Preventing the Preventable: Surgical Site Infections and Post Operative Infection-related Complications

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Background

- SSIs are estimated to account for 25-35% of HAIs in the US
- SSIs occur in 0.5-3% of patients undergoing surgery
- Anywhere from 38%-51% of organisms causing SSIs are resistant to standard prophylactic antibiotics in the US
- Most SSIs are caused by endogenous sources. Most common are:
  - Staph aureus
  - Coag neg Staph
  - Enterococcus
  - E. coli

50% of SSIs are deemed preventable

How are SSIs deemed preventable?

It has been argued that if all evidence-based prevention practices have not been applied, an infection should be declared as preventable

Objectives

- Examine evidence-based and accepted standards of practice for the prevention of SSIs and other post operative infection-related complications
- Review environmental standards aimed at preventing SSIs in the operating room
- Define criteria used to conduct surveillance and report healthcare-associated infections

Identifying and adhering to evidence-based practices and accepted standards of care

(establish policies & SOPs)

Education & Training

Surveillance

HAI Prevention

Identify and address barriers to compliance or gaps in practices

Monitoring, audit, and feedback

(process outcomes)

HAND HYGIENE: Back to the Basics

- Use alcohol-based hand sanitizer in most clinical situations
  - Rub for a minimum of 15 seconds covering all surfaces
  - Hands should be dry prior to any contact
- When using soap and water,
  - wash for at least 15 seconds covering all surfaces of hands
  - use good friction
  - use a paper towel to turn off the faucet
- If a soap or alcohol dispenser is not in a convenient location, voice concerns to your Infection Control Department
- Gloves are not a substitute for hand hygiene

Preoperatively

- Address modifiable risk factors
  - Treat remote infections prior to elective procedures
- Education
- Decolonization
  - Generally, only recommended for high-risk procedures (orthopedic, cardiothoracic, & other high-risk such as spine and brain surgeries)
- Shower/bathe with soap or an antiseptic agent on at least the night before surgery
  - RCT evidence varies regarding optimal timing of shower/bath, the total number of soap or antiseptic agent applications, and use of CHG washcloths for SSI prevention.

Preoperatively

- Do not discontinue immunosuppressive therapy
- Do not use mechanical bowel prep (without oral antibiotics) alone for the purpose of reducing SSI in patients undergoing elective colorectal procedures
- Don’t remove hair unless it will interfere with the procedure.
  - If hair removal is necessary, avoid razors –Strong evidence
  - Perform just prior to surgery
  - Do not perform hair removal in the OR

Parenteral Antimicrobial Prophylaxis

- Administer only when indicated based on published clinical practice guidelines (facility-specific guidelines)
  - general accepted practice is within 60-120 minutes before incision depending on drug
- Not sufficient RCT evidence evaluating the harms and benefits of intraoperative redosing of parenteral prophylactic antimicrobial agents for the prevention of SSI
  - individual organizations have made recommendations.
- In clean/clean-contaminated procedures, do not administer additional prophylactic antimicrobial agent doses after the surgical incision is closed in the operating room, even in the presence of a drain (High quality evidence)

Personal Items in the OR

- Jewelry that cannot be contained or confined within the scrub attire should not be worn in the semirestricted or restricted areas.
- Cell phones, tablets, and other personal communication or hand-held electronic equipment should be cleaned with a low-level disinfectant according to the manufacturer's instructions for use before and after being brought into the perioperative setting

General OR Attire

- Scrub suits and cover apparel
  - Utilize hospital-laundered scrub attire and cover apparel (accepted standard for most)
  - Change as soon as possible if they become soiled
- Wear a new, disposable, or clean head covering
  - Change if visibly soiled
  - Hair should not be dangling
  - Includes the need to cover facial hair not contained in a mask
- Shoe covers are not shown to reduce SSI
- Wear a surgical mask that fully covers mouth and nose in the OR if sterile instruments are open or if procedure is about to begin or already underway

Preoperative hand/forearm antisepsis

Members of the surgical team in direct contact with the sterile operating field, sterile instruments or supplies used in the field must scrub immediately before donning sterile gloves and gowns.

- Scrubbed personnel should not wear artificial nails, fingernail polish and gel shellac. For those not scrubbing in, policy is generally up to the facility.
- Perform preoperative surgical hand/forearm antisepsis according to manufacturer's recommendations for the product being used
- Factors affecting the effectiveness of surgical scrub include technique, duration, and condition of the hands
- Scrub brushes should be avoided because they damage skin and may increase shedding (Quality of Evidence: High)

Preoperative hand/forearm antisepsis products

- Waterless surgical hand rubs provide bacterial reductions that have been found to be no different than those provided by surgical hand scrubs and are less damaging to skin
  - Alcohol-based hand scrub has been shown to improve quality of hand hygiene and duration of preparation with no significant change in surgical-site infection rates.
  - Waterless surgical hand rub and hand scrub formulated with CHG have been found superior in reducing colony-forming units on hands than povidone iodine
  - Scrubbed personnel should pay attention to the amount of waterless product dispensed as most manufacturers recommend 4-6 mL but larger hands and forearms may require more to keep the skin wet for the duration recommended by the specific manufacturer

Gowns and gloves

- Sterile Gloves & Gown for those serving as a member of the scrubbed surgical team
  - Fluid resistant gowns
  - Gloves applied after donning a sterile gown
  - If the integrity of the gloves or gown is compromised, remove immediately
  - Routine changes of the outer glove should be considered in lengthy cases
  - Make sure gloves fit well
- When in restricted areas, all nonscrubbed personnel should completely cover their arms with a long-sleeved scrub top or jacket

Patient Skin Prep

- Site is free of gross contamination prior to applying skin prep
- Perform intraoperative skin preparation with an alcohol-based antiseptic agent unless contraindicated. (Category IA)
  - WHO recommends use of alcohol-based solution containing CHG in their guidelines
    - Recent JAMA review (January 2023) of SSI Prevention supports superiority of Alcohol+CHG over Alcohol+povidone iodine
- Do not use microbial sealant immediately after intraoperative skin preparation. (Category II)

Intraoperatively

- Plastic adhesive drapes with or without antimicrobial properties is not necessary for the prevention of SSI. (Category II)
- Consider:
  - wound protector devices in clean-contaminated, contaminated and dirty procedures (WHO)
  - use of triclosan-coated sutures (WHO & AMA)
- If drainage is necessary,
  - use a closed suction drain.
  - place a drain through a separate incision distant from the operative incision
  - remove the drain as soon as possible.
- No recommendations regarding repeat application of antiseptic agents to the patient's skin immediately before closing the surgical incision for the prevention of SSI (insufficient evidence regarding risks/benefits)

Intraoperative Irrigation

- Consider intraoperative irrigation of deep or subcutaneous tissues with aqueous iodophor solution for the prevention of SSI in clean/clean contaminated cases.
- Intraperitoneal lavage with aqueous iodophor solution in contaminated or dirty abdominal procedures is not necessary. (Category II)
- WHO recommends against antimicrobial wound irrigation & AMA makes no recommendations.

Perioperative Glycemic Control

- Optimal Glucose levels vary by organization:
  - 2017 AMA recommended glucose < 200 mg/dL
  - Review published in JAMA 2023- data supported tighter target at < 150mg/dL (meta-analysis of 15 RCT but involving only patients with diabetes)
  - WHO recommends “considering use of a protocol for intensive blood glucose control for both diabetic and nondiabetic patients”
  - Evidence doesn’t support any particular A1C target

Society Guideline Recommendations for Treatment of Perioperative Hyperglycemia and Diabetes

	Ambulatory Surgery	ICU	Non-ICU
SAMBA[50]	SC rapid-acting insulin analogs are preferred over IV or SC regular insulin Treatment goal: intraoperative blood glucose levels < 180 mg/dl (10 mM)		
ADA/AACE[51]		Initiate insulin therapy for glucose > 180 mg/dl (10 mM) Treatment goal: For most patients, target a glucose level between 140 and 180 mg/dl (7.7–10 mM). Glucose target between 110 and 140 mg/dl (6.1–7.7 mM) may be appropriate for select patients if achievable without significant risk for hypoglycemia	Treatment goal: If treated with insulin, premeal glucose targets should generally be < 140 mg/dl (< 7.7 mM), with random glucose levels < 180 mg/dl (10 mM)
ACP[54]		Recommends against intensive insulin therapy in patients with or without diabetes in surgical/medical ICUs Treatment goal: Target glucose is between 140 and 200 mg/dl (7.7–11.1 mM) in patients with or without diabetes	
Critical Care Society[52]		BG > 150 mg/dl (8.3 mM) should trigger insulin therapy Treatment goal: Maintain glucose < 150 mg/dl (8.3 mM) for most patients in ICU	
Endocrine Society[30]			Treatment goal: Target premeal blood glucose < 140 mg/dl (7.7 mM) and random glucose < 180 mg/dl (10 mM) Higher target glucose < 200 mg/dl (11.1 mM) is acceptable in patients with terminal illness and/or with limited life expectancy or at high risk for hypoglycemia
Society of Thoracic Surgeons[53]		Continuous insulin infusion preferred over SC or intermittent IV boluses Treatment goal: Recommend glucose < 180 mg/dl (10 mM) during surgery, ≤ 110 mg/dl (6.1 mM) in fasting and premeal states	
Joint British Diabetes Societies[55]			Initiate insulin therapy for glucose > 10 mM (180 mg/dl) Target blood glucose levels in most patients are between 6 and 10 mM (108–180 mg/dl) with an acceptable range of between 4 and 12 mM (72–216 mg/dl)

ACP = American College of Physicians; ADA/AACE = American Diabetes Association/American Association of Endocrinologists; ICU = intensive care unit; IV = intravenous; SAMBA = Society for Ambulatory Anesthesia; SC = subcutaneous.

Perioperative Hyperglycemia Management | Anesthesiology | American Society of Anesthesiologists (asahq.org) (2017)

Perioperative Normothermia

- Maintain perioperative normothermia-Strong recommendation
- Targets for core temperatures vary: > 35.5 °C to >36 °C
- No RCTs evaluating strategies to achieve and maintain, lower limit of normothermia or optimal timing and duration of normothermia
  - WHO says “consider a forced air warming device

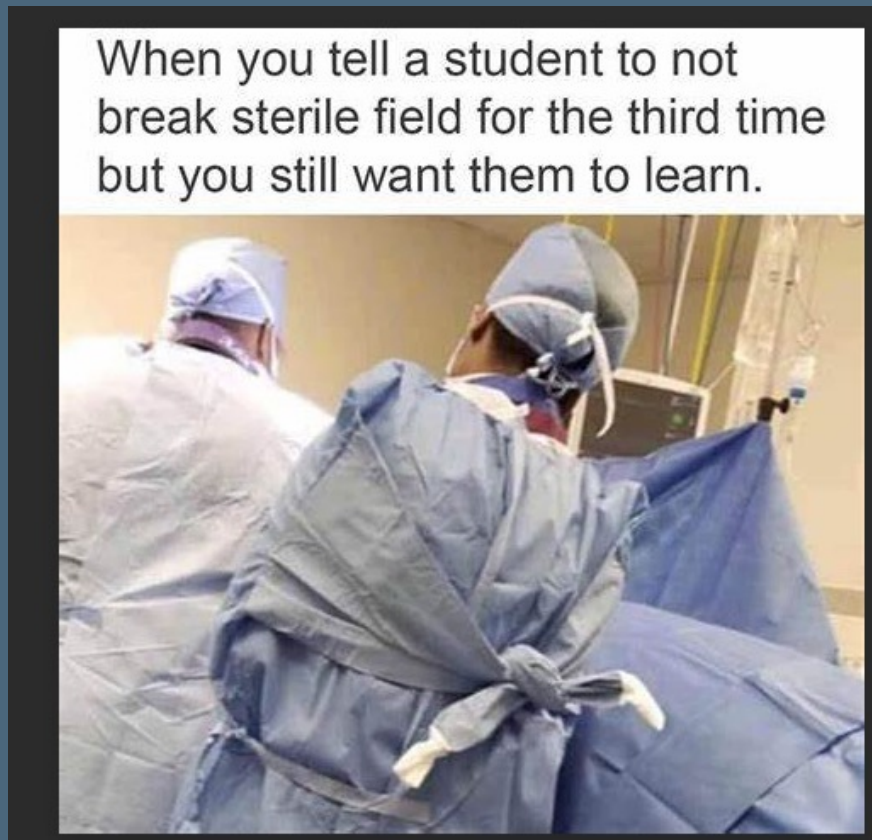
Oxygenation

- For patients with normal pulmonary function undergoing general anesthesia with endotracheal intubation, administer increased fraction of inspired oxygen (Fio_2) during surgery and after extubation in the immediate postoperative period. To optimize tissue oxygen delivery, maintain perioperative normothermia and adequate volume replacement. (Category IA–strong recommendation)
  - Lack of RCTs and Systematic Reviews that evaluated the optimal target level, duration, and delivery method of FIO_2 for the prevention of SSI.
  - All studies evaluating the use of supplemental increased oxygenation both intraoperatively and postoperatively used 80% FiO2 as the target level. (WHO specifically states 80%)

Oxygenation (Cont.)

- RCT evidence suggested uncertain trade-offs between the benefits and harms regarding the administration of increased $FI0_2$
  - via endotracheal intubation during only the intraoperative period in patients with normal pulmonary function undergoing general anesthesia for the prevention of SSI.
  - via face mask during the perioperative period in patients with normal pulmonary function undergoing general anesthesia without endotracheal intubation or neuraxial anesthesia (ie, spinal, epidural, or local nerve blocks)
  - via face mask or nasal cannula during only the postoperative period in patients with normal pulmonary function for the prevention of SSI.

Aseptic Technique



Aseptic Technique

- All items in the sterile field must be sterile
- Sterile packages or fields are opened or created as close as possible to time of actual use-don't leave unattended
- A safe space or margin of safety is maintained between sterile and nonsterile objects and areas
  - Nonsterile items should not cross above a sterile field.
- Do not turn back on sterile field-should be set up conducive to flow
- Use of new instruments before closure is recommended in colorectal cases

Reprocessing of Reusable Medical Devices

- Association for the Advancement of Medical Instrumentation (AAMI) standards
- Ensure that all instruments are sterile
  - No contamination is present
  - Packaging is intact with no stains & not damp
  - Proper technique when unwrapping
- Immediate-use Steam Sterilization (IUSS) formerly known as flash sterilization
  - Emergency use only
  - Follow facility-procedures

General Environmental Controls

- Maintain positive pressure in all OR suites
- Vents should be appropriately located
- Maintain temperature between 68-75°F (CLASS A 70-75 °F) and humidity at 20-60%.
- Laminar air flow ventilation systems are not recommended
- Keep OR doors closed
  - Limit traffic to essential personnel in and out of the OR and around the sterile field

General Practices and Cleaning

- Inspect OR for cleanliness before case carts, supplies or instruments are brought into the room
- Keep clean, sterile, and soiled items separate
- Don’t let items touch the floor (infusion lines, catheter bags)
- Cleaning
  - Before and after each case.
  - Terminally cleaned daily. Do not perform special cleaning or closing of operating rooms after contaminated or dirty operations
  - All horizontal surfaces should be damp dusted before the first case of the day
  - Equipment should be damp dusted before it is brought into the OR
  - Gross contamination outside the surgical field should be cleaned as soon as possible

Post Op Care

- Protect primarily closed incisions with a sterile dressing for 24-48 hours postoperatively.
  - Not enough evidence to support antimicrobial dressings or advanced dressings (hydrogel, hydrocolloid, alginate)
- Consider incisional negative pressure wound therapy for primary wound closure in high-risk wounds
  - Meta-analysis of 23 RCTs involving 2547 patients undergoing various surgical procedures (eg, abdominal, cesarean delivery, orthopedic, vascular) concluded that use of incisional negative pressure wound therapy for primary wound closure was associated with lower rates of surgical site infection than use of standard dressings: 9.7% (124 of 1279) vs 15% (191 of 1268; RR, 0.67 [95% CI, 0.53-0.85]; P < .001); however, the effect varied by procedure type.

Post Op Care

- Incisions with delayed primary closure should be packed with a sterile dressing.
- Use aseptic technique when changing dressings.
- Routinely inspect incision for signs and symptoms of infection
  - Pain, swelling, redness, purulent drainage, dehiscence, poor healing
- HAND HYGIENE before and after contact with wounds and during dressing changes
- Discharge planning and education


Teach it
training
and
education
Check it
monitoring
and
feedback
Sell it
reminders
and
communications
Live it
culture
change
Build it
system change

Surgical Procedure Observation Checklist for Assessment of Infection Prevention Efforts

Date of Observation: _____ **Observer:** _____

Procedure(s): _____ **Surgeon/MD:** _____

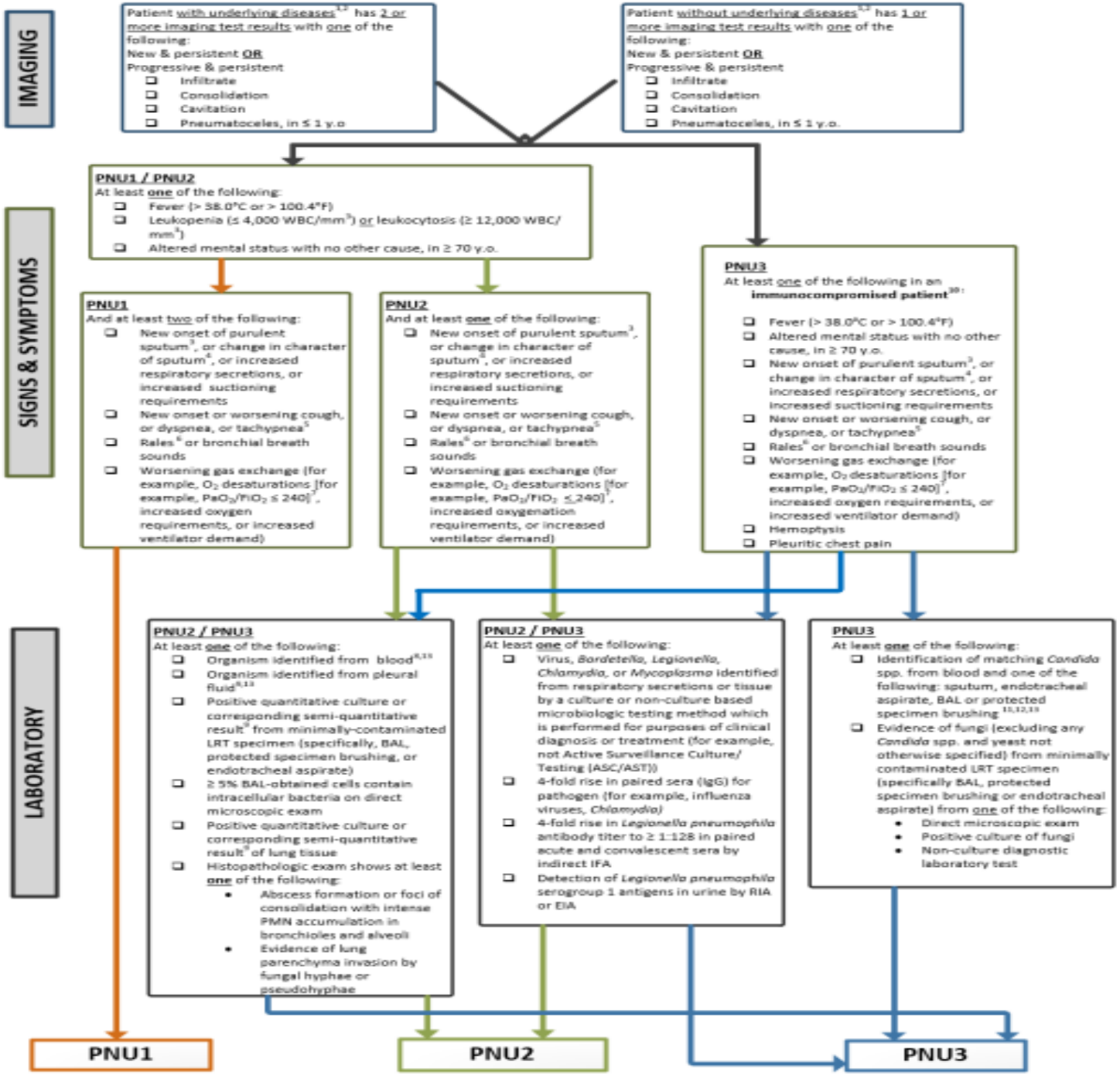
STANDARDS	YES	NO	N/A	DESCRIPTION / COMMENTS	Reference
Environment:					
Inspects OR for cleanliness before case carts, supplies, instruments are brought into the room. OR is dust free, uncluttered, no holes in walls, floors or ceiling					AORN. Tool Kit/Env. Cleaning
Cleans and disinfects items that are used during patient care and after every patient use.					AORN. Tool Kit/Env. Cleaning
Single-use items disposed between cases, including O2 tubing, blades, suction canisters, etc.					AORN. Tool Kit/Env. Cleaning
Clean, sterile, and soiled items are kept separate					APIC 108, Sterile Processing
Supplies stored on open rack or behind closed doors, bottom rack should have a solid bottom.					ANSI/AAMI ST
Pre-op:					
If indicated: pre-op antibiotic administered prior to incision (timed to allow for adequate tissue and serum concentration at a bactericidal level, about one hour prior to incision)					APIC Text Ch. 69 SS / CDC
Hair removal: if needed should be done prior to entering OR use clipper with vacuum to contain clipped hair, if possible.					AORN GL / Sterile Tech.& APIC 69 SS
Skin prep with antiseptic scrub: • Follows the manufacturer's instruction for maximum and minimum surface area per applicator when using a pre-filled antiseptic applicator. • Applies antiseptic with care, on fragile skin, protects from dripping and pooling. • Verifies antiseptic is applied to all surfaces between fingers or toes for surgical site preparation on hand or foot surgical site. • Prep is allowed to dry					AORN GL / Skin Antisepsis
Once opened, sterile items are supervised to prevent contamination.					APIC Text Ch. 69 SS
Opens, dispenses, and transfers items to the sterile field by methods that maintain the sterility and integrity of the item and the sterile field. * Inspects sterile items before presenting them to the sterile field (e.g., package integrity, expiration dates).					AORN GL Sterile Tech - competency
* Presents items in a manner that prevents unsterile objects or non-scrubbed team members from leaning or reaching over the sterile field.					
Staff Attire:					
Non-scrubbed staff: Hand hygiene prior to applying gloves and after glove removal					AORN GL Hand Hygiene
Surgical Scrub Attire in semi-restricted and restricted OR areas: • All head, scalp, and hair covered • Chest and beard hair fully covered in restricted areas • Surgical scrub attire worn is laundered by approved institution/service, not at home • No fleece attire on OR staff • Individuals with direct involvement with the surgical field must don sterile gown/gloves					APIC Text Ch. 69 SS / AORN GL Surgical Attire
Covers arms during performance of preoperative patient skin antisepsis (if required)					AORN GL Surgical attire
When lifting and holding the patient's extremity during skin antisepsis: • Use two hands to hold the extremity • Obtain assistance from another team member • Uses an assistive device					AORN GL Patient Skin Antisepsis
No artificial nails or chipped nail polish. Best practice, short natural nails (1/4" long)					RHJ IC GL # 14 & AORN GL Hand Hygiene & APIC Text Ch. 69 SS
Intra-operative:					
Doors closed, traffic in and out of room kept to minimum during case (count #)					AORN GL Env. Of Care & Sterile Technique
Patient temp maintained during case via fluid, underbody warming pad, forced air warming blanket, other.					APIC Text Ch. 69 SS
All personnel moving in/around sterile field do so in manner to maintain sterility – e.g. • Staff do not turn back to sterile field • Hands above waist • Separation of sterile team from non-sterile team maintained					AORN GL Sterile Tech
After use, sterile instruments placed in sterile water off sterile field, or otherwise kept moist prior to transport to SPD – instruments with lumen flushed					APIC Text Ch.108, Sterile Processing
For open abdominal cases, wound edge protector used to protect wound edges from contamination during case.					Meta Analysis (Ref #9)
Closure:					
Irrigation prior to closing to remove contaminants					CDC Recommendations
Surgeon and scrub change sterile gloves prior to closing incision					NIHR Global Health Research (Ref #11)
Separate sterile instrument tray used for closure of incision for at least colon cases					AORN Journal (Ref #10)
Anesthesia:					
Ideally, hand hygiene is performed before and after patient contact, after bodily fluid exposure, after contact with the contaminated environment, and before performing a clean/aseptic task.					Anesthesia Patient Safety Foundation and WHO
Suction is available and ready for use.					AORN GL General Anesthesia
Aseptic practice used for all invasive procedures: (epidurals, blocks, IV insertion)					Anesthesia Patient Safety Foundation
Aseptic practice used for accessing IV tubing, administering fluids and medications. All medication vial tops are disinfected with alcohol before accessing, after popping off cover.					Anesthesia Patient Safety Foundation
Anesthesia cart (if applicable) appears clean and is cleaned and processed per the manufacturer's recommendations, after each patient, and terminally cleaned at the end of the day.					AORN GL and Anesthesia Patient Safety Foundation
Drainage bags (e.g., Foley), IV tubing, and other equipment are kept off the floor					CDC

Definitions	Deviations	
	NHSN	NSQIP
Superficial site infection • Monitoring 30 days AND Involves only skin and subcutaneous tissue of the incision AND At least one of the following: a. purulent drainage from superficial incision b. Positive culture from incision site c. Superficial incision deliberately opened by surgeon AND patient has at least one symptom (localized swelling, redness, heat, pain/tenderness) d. diagnosis of a superficial incisional SSI by physician Exclusions: • Diagnosis/treatment of cellulitis by itself • Stitch abscess alone • Localized stab wound or pin site infection (depending on depth, they might be SSTI)	(c.)Only applicable if no culture is performed Diagnosis can be made by surgeon, infectious disease physician, emergency physician, other physician on the case, or physician's designee (nurse practitioner or physician's assistant). For NHSN op procedure, laparoscopic trocar site is considered surgical incision. 2 types: Superficial Incisional Primary & and Superficial Incisional Secondary 100% surveillance on selected NHSN eligible procedures	(c.) Only applicable if incision is culture-negative Diagnosis by surgeon or attending physician. NP can diagnose but PA cannot unless co-signed by MD Excludes burn wounds 20% of cases via 8-day systematic cycling
Definitions	NHSN	NSQIP
Deep Incisional Surgical Site Infection: • Monitoring 30 days AND • Involves deep soft tissue of incision (fascial and muscle layers) AND • Has at least one of the following: a. Purulent draining from deep incision b. Deep incision is deliberately opened or aspirated AND organism identified from deep soft tissues of incision by a culture or non-culture based microbiologic testing method or no culture performed AND at least one s/s-fever >38 degrees Celsius, localized pain or tenderness c. An abscess or other evidence of infection involving the deep incision detected on gross anatomical exam, histopathologic exam or imaging test	Monitoring for 90 days for some procedures (prosthetic TKA/THA) 2 types: Deep Incisional Primary & and Deep Incisional Secondary 100% surveillance on selected NHSN eligible procedures	*States "Infection appears to be related to the operation" Includes "spontaneously dehisces" Allows for diagnosis by a surgeon or attending physician. 20% of cases via 8-day systematic cycling
Definitions	NHSN	NSQIP
Organ/Space Surgical Site Infection: • Monitoring 30 days AND • involves any part of the body deeper than the fascial/muscle layers that is opened or manipulated during the operative procedure AND • patient has at least one of the following: a. purulent drainage from a drain placed into the organ/space (for example, closed suction drainage system, open drain, T-tube drain, CT-guided drainage) b. organism(s) identified from fluid or tissue in the organ/space by a culture or non-culture based microbiologic testing method which is performed for purposes of clinical diagnosis or treatment (for example, not Active Surveillance Culture/Testing [ASC/AST]). c. an abscess or other evidence of infection involving the organ/space detected on gross anatomical exam or histopathologic exam, or imaging test evidence definitive or equivocal for infection.	Monitoring for 90 days for some procedures Meets definition PLUS meets at least one criterion for a specific organ/space infection site in NHSN (i.e., osteomyelitis) 100% surveillance on selected NHSN eligible procedures	*States "Infection appears to be related to the operation" Allows for diagnosis by a surgeon or attending physician. 20% of cases via 8-day systematic cycling

Post Operative Infection-related Complications

Pneumonia

- 3rd most common post op complication for surgical procedures
  - Includes ventilator-associated pneumonia and non-vent associated pneumonia
- Preventative Measures:
  - Hand hygiene
  - Deep breathing & use of incentive spirometer
  - Coughing
  - Upright position
  - Early mobility
  - Optimal pain management
  - Daily oral care


IMAGING
Patient with underlying diseases[12] has 2 or more imaging test results with one of the following:
New & persistent OR
Progressive & persistent
Infiltrate
Consolidation
Cavitation
Pneumatoceles, in ≤ 1 y.o
Patient without underlying diseases[12] has 1 or more imaging test results with one of the following:
New & persistent OR
Progressive & persistent
Infiltrate
Consolidation
Cavitation
Pneumatoceles, in ≤ 1 y.o.
SIGNS & SYMPTOMS
PNU1 / PNU2
At least one of the following:
Fever (> 38.0°C or > 100.4°F)
Leukopenia (≤ 4,000 WBC/mm³) or leukocytosis (≥ 12,000 WBC/mm³)
Altered mental status with no other cause, in ≥ 70 y.o.
PNU1
And at least two of the following:
New onset of purulent sputum[3], or change in character of sputum[4], or increased respiratory secretions, or increased suctioning requirements
New onset or worsening cough, or dyspnea, or tachypnea[5]
Rales[6] or bronchial breath sounds
Worsening gas exchange (for example, O2 desaturations [for example, PaO2/FiO2 ≤ 240][7], increased oxygen requirements, or increased ventilator demand)
PNU2
And at least one of the following:
New onset of purulent sputum[3], or change in character of sputum[4], or increased respiratory secretions, or increased suctioning requirements
New onset or worsening cough, or dyspnea, or tachypnea[5]
Rales[6] or bronchial breath sounds
Worsening gas exchange (for example, O2 desaturations [for example, PaO2/FiO2 ≤ 240][7], increased oxygenation requirements, or increased ventilator demand)
PNU3
At least one of the following in an immunocompromised patient[10]:
Fever (> 38.0°C or > 100.4°F)
Altered mental status with no other cause, in ≥ 70 y.o.
New onset of purulent sputum[3], or change in character of sputum[4], or increased respiratory secretions, or increased suctioning requirements
New onset or worsening cough, or dyspnea, or tachypnea[5]
Rales[6] or bronchial breath sounds
Worsening gas exchange (for example, O2 desaturations [for example, PaO2/FiO2 ≤ 240][7], increased oxygen requirements, or increased ventilator demand)
Hemoptysis
Pleuritic chest pain
LABORATORY
PNU2 / PNU3
At least one of the following:
Organism identified from blood[8,11]
Organism identified from pleural fluid[8,13]
Positive quantitative culture or corresponding semi-quantitative result[9] from minimally-contaminated LRT specimen (specifically, BAL, protected specimen brushing, or endotracheal aspirate)
≥ 5% BAL-obtained cells contain intracellular bacteria on direct microscopic exam
Positive quantitative culture or corresponding semi-quantitative result[9] of lung tissue
Histopathologic exam shows at least one of the following:
Abscess formation or foci of consolidation with intense PMN accumulation in bronchioles and alveoli
Evidence of lung parenchyma invasion by fungal hyphae or pseudohyphae
PNU2 / PNU3
At least one of the following:
Virus, Bordetella, Legionella, Chlamydia, or Mycoplasma identified from respiratory secretions or tissue by a culture or non-culture based microbiologic testing method which is performed for purposes of clinical diagnosis or treatment (for example, not Active Surveillance Culture/Testing (ASC/AST))
4-fold rise in paired sera (IgG) for pathogen (for example, influenza viruses, Chlamydia)
4-fold rise in Legionella pneumophila antibody titer to ≥ 1:128 in paired acute and convalescent sera by indirect IFA
Detection of Legionella pneumophila serogroup 1 antigens in urine by RIA or EIA
PNU3
At least one of the following:
Identification of matching Candida spp. from blood and one of the following: sputum, endotracheal aspirate, BAL or protected specimen brushing[11,12,13]
Evidence of fungi (excluding any Candida spp. and yeast not otherwise specified) from minimally contaminated LRT specimen (specifically BAL, protected specimen brushing or endotracheal aspirate) from one of the following:
Direct microscopic exam
Positive culture of fungi
Non-culture diagnostic laboratory test
PNU1
PNU2
PNU3

Vent-associated Pneumonia Prevention

Category	Rationale	Intervention	Quality of Evidence
Essential practices	Good evidence that the intervention decreases the average duration of mechanical ventilation, length of stay, mortality, and /or costs. Benefits likely outweigh risks.	Avoid intubation and prevent reintubation • Use high-flow nasal oxygen or noninvasive positive pressure ventilation (NIPPV) as appropriate whenever safe and feasible[91–93,96,99]	HIGH
		Minimize sedation[105,106] • Avoid benzodiazepines in favor of other agents[106] • Use a protocol to minimize sedation[110] • Implement a ventilator liberation protocol[113]	MODERATE
		Maintain and improve physical conditioning[113,120–123]	MODERATE
		Elevate the head of the bed to 30–45°[125,388–390]	LOW[a]
		Provide oral care with toothbrushing but *without* chlorhexidine[126,127]	MODERATE
		Provide early enteral vs. parenteral nutrition[131]	HIGH
		Change the ventilator circuit only if visibly soiled or malfunctioning (or per manufacturers' instructions)[391–394]	HIGH
Additional approaches	Good evidence that the intervention improves outcomes in some populations, but may confer some risk in others.	Use selective oral or digestive decontamination in countries and ICUs with low prevalence of antibiotic-resistant organisms[128,134,135]	HIGH[a]
	May lower VAP rates but insufficient data to determine impact on duration of mechanical ventilation, length of stay, or mortality.	Utilize endotracheal tubes with subglottic secretion drainage ports for patients expected to require >48–72 hours of mechanical ventilation[395]	MODERATE
		Consider early tracheostomy[144]	MODERATE
		Consider postpyloric rather than gastric feeding for patients with gastric intolerance or at high risk for aspiration[131,147]	MODERATE
Generally not recommended	Inconsistently associated with lower VAP rates and no impact or negative impact on duration of mechanical ventilation, length of stay, or mortality.	Oral care with chlorhexidine[75,128–130,150]	MODERATE
		Probiotics[153–156]	MODERATE
		Ultrathin polyurethane endotracheal tube cuffs[165–167]	MODERATE
		Tapered endotracheal tube cuffs[169]	MODERATE
		Automated control of endotracheal tube cuff pressure[170,171,174,175]	MODERATE
		Frequent cuff-pressure monitoring[176]	MODERATE
		Silver-coated endotracheal tubes[178]	MODERATE
		Kinetic beds[180]	MODERATE
		Prone positioning[181,183,a]	MODERATE
		Chlorhexidine bathing[184–186,a]	MODERATE
	No impact on VAP rates, average duration of mechanical ventilation, length of stay, or mortality.[a]	Stress-ulcer prophylaxis[190,191,193]	MODERATE
		Monitoring residual gastric volumes[194]	MODERATE
		Early parenteral nutrition[195]	MODERATE
No recommendation	No impact on VAP rates or other patient outcomes, unclear impact on costs.	Closed endotracheal suctioning systems[197–199]	MODERATE

Figure 1: Ventilator-Associated Events (VAE) Surveillance Algorithm

Patient has a baseline period of stability or improvement on the ventilator, defined by ≥ 2 calendar days of stable or decreasing daily minimum* FiO_2 or PEEP values. The baseline period is defined as the 2 calendar days immediately preceding the first day of increased daily minimum PEEP or FiO_2.

*Daily minimum defined by lowest value of FiO_2 or PEEP during a calendar day that is maintained for > 1 hour.

↓

After a period of stability or improvement on the ventilator, the patient has at least one of the following indicators of worsening oxygenation:

1) Increase in daily minimum* FiO_2 of ≥ 0.20 (20 points) over the daily minimum FiO_2 of the first day in the baseline period, sustained for ≥ 2 calendar days.
2) Increase in daily minimum* PEEP values of ≥ 3 cmH_2O over the daily minimum PEEP of the first day in the baseline period†, sustained for ≥ 2 calendar days.

*Daily minimum defined by lowest value of FiO_2 or PEEP during a calendar day that is maintained for > 1 hour.

†Daily minimum PEEP values of 0-5 cmH_2O are considered equivalent for the purposes of VAE surveillance.

↓

Ventilator-Associated Condition (VAC)

↓

On or after calendar day 3 of mechanical ventilation and within 2 calendar days before or after the onset of worsening oxygenation, the patient meets both of the following criteria:

1) Temperature > 38 °C or < 36°C, **OR** white blood cell count ≥ 12,000 cells/mm^3 or ≤ 4,000 cells/mm^3.

AND

2) A new antimicrobial agent(s) (see Appendix for eligible antimicrobial agents) is started and is continued for ≥ 4 qualifying antimicrobial days (QAD).

↓

Infection-related Ventilator-Associated Complication (IVAC)

↓

On or after calendar day 3 of mechanical ventilation and within 2 calendar days before or after the onset of worsening oxygenation, ONE of the following criteria is met (**taking into account organism exclusions specified in the protocol**):

1) Criterion 1: Positive culture of one of the following specimens, meeting quantitative or semi-quantitative thresholds† as outlined in protocol, without requirement for purulent respiratory secretions:
   - Endotracheal aspirate, ≥ 10^5 CFU/ml or corresponding semi-quantitative result
   - Bronchoalveolar lavage, ≥ 10^4 CFU/ml or corresponding semi-quantitative result
   - Lung tissue, ≥ 10^4 CFU/g or corresponding semi-quantitative result
   - Protected specimen brush, ≥ 10^3 CFU/ml or corresponding semi-quantitative result
2) Criterion 2: Purulent respiratory secretions (defined as secretions from the lungs, bronchi, or trachea that contain ≥ 25 neutrophils and ≤ 10 squamous epithelial cells per low power field [lpf, x100])† **PLUS** organism identified from one of the following specimens (to include qualitative culture, or quantitative/semi-quantitative culture without sufficient growth to meet Criterion #1):
   - Sputum
   - Endotracheal aspirate
   - Bronchoalveolar lavage
   - Lung tissue
   - Protected specimen brush
3) Criterion 3: One of the following positive tests:
   - Organism identified from pleural fluid (where specimen was obtained during thoracentesis or within 24 hours of chest tube placement; pleural fluid specimens collected after a chest tube is repositioned or from a chest tube in place > 24 hours are not eligible for PVAP)
   - Lung histopathology, defined as: 1) abscess formation or foci of consolidation with intense neutrophil accumulation in bronchioles and alveoli; 2) evidence of lung parenchyma invasion by fungi (hyphae, pseudohyphae, or yeast forms); 3) evidence of infection with the viral pathogens listed below based on results of immunohistochemical assays, cytology, or microscopy performed on lung tissue
   - Diagnostic test for *Legionella* species
   - Diagnostic test on respiratory secretions for influenza virus, respiratory syncytial virus, adenovirus, parainfluenza virus, rhinovirus, human metapneumovirus, coronavirus

† If the laboratory reports semi-quantitative results, those results must correspond to the quantitative thresholds. Refer to Table 2 and 3.

↓

Possible Ventilator-Associated Pneumonia (PVAP)

Urinary Tract Infections

- Approximately 1-2% of surgical patients will get a UTI
  - Catheters increase the risk dramatically
- **STOP**: **S**terile catheter placement, **T**imely catheter removal, **O**ptimal collection bag position, and **P**roper urine sampling for urinalysis and culture.
  - From 2012 to 2015, non-risk-adjusted UTI rates in surgical patients decreased from 2.90% to 0.46% ($p = 0.0003$), and the American College of Surgeons National Surgical Quality Improvement Program risk-adjusted comparison improved from the 8th to the 4th decile.
- Have protocols for removing catheters as soon as possible following surgery

Criterion	Urinary Tract Infection (UTI)
	Symptomatic UTI (SUTI) Must meet at least ***one*** of the following criteria:
SUTI 1a **Catheter-associated Urinary Tract Infection (CAUTI) in any age patient**	Patient must meet 1, 2, and 3 below: 1. Patient had an indwelling urinary catheter that had been in place for more than 2 consecutive days in an inpatient location on the date of event AND was either: • Present for any portion of the calendar day on the date of event†, **OR** • Removed the day before the date of event‡ 2. Patient has at least ***one*** of the following signs or symptoms: • fever (>38.0°C) • suprapubic tenderness* • costovertebral angle pain or tenderness* • urinary urgency ^ • urinary frequency ^ • dysuria ^ 3. Patient has a urine culture with no more than two species of organisms identified, at least one of which is a bacterium of ≥10^5 CFU/ml (See Comments). All elements of the SUTI criterion must occur during the IWP (See IWP Definition Chapter 2 Identifying HAIs in NHSN). † When entering event into NHSN choose "INPLACE" for Risk Factor for IUC ‡ When entering event into NHSN choose "REMOVE" for Risk Factor for IUC *With no other recognized cause (see Comments) ^ These symptoms cannot be used when catheter is in place. An IUC in place could cause patient complaints of "frequency" "urgency" or "dysuria". **Note:** • Fever is a non-specific symptom of infection and cannot be excluded from UTI determination because it is clinically deemed due to another recognized cause.

SUTI 1b **Non-Catheter-associated Urinary Tract Infection (Non-CAUTI) in any age patient**	Patient must meet 1, 2, and 3 below: 1. One of the following is true: • Patient has/had an indwelling urinary catheter, but it has/had not been in place for more than two consecutive days in an inpatient location on the date of event† **OR** • Patient did not have an indwelling urinary catheter in place on the date of event nor the day before the date of event † 2. Patient has at least ***one*** of the following signs or symptoms: • fever (>38°C) • suprapubic tenderness* • costovertebral angle pain or tenderness* • urinary frequency ^ • urinary urgency ^ • dysuria ^ 3. Patient has a urine culture with no more than two species of organisms identified, at least one of which is a bacterium of ≥10^5 CFU/ml. (See Comments) All elements of the SUTI criterion must occur during the IWP (See IWP Definition Chapter 2 Identifying HAIs in NHSN). † When entering event into NHSN choose "NEITHER" for Risk Factor for IUC *With no other recognized cause (see Comments) ^These symptoms cannot be used when IUC is in place. An IUC in place could cause patient complaints of "frequency" "urgency" or "dysuria". **Note:** • Fever is a non-specific symptom of infection and cannot be excluded from UTI determination because it is clinically deemed due to another recognized cause.

Asymptomatic Bacteremic Urinary Tract Infection (ABUTI)
(in any age patient)

Patient must meet 1, 2, and 3 below:

1. Patient with* or without an indwelling urinary catheter has no signs or symptoms of SUTI 1 or 2 according to age.

2. Patient has a urine culture with no more than two species of organisms identified, at least one of which is a bacterium of ≥10^5 CFU/ml (see Comment section below).

3. Patient has organism identified** from blood specimen with at least ***one*** matching bacterium to the bacterium at ≥ 100,000 CFU/ml identified in the urine specimen, or is eligible LCBI criterion 2 (without fever) and matching common commensal(s) in the urine. All elements of the ABUTI criterion must occur during the Infection Window Period (See Definition Chapter 2 Identifying HAIs in NHSN).

*Patient had an IUC in place for more than two consecutive days in an inpatient location on the date of event, and IUC was in place on the date of event or the day before. *Catheter - associated ABUTI is reportable if CAUTI is in the facility's reporting plan for the location.*

** Organisms identified by a culture or non-culture based microbiologic testing method which is performed for purposes of clinical diagnosis or treatment (e.g., not Active Surveillance Culture/Testing (ASC/AST).

Clostridioides difficile Infection (CDI)

- Highest risk associated with antibiotics or procedures that alter gut microbiota (gastrointestinal surgeries)
  - Risk increases with even one dose of prophylactic antibiotics and risk can persist for months
  - Persons with IBD are at increased risk
  - Use of NGTs have shown increased risk for severe or complicated outcomes of CDI (RR 1.81 (95% CI 1.17–2.81)).
- While some studies suggest association between PPIs and CDI, there is insufficient evidence for discontinuation of necessary PPIs
- Insufficient evidence that probiotics are effective in prevention of CDI

CDI Testing

- Screening and testing protocol
  - ≥ 3 unformed stools in a 24-hour period w/no other cause (i.e., laxatives, implementation of tube feeds)
- Multistep testing methods are more popular given it can differentiate between possible colonization versus infection and potentially determine if treatment is warranted
  - (ie, glutamate dehydrogenase [GDH] plus toxin; GDH plus toxin, arbitrated by nucleic acid amplification test [NAAT]; or NAAT plus toxin) rather than a NAAT alone for all specimens received in the clinical laboratory)
  - NHSN and VA will eventually require reporting of patient treated with antibiotics for C.diff regardless of the second test
- Do not repeat tests within 7 days for same episode of diarrhea and don't test asymptomatic persons
- Lab ID Event-Considered HAI if test is positive >3 days after admission

Prevention of CDI

- Antibiotic Stewardship
- Appropriate Screening and Testing Protocols
- Hand Hygiene
- Isolation
- Environmental disinfection

Bloodstream Infections

- Central lines
  - Avoid central lines when possible and remove as soon as possible
  - Insertion Bundle Checklists and documentation
  - Proper maintenance of lines
- Hand hygiene
- Proper blood culture collection to avoid contamination
- Lab ID Event- Signs/Symptoms don't matter
- Consider culturing practices so that a BSI can properly be assigned to the potential source of infection, better determine if present at time of surgery or admission, and guide process improvement efforts
  - Most infection surveillance criteria require matching organisms at a site for a BSI to be secondary

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