time!*

AS a hospital epidemiologist, my inclination when I reviewed the article by Pittet *et al.* entitled "Hand-cleansing during Postanesthesia Care"[1] was to say, "It's about time someone addressed this issue in the PACU"! In contrast, readers of the Journal may be asking, "What's the big deal? These authors haven't demonstrated that poor compliance with hand-cleansing, or hand hygiene, in the PACU is linked to subsequent nosocomial infections." If that is how you responded, you are correct when you say the authors did not prove that poor compliance with hand hygiene caused nosocomial infections. In fact, their goal was simply to evaluate compliance with hand hygiene in their PACU. They accomplished this goal and documented that compliance with this basic infection-control measure was as low or lower than that previously reported from intensive care units (ICUs).

Before I go further, I want to congratulate the authors for addressing this difficult topic. I also want to congratulate nurses and physicians working in PACUs who take hand hygiene seriously. That said, I'd like to address skeptics in the reading audience. I also would like to address the issue of time—because it is not only about time someone did a study on this topic, but it is also time that makes this a difficult topic to study, and time (or lack thereof) that may prevent some staff from practicing good hand hygiene.

Given the brief time that patients are in the PACU, it will be difficult to prove that specific nosocomial infections occurring while the patient is in the surgical ICU or on the surgical ward were caused by the PACU staff's failure to perform hand hygiene appropriately. However, data from ICUs indicate that patients typically acquire pathogens from the hands of healthcare workers and that hand hygiene decreases the transmission of these organisms and prevents nosocomial infections.[2,3] I cannot envision a universe in which rules that apply in ICUs do not apply in PACUs. Thus, a Gram-negative organism may be carried on a PACU nurses' hands from the Foley catheter to the hub of the central venous catheter and from there into the bloodstream of a patient. When signs and symptoms of bloodstream infection are manifest, the patient will be in the surgical ICU. The infection-control program will report the infection to surgical ICU staff, and PACU staff will never receive feedback about that or any other infection.

PACU staff members are extremely busy caring for patients who are unstable, in pain, have numerous invasive devices, and require substantial nursing care. Obviously, if the choice is between performing hand hygiene and performing a task that will save the patient's life, staff members should save the patients' life. However, this author suspects that staff members infrequently must choose between performing hand hygiene and saving the patient's life. Instead, I believe that PACU staff and other staff neglect to cleanse their hands because they have not been trained to identify all situations in which hand hygiene should be performed or because the culture in the unit is such that staff members do not put a high priority on this practice.

The argument that PACU staff members do not have time for hand hygiene is mitigated in part by the alcohol-based hand-hygiene products available in many hospitals. These products can be placed at the bedside so that staff members do not even need to cross the room to cleanse their hands. Moreover, Voss and Widmer documented that these products reduce by 50–75% the time needed for hand hygiene in an ICU.[4]

Two recently published studies are pertinent to the study by Pittet *et al.* Rogues *et al.* documented that 33% and 41% of patients carried pathogenic organisms in their nares or on skin adjacent to their surgical sites when they were admitted to the PACU and when they were discharged, respectively.[5] Nineteen percent of staff also carried pathogenic organisms. These investigators concluded that cross-contamination could occur in PACUs and that staff needed education regarding hand hygiene, isolation precautions, and environmental cleaning. Hajjar and Girard conducted surveillance for nosocomial infections related to anesthesia, which they defined as infections occurring within 72 h of a general or regional anesthetic procedure.[6] They identified 25 infections—12 respiratory, 9 vascular catheter–associated, 2 eye, and 2 mouth—for a rate of 3.4 infections/1,000 patients. The infections could have been acquired in the operating room, PACU, or surgical ICU. Although we can't prove that they originated from errors in the PACU, we also can't prove that they didn't.

The PACU is usually an open ward without barriers, such as walls, between patients to remind staff members that they need to cleanse their hands when moving from one patient to another. Also, patients usually are not

This Editorial View accompanies the following article: Pittet D, Stéphan F, Hugonnet S, Akakpo C, Souweine B, Clergue F: Hand-cleansing during postanesthesia care. ANESTHESIOLOGY 2003; 99:530–5.

Accepted for publication May 19, 2003. The author is not supported by, nor maintains any financial interest in, any commercial activity that may be associated with the topic of this article.

**Study aim:**

**Assess healthcare workers' compliance with hand washing and identify factors associated with poor compliance**

# Study Parameters

- 2,300 bed academic center
- 12 open bed PACU RN to patient 1:3
- 3 sinks & individual bed alcohol hand-rub
- Staff aware of monitoring / not of the study's purpose

- Observed over continuum of PACU care

- Total observation time was 39 hours
- 120 nurses, 17 physicians, 16 nurse assistants
- Observed 3,143 patient care interventions
- 1,091 interventions had "strong risk" for cross transmission

- **Average compliance with hand-cleansing =12.5%**
- **Type of hand-cleansing when performed**
  - **Soap & water = 17%  Alcohol hand-rub = 83%**

***"A particularly low compliance with hand-cleansing in the PACU at time of patient admission & during stay."***

# Factors moderating PACU compliance

- Intensity of care activities was very high
- Unpredictable events add to burden

- *Sense of personal* exposure risk? → ⬆ compliance
- Increasing patient age → ⬆ compliance

***Anesthesia care??***

***Is absence of evidence, evidence of absence?***

**Intraoperative environment**

- **Aerosolized particles everywhere**
- **Liquids from patients and our work materials**
- **Ubiquitous hard & soft surface contamination**

**Paucity of objective evidence**

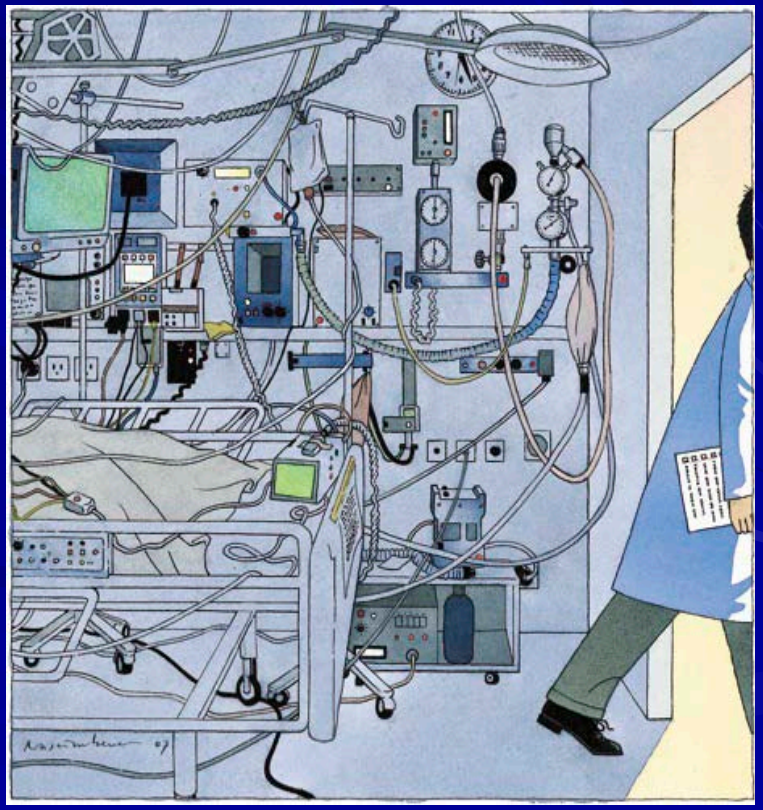
- ➡ **belief we have little role in nosocomial infection**

- TRALI
- Awareness
- Acute ischemic stroke
- Cancer recurrence (?)
- Cognitive impairment
- Peripheral nerve injury
- Occult vision disturbance
- Occult hearing disturbance

*Infection……*

# Pathogens in the Workplace

- Drug resistant microbes are increasing*
- ICUs are epicenters of bacterial colonization & resistance**
- ? the anesthesia workplace



*Am J Infect Control. 2004;32:470
*Am J Infect Control. 2008;36:309
**JAMA. 2007;298:1763

# Study Objectives:

- Characterize the risk of bacterial transmission during routine care
- Identify areas for risk modification

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## *Transmission of Pathogenic Bacterial Organisms in the Anesthesia Work Area*

*Randy W. Loftus, M.D.,* Matthew D. Koff, M.D.,† Corey C. Burchman, M.D.,‡ Joseph D. Schwartzman, M.D.,§ Valerie Thorum, M.T. (A.S.C.P.),‖ Megan E. Read, M.T. (A.S.C.P.),‖ Tammara A. Wood, M.T., (A.M.T.),‖ Michael L. Beach, M.D., Ph.D.#*

***Background:*** **The current prevalence of hospital-acquired infections and evolving amplification of bacterial resistance are major public health concerns. A heightened awareness of intraoperative transmission of potentially pathogenic bacterial organisms may lead to implementation of effective preventative measures.**

***Methods:*** **Sixty-one operative suites were randomly selected for analysis. Sterile intravenous stopcock sets and two sites on the anesthesia machine were decontaminated and cultured aseptically at baseline and at case completion. The primary outcome was the presence of a positive culture on the previously sterile patient stopcock set. Secondary outcomes were the number of colonies per surface area sampled on the anesthesia machine, species identification, and antibiotic susceptibility of isolated organisms.**

***Results:*** **Bacterial contamination of the anesthesia work area increased significantly at the case conclusion, with a mean difference of 115 colonies per surface area sampled (95% confidence interval [CI], 62–169; $P < 0.001$). Transmission of bacterial organisms, including vancomycin-resistant enterococcus, to intravenous stopcock sets occurred in 32% (95% CI, 20.6–44.9%) of cases. Highly contaminated work areas increased the odds of stopcock contamination by 4.7 (95% CI, 1.42–15.42; $P = 0.011$). Contaminated intravenous tubing was associated with a trend toward increased nosocomial infection rates (odds ratio, 3.08; 95% CI, 0.56–17.5; $P = 0.11$) and with an increase in mortality (95% CI odds ratio, 1.11–∞; $P = 0.0395$).**

***Conclusions:*** **Potentially pathogenic, multidrug-resistant bacterial organisms are transmitted during the practice of general anesthesia to both the anesthesia work area and intravenous stopcock sets. Implementation of infection control measures in this area may help to reduce both the evolving problem of increasing bacterial resistance and the development of life-threatening infectious complications.**

HOSPITAL-ACQUIRED (nosocomial) infections now affect 10% of patients admitted, and the amplification of bacterial resistance is an evolving problem worldwide.[1,2] As a result, community and hospital outbreaks of infections secondary to resistant organisms are occurring at increasing frequency.[3] In addition, while infections due to resistant bacterial strains were primarily associated with acute care settings, they are now occurring at increased rates within the community.[3] It is well known that intensive care units are epicenters of bacterial resistance, but little is known about the role of the anesthesia environment and anesthetic practice in this process.[1]

For several reasons, the intraoperative environment serves as a risk factor for the development of hospital-acquired infections.[4–10] This, combined with evidence that general anesthesia is associated with immune suppression, suggests that anesthetic practice as a whole may also be linked to the development of hospital-acquired infections.[11,12] Given the current increasing community awareness surrounding this issue and the impending arrival of pay for performance policies, there is further impetus to develop preventative measures. A better understanding of the underlying mechanisms by which bacterial transmission occurs and resistance is increasing may facilitate this process.

The intraoperative environment includes both aerosolized particles and healthcare tools used within the anesthesia work area. This is theoretically associated with the development of nosocomial infections, but there is a lack of objective evidence linking these factors with direct transmission of bacterial organisms to patients.[4,7,9,13]

The mechanism by which these factors generate nosocomial infections remains unclear. However, there is a high probability of patient contamination during the practice of anesthesia due to rapid patient care combined with frequent contact with potential sources of bacterial transmission. In addition, transmission of multidrug-resistant bacterial organisms likely occurs but has not yet been described.

This paucity of objective evidence has led to the belief that the anesthesia work area and anesthetic practice have no role in the development of hospital-acquired infections or amplification of bacterial resistance. As such, we currently have inadequate implementation of infection control measures in this area.[14–16] The aim of this study was to characterize the risk of bacterial transmission during the practice of general anesthesia to stimulate important measures for risk modification and reduction of hospital-acquired infections. We hypothesized that intraoperative bacterial contamination of the anesthesia work area was associated with contamination of peripheral intravenous stopcock sets, partially explaining the association of general anesthesia with the development of nosocomial infections.

This article is featured in "This Month in Anesthesiology." Please see this issue of ANESTHESIOLOGY, page 9A.

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**9/2008**

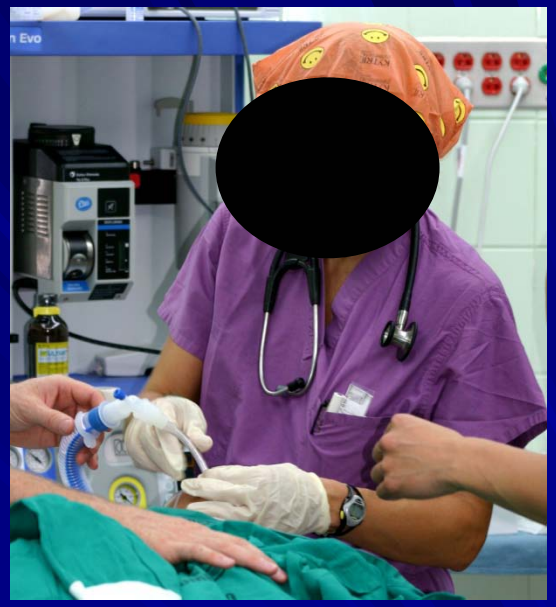
- 400+ bed, 28 OR medical center
- Anesthesia residents, attendings, CRNAs

- 6 days  61 patients in 61 randomly selected ORs

- First case of the day in each room
- Standardized machine sanitized prior to case
  - Cultured
- IV set / stopcocks sterile
  - Cultured

**Case mix:**
**Gen 30%  Peds 15%  Ortho 13%  Gyn 11%**
**CT 10%  ENT 10%  Neuro 5%  Other 6%**

- Peripheral IV tubing became contaminated with pathologic bacteria in 32% (n=20) of cases



- Retrospective 30 day chart review

  5/20 with contaminated stopcocks →HAI

  2/5 died (blood and respiratory infections)

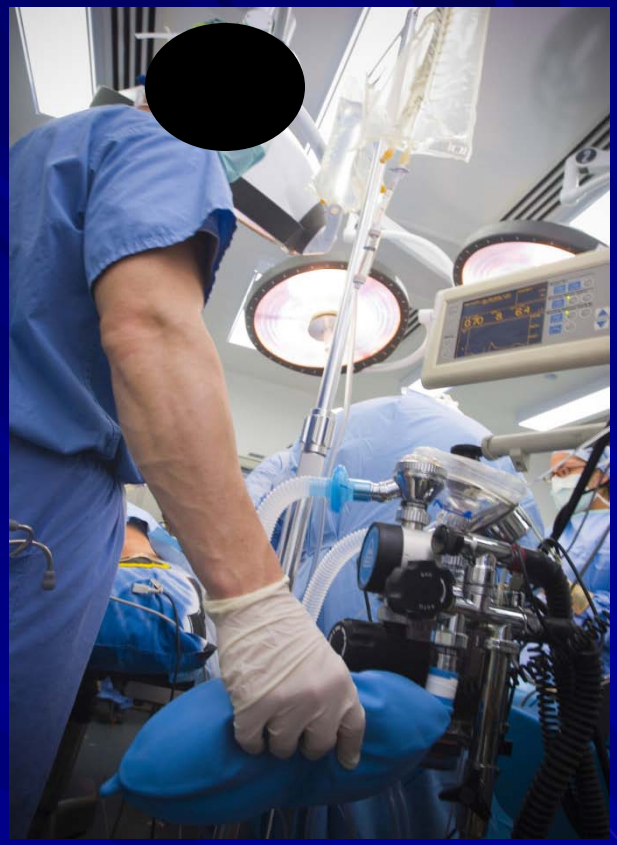
  5/41 without stopcock contamination → HAI

  0 died

  3/20 MRSA or VRE to stopcocks (2 died)

## Risks of working in ICU & OR:

- Dangerous organisms everywhere
- Inconsistent / poor aseptic practice
- High task density
- Complex equipment
- Complex procedures
- Vulnerable subjects (patients and us!)



**Work area contaminated in as few as 4 minutes**

**Early transmission likely occurs due to contamination of provider hands after induction**

# Authors' Conclusions

- "We demonstrated that variable aseptic practice of anesthesia providers leads to contamination of both intravenous tubing and the anesthesia work area with pathogenic bacteria"

?

- "We observed patient mortality that may be due to stopcock contamination secondary to poor aseptic practice"

Anesthesiology 2009; 110:978–85
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# Reduction in Intraoperative Bacterial Contamination of Peripheral Intravenous Tubing Through the Use of a Novel Device

Matthew D. Koff, M.D.,* Randy W. Loftus, M.D.,† Corey C. Burchman, M.D.,‡ Joseph D. Schwartzman, M.D.,§ Megan E. Read, M.T. (A.S.C.P.),‖ Elliot S. Henry, B.S.,# Michael L. Beach, M.D., Ph.D.**

***Background:*** **Hand hygiene is a vital intervention to reduce health-care associated infections, but compliance remains low. The authors hypothesized that improvements in intraoperative hand hygiene compliance would reduce transmission of bacteria to surgical patients and reduce the incidence of postsurgical healthcare-associated infections.**

***Methods:*** **The authors performed a controlled before-and-after study over 2 consecutive months. One hundred fourteen operative cases were enrolled. Two predesignated sites on the anesthesia machine were selected, decontaminated, and cultured *via* aseptic technique. These sites and the peripheral intravenous stopcock were cultured again after completion of the surgery. The treatment phase used a novel personal hand-decontamination device capable of recording hand-decontamination events.**

***Results:*** **There were no significant differences in patient location, age, or case duration and procedure type between groups. Use of the Sprixx GJ device (Harbor Medical Inc., Santa Barbara, CA) increased hourly hand decontamination events by 27-fold as compared with baseline rates ($P < 0.002$; 95% confidence interval, 3.3–13.4). Use of the device was associated with a reduction in contamination in the anesthesia work area and peripheral intravenous tubing. Intravenous tubing contamination was identified in 32.8% of cases in the control group *versus* 7.5% in the treatment group (odds ratio, 0.17; 95% confidence interval, 0.06–0.51; $P < 0.01$). Healthcare-associated infections rates were reduced in the device group (3.8%) as compared with the control group (17.2%) (odds ratio, 0.19; 95% confidence interval, 0.00–0.81; $P = 0.02$).**

***Conclusions:*** **Improved hand hygiene compliance through the use of a novel hand sanitation strategy reduces the risk of intraoperative bacterial transmission. The intervention was associated with a reduction in healthcare-associated infections.**

This article is featured in "This Month in Anesthesiology." Please see this issue of ANESTHESIOLOGY, page 9A.

This article is accompanied by an Editorial View. Please see: Hopf HW, Rollins MD: Reducing perioperative infection is as simple as washing your hands. ANESTHESIOLOGY 2009; 110:959–60.

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THE importance of hand hygiene in healthcare-associated infection (HCAI) was demonstrated before microorganisms were known to cause infection. In 1847, Ignaz Philipp Semmelweis, M.D. (Professor of Obstetrics at the University of Pest, Budapest, Hungary, 1818–1865), ordered all students and physicians to scrub their hands with a 4% chlorinated lime solution, yielding a 15% reduction in peripartum mortality. However, despite the continued success of this disinfection strategy, this practice was strongly opposed by his colleagues and never gained generalized acceptance.[1,2] Therefore, despite modern advances in microbiology, epidemiology, and infection control, widespread and consistent use of hand disinfection strategies continues to remain elusive more than 160 yr later.

As a result of the ineffective adherence to preventative measures, including aseptic practice, inanimate surface decontamination, barrier techniques, hand hygiene, antibiotic prophylaxis, and maximizing host defenses, 10% of hospitalized patients in the United States acquire a healthcare-associated infection. These infections contribute to the mortality of 90,000 hospitalized patients and $4.5 billion in additional healthcare costs annually.[3] With widespread adoption of these important preventative strategies, the majority of these infections can be prevented. Current rates are indefensible and, if not aggressively reduced, will serve as a disgrace to the entire healthcare community. In the near future, the Centers for Medicare and Medicaid Services may not reimburse for healthcare costs associated with these infections.[4]

Extensive work has been focused on the prevention of surgical site infections with regard to maintenance of a sterile surgical environment, preoperative antibiotics, and maintenance of patient temperature and oxygen tension. Relatively little is known about the anesthesia workspace, including the anesthesia machine, anesthesia cart, and intravascular devices. However, the risk of bacterial transmission to patients exists within the operative environment,[5] and surveys suggest that anesthesia personnel inconsistently adhere to preventative measures such as hand hygiene guidelines and aseptic technique.[6,7] In an observational study looking at physician adherence to hand hygiene, anesthesiologists were the worst performers of all specialties observed.[8] The aseptic practice of anesthesia personnel must be considered

5/2009

Trained observers

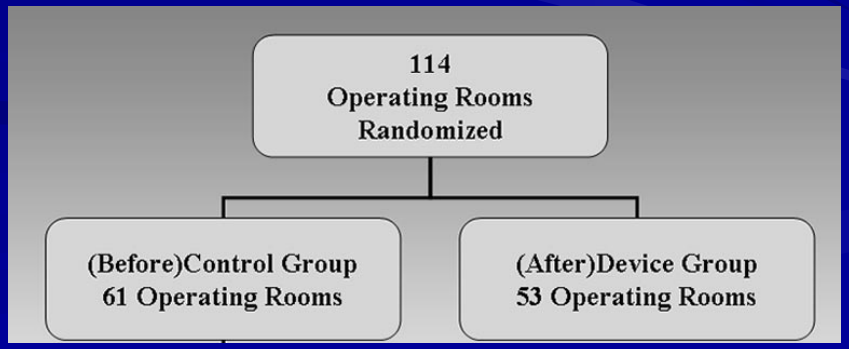


Table 2. Comparison of the Hourly Hand-decontamination Events of the Observational Study with the Device Group

| | Device | | Control | | Comparison | | |
|---|---|---|---|---|---|---|---|
| | Mean (SD) | n | Mean (SD) | n | Difference | 95% CI | *P* Value |
| Attending physicians | 7.1 (1.4) | 52 | 0.15 (0.05) | 17 | 6.9 (2.51) | (1.9 to 11.0) | 0.008* |
| Other providers | 8.7 (2.0) | 45 | 0.38 (0.12) | 29 | 8.3 (2.5) | (3.3 to 13.4) | 0.002* |

**Hourly decontamination events increased 27-fold**

**IV contamination: 33% control group 7.4% Rx group**

**HAI*: 17.2% control group 3.8% Rx group**

*** Review of medical record over 30 postop days**

In conclusion, our results demonstrate that the provision of a simple, cost-effective device containing an alcohol-based solution significantly reduces intraoperative transmission of potentially pathogenic bacterial organisms. Our study also suggests that use of this device reduces the incidence of postoperative healthcare-associated infections, but further study is required to verify these results.

# A clandestine, observational study of the hand hygiene behaviors of anesthesia providers over the perioperative continuum at a large, metropolitan medical center

**Research Session**

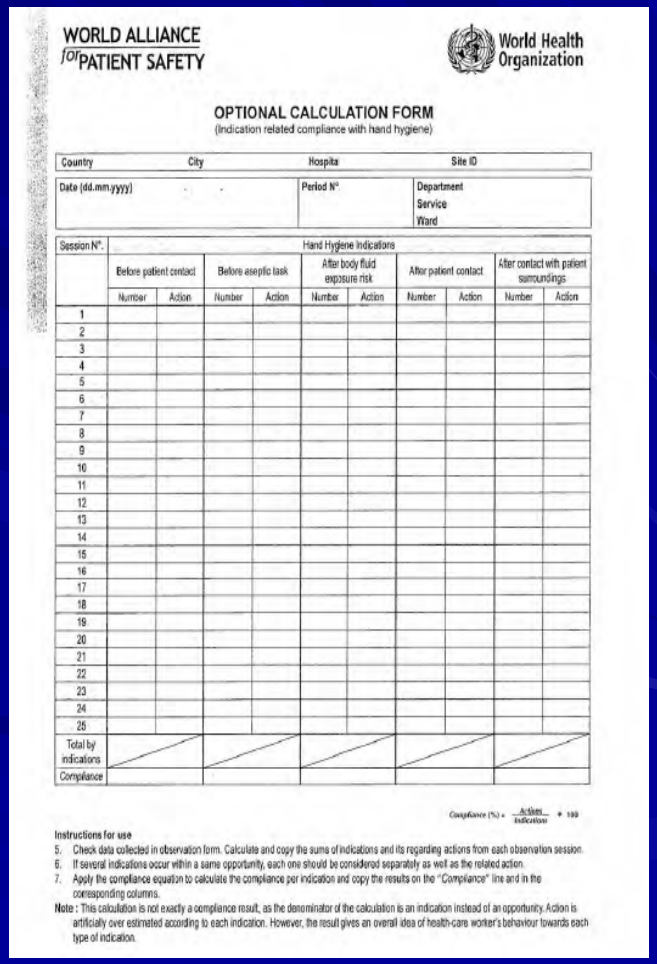
**AANA National Meeting, 8/2010**

# Study Design

**3-week period, trained observers recorded hand hygiene activity of providers in the preop, intraop and PACU domains**

**Standardized WHO recording instrument, data entered into an EXCEL spreadsheet**

**No names recorded. Only "provider type" and "nature of observation" was recorded**



WORLD ALLIANCE *for* PATIENT SAFETY

World Health Organization

OPTIONAL CALCULATION FORM
(Indication related compliance with hand hygiene)

| Country | City | Hospital | Site ID |
|---|---|---|---|

| Date (dd.mm.yyyy) | Period N° | Department<br>Service<br>Ward |
|---|---|---|

| Session N°. | Hand Hygiene Indications | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Before patient contact | | Before aseptic task | | After body fluid exposure risk | | After patient contact | | After contact with patient surroundings | |
| | Number | Action | Number | Action | Number | Action | Number | Action | Number | Action |
| 1 | | | | | | | | | | |
| 2 | | | | | | | | | | |
| 3 | | | | | | | | | | |
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| 22 | | | | | | | | | | |
| 23 | | | | | | | | | | |
| 24 | | | | | | | | | | |
| 25 | | | | | | | | | | |
| Total by indications | | | | | | | | | | |
| Compliance | | | | | | | | | | |

$$\text{Compliance (\%)} = \frac{\text{Actions}}{\text{Indications}} \times 100$$

Instructions for use

5. Check data collected in observation form. Calculate and copy the sums of indications and its regarding actions from each observation session.
6. If several indications occur within a same opportunity, each one should be considered separately as well as the related action.
7. Apply the compliance equation to calculate the compliance per indication and copy the results on the "Compliance" line and in the corresponding columns.

Note : This calculation is not exactly a compliance result, as the denominator of the calculation is an indication instead of an opportunity. Action is artificially over estimated according to each indication. However, the result gives an overall idea of health-care worker's behaviour towards each type of indication.

## What was learned from hundreds of observations:

There were differences in the rates of failed hand hygiene among the four observed provider groups

Indications for hand hygiene varied by domain & period of care, but not infrequently approached 15-35 / hour

The hand hygiene failure rate ranged from 64% - 93% by group, with a mean failure rate of 82%

# Taxonomy of the major categories of hand hygiene failures:


Moving between/among patients during preop assessment

Before, during and after pain service interventions

Innovian / Pyxis system keyboard use with soiled hands

IV starts and blood draws (high rate of no gloves!)

Drawing up meds for next case with soiled hands/gloves

Soiled gloves left on after airway intervention

Soiled gloves left on after Foley/IV/central line manipulation

# OR *vs* ICU
# A parallel comparison

**ICU: published audits suggest that hand hygiene is indicated about 20 x per hour (1)**

**Direct observation suggests this number is higher in anesthesia particularly at the start / end of cases (2-4)**


1. BoyceBoyce JM, Pittet D. Am J Infect Control 2002; 30:S1–46
2. Hopf HW, Rollins MD. Anesthesiology. 2009;110:959-960
3. Koff M et al. Anesthesiology. 2009;110:959-960.
4. Biddle C. AANA Jo. 2009;77:229-237.

Anesthesiology 2006; 105:241–3 © 2006 American Society of Anesthesiologists, Inc. Lippincott Williams & Wilkins, Inc.

# *Gloved and Masked—Will Gowns Be Next?*

## *The Role of Asepsis during Neuraxial Instrumentation*

SINCE the discovery of "spinal anesthesia" in 1885 by J. Leonard Corning and its subsequent application in humans by Augustus Bier in 1898, close scrutiny has been paid to possible complications related to this technique. Although neurologic complications after spinal anesthesia, including aseptic meningitis, were described as early as 1936, it was not until the Woolley and Roe cases in 1947 that these complications were highly publicized. In these cases, two relatively young healthy males became paraplegic after spinal anesthesia secondary to contamination of the syringes and spinal needles by an acidic descaler.[1] Ever since, clinicians continue to improve and modify this technique to increase safety and minimize complications. In this issue of ANESTHESIOLOGY, Baer[2] presents a review of cases of post- dural puncture meningitis (PDPM) purportedly related to a dural puncture. In another report in this issue of the journal, Ruppen *et al.*[3] present a meta-analysis of well over one million parturients describing the incidence of serious neurologic injuries, including infection, after epidural analgesia and anesthesia.

A statement on regional anesthesia approved by the House of Delegates of the American Society of Anesthesiologists* states that regional techniques are best performed by an anesthesiologist who possesses competence and skills necessary for safe and effective performance. Although the statement mentions that recognition of complications and provision of appropriate postprocedure care is the duty of the physician, there is no reference to sterile technique. More importantly, a physician booklet drafted by the American Society of Anesthesiologists Task Force on Infection Control† recommends the use of maximal sterile barrier precautions during central venous catheter infection but does not address neuraxial techniques. Baer[2] correctly points out that unlike regional techniques, guidelines for the prevention of intravascular catheter-related infections were developed by practitioners who insert catheters, including intensivists and anesthesiologists.[4] They emphasize the use of maximal sterile barrier precautions during central venous catheter infection and the preferred use of 2% chlorhexidine preparation for skin antisepsis. Sterile precautions including cap, mask, sterile gown, sterile gloves, and large sterile drape have been demonstrated to reduce the incidence of intravascular catheter-related bloodstream infections when compared with standard precautions, including sterile gloves and small drapes.[5]

This begs the question of whether the same precautions ought to be used for the placement of neuraxial anesthesia. Central venous catheter-related infections are more common than neuraxial-related infections, and the use of maximum sterile barriers while placing central lines was targeted by the Agency for Healthcare Research Quality as a practice that needs more widespread implementation.[6] Interestingly, although there are no data supporting the use of all components of maximal precautions when performing neuraxial techniques, aseptic practice for neuraxial techniques varies tremendously between practitioners.[7–9] Despite the abundance of data cited by Baer[2] demonstrating that aerosolized organisms often originate from the physician performing a dural puncture, some even question the use of a surgical mask while performing these techniques. Even in the presence of laminar airflow in operating rooms, bacterial counts measured on settle plates at head and waist height were higher when either hat or mask was not worn.[10] The increase in count was greater when a mask was not worn, and the absence of both hat and a mask led to an exponential increase.[10] Other basic components of aseptic technique are often breached. Although the bactericidal effect of skin disinfectants (povidone iodine and chlorhexidine) peaks at 2 min,[4] it is common to leave skin cleansing as the last step before skin infiltration, which does not leave adequate time for disinfectants to be effective. Medications are frequently drawn up without a filter needle, although microparticles are often found in local anesthetics or other sterile solutions after the syringe has been filled.[11]

Some have expressed skepticism that true sterile technique is actually practiced. Pointing to the many possible breeches leading to potential contamination, they have emphasized the need for a consensus conference to clarify the meaning of good aseptic practice for neuraxial techniques.[7,12] To this end, the American Society of Regional Anesthesia and Pain Medicine convened a con-

This Editorial View accompanies the following two articles: Baer ET: Post-dural puncture bacterial meningitis. ANESTHESIOLOGY 2006; 105:381–95; Ruppen W, Derry S, McQuay H, Moore RA: Incidence of epidural hematoma, infection, and neurologic injury in obstetric patients with epidural analgesia/anesthesia: Meta-analysis. ANESTHESIOLOGY 2006; 105:394–9.

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* Available at: http://www.asahq.org/publicationsAndServices/standards/26.pdf. Accessed April 28, 2006.

† Available at: http://www.asahq.org/publicationsAndServices/infectioncontrol.pdf. Accessed April 28, 2006.



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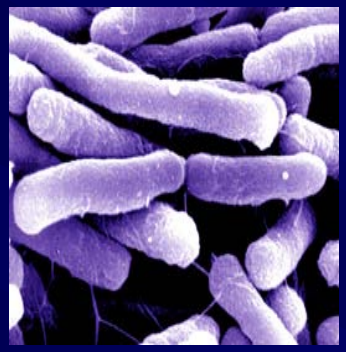
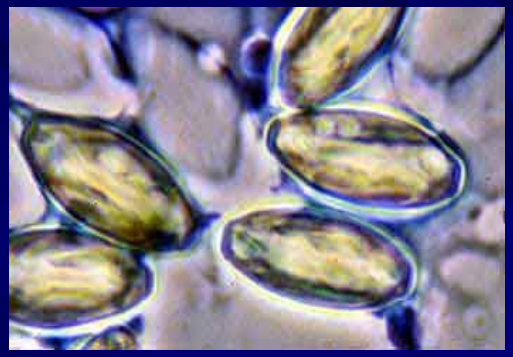
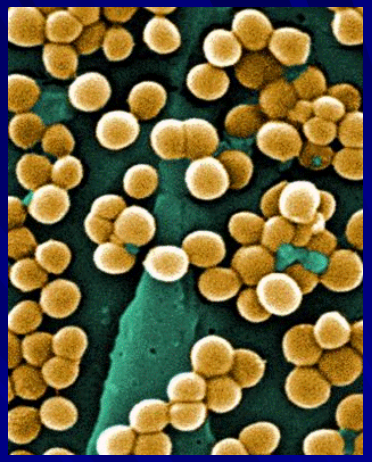
***Anesthesiology*. August 2005**

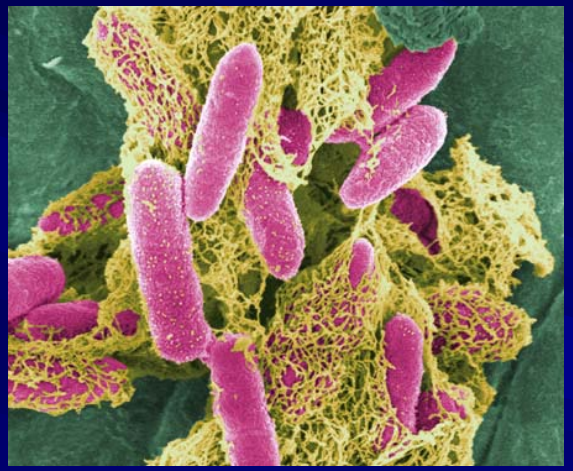
**Barrier drape?**
**Head cover?**
**Mask?**
**Hand washing?**
**Gown?**

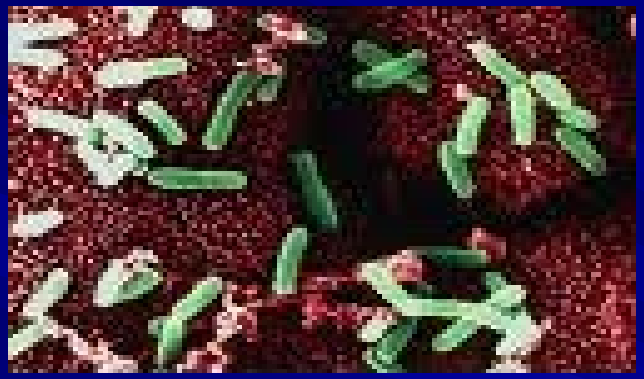




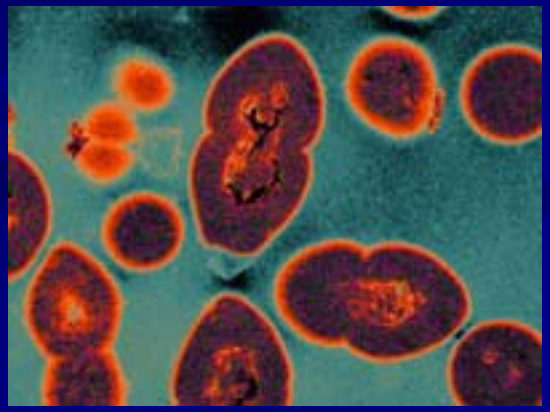
MRSA







C difficile



VRE

# Emergence of a new antibiotic resistance mechanism in India, Pakistan, and the UK: a molecular, biological, and epidemiological study

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## Summary

**Background** Gram-negative Enterobacteriaceae with resistance to carbapenem conferred by New Delhi metallo-β-lactamase 1 (NDM-1) are potentially a major global health problem. We investigated the prevalence of NDM-1, in multidrug-resistant Enterobacteriaceae in India, Pakistan, and the UK.

**Methods** Enterobacteriaceae isolates were studied from two major centres in India—Chennai (south India), Haryana (north India)—and those referred to the UK's national reference laboratory. Antibiotic susceptibilities were assessed, and the presence of the carbapenem resistance gene $bla_{NDM-1}$ was established by PCR. Isolates were typed by pulsed-field gel electrophoresis of XbaI-restricted genomic DNA. Plasmids were analysed by S1 nuclease digestion and PCR typing. Case data for UK patients were reviewed for evidence of travel and recent admission to hospitals in India or Pakistan.

**Findings** We identified 44 isolates with NDM-1 in Chennai, 26 in Haryana, 37 in the UK, and 73 in other sites in India and Pakistan. NDM-1 was mostly found among *Escherichia coli* (36) and *Klebsiella pneumoniae* (111), which were highly resistant to all antibiotics except to tigecycline and colistin. *K pneumoniae* isolates from Haryana were clonal but NDM-1 producers from the UK and Chennai were clonally diverse. Most isolates carried the NDM-1 gene on plasmids: those from UK and Chennai were readily transferable whereas those from Haryana were not conjugative. Many of the UK NDM-1 positive patients had travelled to India or Pakistan within the past year, or had links with these countries.

**Interpretation** The potential of NDM-1 to be a worldwide public health problem is great, and co-ordinated international surveillance is needed.

**Funding** European Union, Wellcome Trust, and Wyeth.

## Introduction

Bacteria from clinical and non-clinical settings are becoming increasingly resistant to conventional antibiotics. 10 years ago, concern centred on Gram-positive bacteria, particularly meticillin-resistant *Staphylococcus aureus* and vancomycin-resistant *Enterococcus* spp. Now, however, clinical microbiologists increasingly agree that multidrug-resistant Gram-negative bacteria pose the greatest risk to public health. Not only is the increase in resistance of Gram-negative bacteria faster than in Gram-positive bacteria,[1,2] but also there are fewer new and developmental antibiotics active against Gram-negative bacteria[3–6] and drug development programmes seem insufficient to provide therapeutic cover in 10–20 years.[7–9]

The increase in resistance of Gram-negative bacteria is mainly due to mobile genes on plasmids that can readily spread through bacterial populations. Standardised plasmid typing methods are enhancing our understanding of the host ranges of these elements and their worldwide distribution.[10,11] Moreover, unprecedented human air travel and migration allow bacterial plasmids and clones to be transported rapidly between countries and continents.[12,13] Much of this dissemination is undetected, with resistant clones carried in the normal human flora and only becoming evident when they are the source of endogenous infections. The CTX-M-15 extended-spectrum β-lactamase (ESBL) encoded by $bla_{CTX-M-15}$ was first reported in India in the mid-1990s.[14,15] The gene jumped from the chromosome of its natural hosts, *Kluyvera* spp, to plasmids that have subsequently spread widely,[16,16] establishing CTX-M-15 as the globally-dominant ESBL and the primary cause of acquired resistance to third-generation cephalosporins in Enterobacteriaceae.[17,18]

Recent surveys have identified ESBLs in 70–90% of Enterobacteriaceae in India and; although these collections might be a biased sample, they do suggest a serious problem, making the widespread use of reserved antibiotics such as carbapenems necessary.[15,19] Rates of cephalosporin resistance are lower in other countries but the growing prevalence of ESBL producers is sufficient to drive a greater reliance on carbapenems. Consequently, there is selection pressure for carbapenem resistance in Enterobacteriaceae, and its emergence is a worldwide public health concern since there are few antibiotics in



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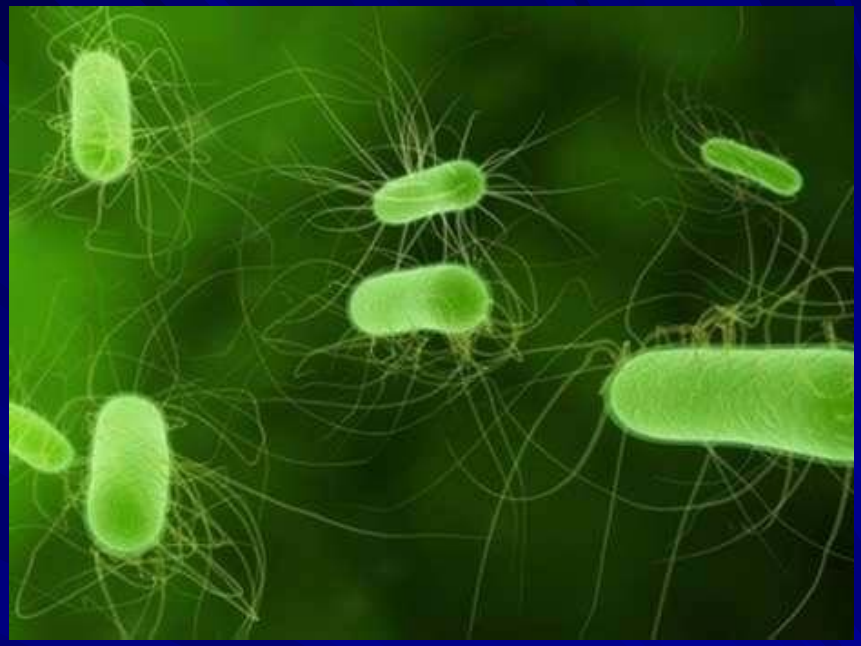
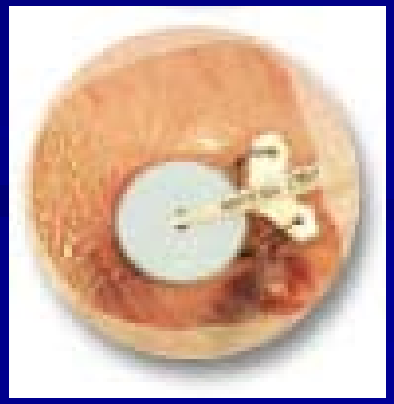


**New Delhi metallo-beta-lactamase (NDM-1)**

**Mutation that renders bacteria highly resistant to chemotherapy**



# Best evidence: *what can we do?*

- Be aware → hand hygiene!
- Timely periop antibiotics
- Attention to aseptic practices
- Chlorhexidine-alcohol skin prep (1)
- Optimize tissue oxygenation
- Maintain normothermia (4)
- Minimize RBC transfusion (2,4)
- Consider salutary (?) role of regional anesthesia (3,4)


1) Darouiche. NEJM. 2010;362:18-26
2) Hill. Jo Trauma. 2003;54:908-914.
3) Chang. Anesthesiology. 2010;113:279-84
4) Sessler. Anesthesiology 2010;113:265-7