INTERNATIONAL SOCIETY FOR INFECTIOUS DISEASES

GUIDE TO INFECTION CONTROL IN THE HEALTHCARE SETTING

Impact of SARS-CoV-2 on HAIs and Recommendations to Prevent HAIs

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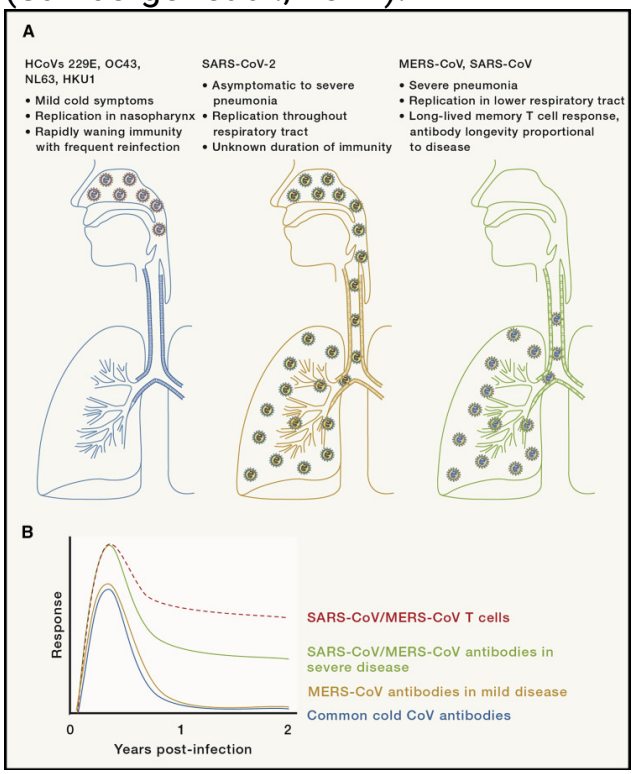
EPIDEMIOLOGY OF SARS-CoV-2

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has rapidly spread globally since December 2019. A first wave was visible up to the end of June 2020 in many regions (Salzberger et al., 2021).

The SARS-CoV2 predominantly replicates in the upper and lower respiratory tracts in contrast to MERS-CoV which replicates predominantly in the lower respiratory tract and is particularly transmitted by droplets and aerosols. The estimate for the basic reproduction number (R0) is between 2 and 3 and the median incubation period is 6 days (range 2-14 days). A high proportion of infections are uncomplicated, but moderate or severe courses develop in 5-10% of infected persons. Pneumonia, cardiac involvement and thromboembolisms are the most frequent manifestations leading to hospitalization (Salzberger et al., 2021). The estimation for the infection fatality rate (IFR) is between 0.5% and 1% across all age groups (Salzberger et al., 2021). Risk factors for a complicated course are advanced age, hypertension, diabetes mellitus and chronic cardiovascular and pulmonary diseases as well as immunodeficiency (Salzberger et al., 2021).



(Sariol and Perlman, 2020)

SIGNS AND SYMPTOMS OF PATIENTS WITH SARS-CoV-2

A comprehensive review and meta-analysis were undertaken by Al Maqbali et al. to determine the frequency of COVID-19 patient's clinical symptoms. The inclusion criteria were satisfied by a total of 215 studies involving 132,647 COVID-19 participants. The four most prevalent symptoms' combined prevalence was as follows: fever 76.2% (n = 214; 95% CI 73.9-78.5); coughing 60.4% (n = 215; 95% CI 58.6-62.1); fatigue 33.6% (n = 175; 95% CI 31.2-36.1); and dyspnea 26.2% (n = 195; 95% CI 24.1-28.5). Other signs and symptoms range in prevalence from highest to lowest, including expectorant (22.2%), anorexia (21.6%), myalgias (17.5%), chills (15%), sore throat (14.1%), headache (11.7%), nausea or vomiting (8.7%), rhinorrhea (8.2%), and hemoptysis (3.3%). (Al Maqbali et al., 2022). It is important to note that the omicron variant of SARS-CoV-2 which emerged in 2021 produces milder symptoms including runny nose, headache, fatigue, sneezing and sore throat. This is a sharp contrast to the initial list of symptoms associated with SARS-CoV-2 which included high temperature, a new continuous cough or loss of charge in sense of smell or taste (Rae, 2022).

ASSOCIATION BETWEEN SARS-CoV-2 AND HEALTHCARE ASSOCIATED INFECTIONS IN THE USA

The most common healthcare associated infection (HAI) in intensive care units (ICUs) are catheter-associated urinary tract infections (CAUTI), ventilator-associated events (VAE), and central line-associated bloodstream infections (CLABSI) (Dudeck et al., 2011a, Dudeck et al., 2011b, Dudeck et al., 2013, Edwards et al., 2008, Edwards et al., 2007, Edwards et al., 2009, Klevens et al., 2008, Nguyen et al., 2017).

The purpose of this publication is to update, clarify, and emphasize the need of implementing those interventions as the rate of those three types of HAIs increased during the COVID pandemic.

Prior to the emergence and global spread of the coronavirus disease 2019 pandemic, hospitals in the United States had seen a significant decline in the prevalence of HAIs (Weiner-Lastinger et al., 2021b) .

As COVID-19 spread across the US in waves throughout 2020, several areas saw substantial increases in the number of cases and

hospitalizations. In certain investigations, secondary infections were particularly mentioned as occurring in COVID-19 patients (Ripa et al., 2021).

Single-site studies observed signs of increases in select HAIs in the US as early as the spring of 2020 (Fakih et al., 2021, LeRose et al., 2021, McMullen et al., 2020).

As US hospitals across the country responded to the inflow of COVID-19 patients in the second quarter of 2020, rising standardized infection ratios (SIRs) were found. Methicillin-resistant Staphylococcus aureus (MRSA) bacteremia, CLABSIs, and VAE all showed initial elevations in the SIRs (Weiner-Lastinger et al., 2021b).

The third and fourth quarters of 2020 were remarkable for considerable increases in SIRs linked to CLABSIs, VAEs, MRSA bacteremia, and CAUTI compared to the pre-pandemic rates seen throughout 2019. The increase in SIRs for all HAI categories was most significant for CLABSIs when comparing 2020, the first year of COVID-19 hospitalizations throughout the US, to the pre-pandemic experience of 2019 (Weiner-Lastinger et al., 2021b).

According to the CDC- National Healthcare Safety Network (NHSN), increasing rates for CLABSIs were noted in the earliest months of the pandemic (Patel et al., 2021).

Longer patient stays, more comorbidities, higher patient acuity levels, and prolonged device usage are all factors that might contribute to increased risks for device-associated healthcare associated infections (DA-HAI) during the COVID-19 pandemic in 2020 (Weiner-Lastinger et al., 2021b).

Elevated dependence on acute-care hospitals (ACHs) during the pandemic may have further expanded HAI risks in a number of ways, including modified employment of personal protective equipment, changing staffing patterns and procedures, and increased critical care capacity (Rebmann et al., 2021, Weiner-Lastinger et al., 2021a).

ASSOCIATION BETWEEN SARS-COV-2 AND HEALTHCARE ASSOCIATED INFECTIONS IN EUROPE

Bardi et al conducted a study in Spain including 140 patients with severe COVID-19 admitted to the ICU between March and May 2020. Fifty-seven patients (40.7%) developed a bacterial or fungal nosocomial infection during ICU stay. Infection occurred after a median of 9 days (IQR 5-11) of admission and was significantly associated with the

APACHE II score (p = 0.02). There were 91 episodes of infection: primary (31%) and CLABSI (25%) were the most frequent, followed by pneumonia (23%), tracheobronchitis (10%), and urinary tract infection (8%) that were produced by a wide spectrum of Gram-positive (55%) and Gram-negative bacteria (30%) as well as fungi (15%). In 60% of cases, infection was associated with septic shock and a significant increase in SOFA score. Overall ICU mortality was 36% (51/140). Infection was significantly associated with death (OR 2.7, 95% CI 1.2-5.9, p = 0.015) and a longer ICU stay (p < 0.001) (Bardi et al., 2021).

Falcone et al conducted a prospective, observational study including patients with COVID-19 consecutively admitted to the University Hospital of Pisa, Italy, between 4 March and 30 April 2020. A multivariate analysis was performed to identify factors independently associated with superinfections. Overall, 315 patients with COVID-19 were hospitalized and 109 episodes of superinfections were documented in 69 (21.9%) patients. The median time from admission to superinfection was 19 days (range 11-29.75). Superinfections were caused by Enterobacterales (44.9%), non-fermenting Gram-negative bacilli (15.6%), Gram-positive bacteria (15.6%) and fungi (5.5%). Polymicrobial infections accounted for 18.3%. Predictors of superinfections were: intestinal colonization by carbapenem-resistant Enterobacterales (OR 16.03, 95% CI 6.5-39.5, P < 0.001); invasive mechanical ventilation (OR 5.6, 95% CI 2.4-13.1, P < 0.001); immunomodulatory agents (tocilizumab/baricitinib) (OR 5.09, 95% CI 2.2-11.8, P < 0.001); C-reactive protein on admission >7 mg/dl (OR 3.59, 95% CI 1.7-7.7, P = 0.001); and previous treatment with piperacillin/tazobactam (OR 2.85, 95% CI 1.1-7.2, P = 0.028). Length of hospital stay was longer in patients who developed superinfections compared with those who did not (30 versus 11 days, P < 0.001). The risk of bacterial and fungal superinfections in COVID-19 is consistent (Falcone et al., 2021).

ASSOCIATION BETWEEN SARS-COV-2 AND HEALTHCARE ASSOCIATED INFECTIONS IN LIMITED RESOURCES COUNTRIES

A global HAI monitoring network is the International Nosocomial Infection Control Consortium (INICC). Hospitals in several Low-to-Middle-Income Countries employ INICC surveillance online system (LMICs) (Rosenthal, 2016, Rosenthal et al., 2021c, Rosenthal et al., 2008a, Rosenthal et al., 2013b). The incidence of CLABSI, VAE, and

CAUTI have significantly decreased for over 20 years, from 2002 to 2019, among the LMIC members of the INICC, as a result of their adoption and use of INICC online platform and preventative techniques (Rosenthal et al., 2013a, Rosenthal et al., 2010b, Rosenthal et al., 2014b, Rosenthal et al., 2012c, Rosenthal et al., 2012d, Rosenthal et al., 2012e, Rosenthal et al., 2012f, Rosenthal et al., 2012h, Rosenthal et al., 2012i).

A research by INICC looked at how the COVID-19 pandemic affected the occurrence of HAI in LMICs. Patients from 7 LMICs (India, Mongolia, Jordan, Lebanon, Palestine, Egypt, and Turkey) were followed during hospital ICU stays throughout January 2019 to May 2020. HAI rates were calculated using the INICC Surveillance Online System applying CDC-NHSN criteria. Pre-COVID-19 rates for 2019 were compared to COVID-19 era rates for 2020 for CLABSI, CAUTI, VAE, mortality and lengths of stay (LOS). 7,775 patients were followed for 49,506 bed-days. 2019 to 2020 rate comparisons: 2.54 and 4.73 CLABSIs per 1,000 central line days (RR=1.85, $p = 0.0006$), 9.71 and 12.58 VAEs per 1,000 mechanical ventilator days (RR=1.29, $p = 0.10$), 1.64 and 1.43 CAUTIs per 1,000 urinary catheter days (RR=1.14; $p = 0.69$). Mortality rates were 15.2% and 23.2% for 2019 and 2020 (RR=1.42; $p < 0.0001$). Mean LOS were 6.02 and 7.54 days (RR=1.21, $p < 0.0001$). This report documents a rise in HAI rates in 7 LMICs during the first 5 months of the COVID-19 pandemic and highlights the need to reprioritize and return to conventional infection prevention practices (Rosenthal et al., 2022).

EPIDEMIOLOGY AND CLINICAL OUTCOMES OF NOSOCOMIAL PNEUMONIA

- The most prevalent HAI is pneumonia. One percent of hospitalized patients and up to 10% patients undergoing invasive mechanical ventilation develop VAE (Magill et al., 2018, Walter et al., 2018).
- However, it is challenging to determine the real occurrence of nosocomial pneumonia because to the vast variation in diagnostic criteria, poor correlation with histology, frequent subjectivity, and inconsistent application by various surveyors (Ego et al., 2015, Kerlin et al., 2017, Stevens J. P. et al., 2014, Tejerina et al., 2010).
- International Nosocomial Infection Control Consortium (INICC) surveillance data from January 2013 through December 2018 (664 ICUs in 45 countries) reported a VAE rate of 11.4 per 1000 mechanical ventilator days (Rosenthal et al., 2016, Rosenthal et al.,

2020b, Rosenthal et al., 2012b, Rosenthal et al., 2021c, Rosenthal et al., 2010a, Rosenthal et al., 2008b, Rosenthal et al., 2014a).

- Over the past 20 years, several hospitals have reported significant decline in VAE rates; however, it is unclear whether these drops are due to better treatment or to stricter application of subjective monitoring criteria (Dudeck et al., 2011a, Dudeck et al., 2011b, Klompas, 2012).
- According to clinical surveys, 5–10% of ventilated patients are still receiving treatment for VAE, and a Centers for Medicare and Medicaid Services independent audit found that VAE rates remained consistent between 2005 and 2013 (Novosel et al., 2012, Skrupky et al., 2012, Thomas et al., 2011).
- The coronavirus disease 2019 pandemic has been associated with an increase in the incidence of VAE due to hospital-acquired severe acute respiratory coronavirus virus 2 (SARS-CoV-2) infections and hospital-acquired bacterial superinfections in patients admitted with COVID-19 pneumonia. Due to the significant overlap in clinical symptoms, separating superinfection from underlying COVID-19 pneumonia and COVID-19-related ARDS might be difficult (Klompas et al., 2021, Lumley et al., 2021, Russell et al., 2021).
- VAE are expensive and harmful to patients (Rosenthal et al., 2005a). Estimated to be 10%, the attributable mortality of VAE varies greatly depending on the kind and degree of underlying disease (Bekaert et al., 2011, Melsen et al., 2011, Nguile-Makao et al., 2010, Steen et al., 2021). VAE prolong invasive mechanical ventilation for longer periods of time, lengthen hospital stays and ICU stays, and raise mortality risk (Klompas et al., 2012, Rosenthal et al., 2005a, Rosenthal et al., 2011). Additionally, they are linked to increased usage of antibiotics and higher expenses (Hayashi et al., 2013, Rosenthal et al., 2005a).

RISK FACTORS OF NOSOCOMIAL PNEUMONIA

Following variables were identified as risk factor for acquisition of VAE: Trauma patients (Charles et al., 2014, Rello et al., 1992) , post-surgical patients (Garibaldi et al., 1981), burns patients (Garibaldi et al., 1981), longer duration of surgery (Grobmyer et al., 1996), history of smoking (Grobmyer et al., 1996), low serum albumin concentration (Garibaldi et al., 1981), high score on the American Society of Anesthesiologists Physical Status Classification System (Garibaldi et al., 1981), Acute respiratory distress syndrome

(ARDS) (Chastre et al., 1998) , lung injury (Chastre et al., 1998) , chronic obstructive pulmonary disease (COPD) (Rello et al., 1994), upper respiratory tract colonization (Chastre and Fagon, 2002) , sinusitis (Rouby et al., 1994), enteral feeding (Bonten et al., 1995), enteral feeding by nasogastric tube (Kostadima et al., 2005) , biofilm on the surface and within lumen of the endotracheal tube (Sottile et al., 1986), duration of mechanical ventilation (Rello et al., 1999, Trouillet et al., 1998), frequent change in ventilator circuit (Fink et al., 1998) , lack of use of heat and moist exchange humidifiers (Prat et al., 2003) , open suctioning systems (Cobley et al., 1991, Darvas and Hawkins, 2003, Freytag et al., 2003) , supine position (Pelosi et al., 2002) , airway colonisation prior to tracheostomy (Sugerman et al., 1997) , tracheostomy (Sugerman et al., 1997), frequent reintubation (Chastre and Fagon, 2002) , paralytic agents (Park, 2005) , stress ulcer prophylaxis (Atherton and White, 1978), and patients transported out of ICU (A'Court et al., 1993) .

SUGGESTED PRACTICE TO PREVENT VENTILATOR ASSOCIATED EVENTS

REQUIRED PROCEDURES

- Raise the bed's head by 30 to 45 degrees (Drakulovic et al., 1999, van Nieuwenhoven et al., 2006, Wang et al., 2016).
- Prevent intubation and reintubation (Klompas et al., 2022).
- When safe and practical, use noninvasive positive pressure ventilation (NIPPV) or high-flow nasal oxygen (HFNO). (Chaudhuri et al., 2020, Granton et al., 2020, Rochwerg et al., 2019).
- Implement a procedure for ventilator liberation. (Girard et al., 2017).
- Only replace the ventilator circuit if it is obviously dirty or defective (or per the manufacturer's directions) (Dreyfuss et al., 1991, Kollef et al., 1995).
- Brush teeth, providing dental care, but avoiding chlorhexidine (Cooper, 2021, Hua et al., 2016, Shi et al., 2013, Sozkes and Sozkes, 2021, Zhao et al., 2020).
- Reduce sedative medication (Devlin et al., 2018, Shehabi et al., 2018).
- Follow a protocol to reduce sedation (Lewis et al., 2021, Ouellette et al., 2017).
- Opt for alternative medications instead of benzodiazepines (Devlin et al., 2018).

- Give early enteral nutrition rather than parenteral nutrition (Singer et al., 2019).
- Preserve and enhance physical conditioning (Girard et al., 2017, Waldauf et al., 2020, Zang et al., 2020, Zhang et al., 2019).
- Implement a process of monitoring compliance with recommendations to prevent VAE and provide feedback of the monitoring to health care professionals in charge of care of patients (Al-Abdely et al., 2018, Al-Mousa et al., 2018, Guanche-Garcell et al., 2013, Leblebicioglu et al., 2013c, Mehta et al., 2013, Rosenthal et al., 2012a, Rosenthal et al., 2018b, Rosenthal et al., 2006, Rosenthal et al., 2012f, Rosenthal et al., 2012g, Tao et al., 2012).

OTHER STRATEGIES

- In nations and ICUs where the frequency of antibiotic-resistant pathogens is minimal, use selective oral or digestive decontamination (Bos et al., 2017, Plantinga et al., 2018, Price et al., 2014).
- Use endotracheal tubes with subglottic secretion drainage ports for patients predicted to need mechanical ventilation for more than 48 to 72 hours (Cook et al., 1997, Kelley, 2012, Lacherade et al., 2018, Liu et al., 2006, Loupec et al., 2013, Muscedere et al., 2011, Zheng et al., 2008).
- Take into account early tracheostomy (Chorath et al., 2021).
- For individuals with stomach intolerance or at high risk for aspiration, post-pyloric feeding may be preferable to gastric feeding (Liu et al., 2021, Singer et al., 2019).

TYPICALLY, NOT ADVISED

- Using chlorhexidine for oral care (Deschepper et al., 2018, Klompas et al., 2014, Price et al., 2014).
- Probiotics (Batra et al., 2020, Ji et al., 2021).
- Ultrathin polyurethane endotracheal tube cuffs (Lorente et al., 2007, Poelaert et al., 2008).
- Tapered endotracheal tube cuffs (Maertens et al., 2018).
- Control of the endotracheal tube's cuff pressure automatically (Nseir et al., 2011, Valencia et al., 2007).
- Regular cuff-pressure checks (Dat et al., 2018, Dat et al., 2022, del Cotillo Fuente and Valls Matarin, 2014, Young and Wyncoll, 2007).
- Silver-coated endotracheal tubes (Kollef et al., 2008).
- Kinetic beds (Delaney et al., 2006).
- Prone positioning (Ayzac et al., 2016, Dalmedico et al., 2017, Munshi et al., 2017, Pelosi et al., 2002).

- Chlorhexidine bathing (Boonyasiri et al., 2016, Pallotto et al., 2019).

THERE IS NO EFFECT ON VAE RATES, THE MEDIAN LENGTH OF MECHANICAL VENTILATION, HOSPITAL STAY, OR DEATH.

- Stress-ulcer prophylaxis (Alhazzani et al., 2013, Azab et al., 2017, Deliwala et al., 2022, Kondo et al., 2020, Marik, 2016, Marik et al., 2010).
- Keeping track of gastric residual volumes (Reignier et al., 2013).
- Early parenteral nutrition (Bistrian, 2011, Casaer et al., 2011, Felbinger et al., 2011, Marik, 2011, O'Leary and Ferrie, 2011).

NOT RECOMMENDED

- Closed endotracheal suctioning systems (Jongerden et al., 2007, Noll et al., 1990, Siempos et al., 2008, Subirana et al., 2007).

EPIDEMIOLOGY AND CLINICAL OUTCOMES OF CENTRAL LINE ASSOCIATED BLOODSTREAM INFECTIONS

A laboratory-confirmed bloodstream infection that appears within 48 hours of the installation of a central line and is unrelated to an infection at another location is known as a CLABSI. CLABSIs account for the highest economic burden of any HAI, costing around $46,000 per case. CLABSI are associated with longer stays in the hospital (Barnett et al., 2010, Digiovine et al., 1999, Dimick et al., 2001, Goudie et al., 2014, Higuera et al., 2007, Leistner et al., 2014, Rosenthal et al., 2021c, Rosenthal et al., 2003a), higher mortality and morbidity (Barnett et al., 2010, Higuera et al., 2007, Rosenthal et al., 2021c, Rosenthal et al., 2003a, Ziegler et al., 2015) and cost increases. Patients with CLABSI had adjusted variable costs that were, on average, $5,888 to 32,000 (US dollars) more than patients without CLABSI. (Barnett et al., 2010, Duszynska et al., 2020, Higuera et al., 2007, Rosenthal et al., 2003a, Stevens V. et al., 2014, Tarricone et al., 2010).

With appropriate aseptic procedures, surveillance, and management strategies, the majority of CLABSI may be avoided. (Al-Abdely et al., 2017, Alkhawaja et al., 2020, Aloush and Alsaraireh, 2018, Alvarez-Moreno et al., 2016, Franzetti et al., 2009, Hallam et al., 2018, Jaggi et al., 2013, Leblebicioglu et al., 2013b, Maki et al., 2011, Rosenthal, 2020b, Rosenthal et al., 2018a, Rosenthal et al., 2010c, Rosenthal et al., 2012d, Rosenthal et al., 2015).

According to data collected by the CDC NHSN between January 2006 and October 2007, the following bacteria were identified as being most likely to cause CLABSI. Gram negatives (Klebsiella, 5.8 percent; Enterobacter, 3.9 percent; Pseudomonas, 3.1 percent; E. coli, 2.7 percent; Acinetobacter, 2.2 percent), Candida species (11.8 percent), and other organisms are next in frequency. Gram positives (coagulase-negative staphylococci, 34.1 percent; enterococci, 16 percent; and Staphylococcus aureus, 9.9 percent) are (10.5 percent) (Atilla et al., 2017, Wright et al., 2018).

CLABISs are common with tunneled hemodialysis catheters. Gram-positive bacteria are responsible for between 40% and 80% of CLABSI cases. The most prevalent microorganisms are Coagulase-negative staphylococci, staphylococcus aureus, and enterococci. Staphylococcus bacteria that are resistant to methicillin are common. Gram-negative organisms are responsible for 20–30% of infections that result in CRBSIs (Farrington and Allon, 2019).

CLABSIs result in extended hospital stays, rising death rates, and rising healthcare expenses. According to estimates, 250,000 CLABSI happen each year, and the majority of them are caused by the use of intravascular devices. The rate of CLABSI in ICU in the United States is reported to be 0.8 per 1000 central line days (Nguyen et al., 2017).

International Nosocomial Infection Control Consortium (INICC) surveillance data from January 2013 through December 2018 (664 ICUs in 45 countries) reported a CLABSI rate of 5.3 per 1000 central line days (Rosenthal et al., 2016, Rosenthal et al., 2020b, Rosenthal et al., 2012b, Rosenthal et al., 2021c, Rosenthal et al., 2010a, Rosenthal et al., 2008b, Rosenthal et al., 2014a).

INICC also found that majority of catheter related bloodstream infections are associated to the use of peripheral catheters (Rosenthal et al., 2020a, Rosenthal et al., 2021a, Rosenthal et al., 2020c, Rosenthal et al., 2021b, Rosenthal et al., 2020d).

Outside of the ICUs, several central lines could be found. In one research, 24% of patients who were not in the ICU and 55% of ICU patients had central lines. But because there are more patients outside the ICU, 70% of hospitalized patients with CVC were not within the ICU (Ziegler et al., 2015).

Given certain intrinsic benefits that these devices provide, the usage of peripherally inserted central catheters (PICCs) has greatly expanded in recent years (Gibson et al., 2013).

In both ICUs and general medical wards, trained nursing personnel can quickly place central venous access by inserting PICC lines with ultrasound guidance at the patient's bedside. PICCs are CVC by

definition since they are put into a peripheral vein of the arm with the tip advancing into a central vein (cavo-atrial junction or the right atrium). PICCs and traditional central venous catheters (CVCs) have statistically comparable rates of CLABSI in the hospital context (Chopra et al., 2013).

CLABSI rates of the PICCs placed in the ICU compared to the general medical ward were similar in a multi-center study of 27,289 patients. However, the study had certain limitations and there were generally few incidents (Govindan et al., 2018).

RISK FACTORS OF CENTRAL LINE ASSOCIATED BLOODSTREAM INFECTIONS

- **Intensive care unit population:** Patients in the intensive care unit are at a significant risk of CLABSI. The use of particular types of catheters (eg, pulmonary artery catheters with catheter introducers) that are almost exclusively inserted in ICU patients and linked with significant risk. Also the frequent placement of numerous catheters. Also, the fact that catheters are commonly inserted in emergency situations, frequently accessed throughout the day, and frequently required for long periods of time (Dube et al., 2020, Maki et al., 2006, Mermel, 2020).

- **General ward population:** Although the ICU environment has received the majority of attention over the past 20 years, the majority of CLABSIs happen in hospital units outside of the ICU or in outpatients. (Centers for Disease and Prevention, 2011, Kallen et al., 2010, Marschall et al., 2007, Rhee et al., 2015, Zingg et al., 2011).

- **Hemodialysis catheters, intraoperative patients, and oncology patients:** Infection prevention and control efforts should include also this vulnerable population (Loftus et al., 2012, Nguyen et al., 2017, Zakhour et al., 2016).

- **Short-term peripheral catheters, peripherally inserted central venous catheters (PICCs), midline catheters, and peripheral arterial catheters:** In addition to CVCs this devices carry a risk of infection (Mermel, 2017, O'Horo et al., 2014).

- **Independent risk factors for CLABSI** (Almuneef et al., 2006, Alonso-Echanove et al., 2003, Ben-Ami et al., 2012, Buetti et al., 2022,

Callister et al., 2015, Cimiotti et al., 2006, Chopra et al., 2014, Dube et al., 2020, Fridkin et al., 1996, Hsu et al., 2015, Ishizuka et al., 2008, 2009, Leistner et al., 2013, Lorente et al., 2005, Lorente et al., 2010, Maki et al., 2006, Merrer et al., 2001, Milstone et al., 2013b, Parienti et al., 2015, Pongruangporn et al., 2013, Raad et al., 1997, Rey et al., 2011, Sirvent et al., 2006, Templeton et al., 2008): The use of 2 central lines at the same time (Almuneef et al., 2006, Dube et al., 2020), multi-lumen catheters (Buetti et al., 2022), total parenteral nutrition (Almuneef et al., 2006), transfusion of blood products (in children) (Buetti et al., 2022), short-term non-cuffed and nonmedicated CLs (Maki et al., 2006), surgically implanted long-term central venous devices (Maki et al., 2006), cuffed and tunneled catheters (Maki et al., 2006), central venous ports (Maki et al., 2006), patient cared for by a float nurse for more than 60% of CL-days (Alonso-Echanove et al., 2003), femoral as insertion site (Lorente et al., 2005), longer indwelling time (Rey et al., 2011), substandard catheter care (eg, excessive manipulation of the catheter) (Buetti et al., 2022), heavy microbial colonization at insertion site (Buetti et al., 2022), heavy microbial colonization of the catheter hub (Buetti et al., 2022), prolonged hospitalization before catheterization (Buetti et al., 2022), age > 65 years (Hsu et al., 2015), body mass index (BMI) >40 (Buetti et al., 2022), lung cancer (Hsu et al., 2015), neutropenia (Buetti et al., 2022), prematurity (ie, early gestational age) (Buetti et al., 2022).

SUGGESTED PRACTICE TO PREVENT CENTRAL LINE ASSOCIATED BLOODSTREAM INFECTIONS

BEFORE INSERTION

- To reduce the use of unneeded CVCs, establish a list of indications for CVC usage that is supported on evidence based, and is readily available. (Buetti et al., 2022).
- Require HCPs responsible in the insertion, maintenance, and care of CVCs to undergo competency testing and instruction about CLABSI prevention (Al-Abdely et al., 2017, Alkhawaja et al., 2020, Alvarez-Moreno et al., 2016, Coopersmith et al., 2002, Higuera et al., 2005, Jaggi et al., 2013, Leblebicioglu et al., 2013b, Rosenthal et al., 2018a, Rosenthal et al., 2013a, Rosenthal et al., 2003b, Rosenthal et al., 2010c, Rosenthal et al., 2012d, Sherertz et al., 2000, Warren et al., 2003, Warren et al., 2004).

- ICU patients older than two months should daily take a chlorhexidine bath (Bleasdale et al., 2007, Climo et al., 2013, Milstone et al., 2013a).

AT INSERTION

- Use a catheter cart or kit with everything needed. (Berenholtz et al., 2004).
- Before inserting or manipulating a catheter, perform hand hygiene (Elgohari et al., 2017, Rosenthal et al., 2005b, Yilmaz et al., 2007).
- Use maximum sterile barrier precautions during insertion of CVC (Ishikawa et al., 2010, Mermel et al., 1991, Raad et al., 1994).
- For skin preparation, use an alcoholic chlorhexidine antiseptic (Chaiyakunapruk et al., 2002, Garland et al., 1995, Humar et al., 2000).
- When placing the catheter in the ICU setting, the subclavian site is recommended to avoid infection complications (Arvaniti et al., 2017, Parienti, 2017).
- The facility should have a procedure in place, such as a checklist, to guarantee adherence to infection prevention practices at the time of CVC insertion in both ICU and non-ICU settings (Wichmann et al., 2018).
- Utilize ultrasound guidance when inserting catheters (Karakitsos et al., 2006).
- It is recommended to use collapsible closed infusion systems instead of vented open infusion systems in limited resources countries (Franzetti et al., 2009, Graves et al., 2011, Maki et al., 2011, Rangel-Frausto et al., 2010, Rosenthal and Maki, 2004, Tarricone et al., 2010, Vilins et al., 2009).
- At facilities in low resources countries is recommended to use needle free connectors instead of three ways stop cocks (Rosenthal, 2020a, 2020b, Rosenthal et al., 2015).

AFTER INSERTION

- Remove all unnecessary catheters (Buetti et al., 2022).
- At intervals of up to 7 days, administration sets that aren't utilized for blood, blood products, or lipid formulations can be routinely replaced (Rickard et al., 2021).
- Use dressings containing chlorhexidine for CVCs in patients older than two months (Garland et al., 2001, Timsit et al., 2012).
- Change transparent dressings and perform site care for non-tunneled CVCs in adults and kids at least once every seven days, or right away if the dressing is soiled, loose, or damp.

- If the gauze dressing is soiled, loose, or damp, replace it every two days or sooner (Gavin et al., 2016, Maki et al., 1994).
- Before gaining access to the catheter, disinfect the hubs, needleless connectors, and injection ports (Munoz-Price et al., 2012, Salzman et al., 1993, Soothill et al., 2009).
- Limit the use of float nurses in ICUs and ensure an adequate nurse-to-patient ratio. (Cimiotti et al., 2006, Fridkin et al., 1996).
- In ICU and non-ICU settings conduct surveillance for CLABSI (Al-Abdely et al., 2017, Alkhawaja et al., 2020, Alvarez-Moreno et al., 2016, Gastmeier et al., 2006, Jaggi et al., 2013, Leblebicioglu et al., 2013b, Rosenthal et al., 2018a, Rosenthal et al., 2010c, Rosenthal et al., 2012d, Zingg et al., 2009).
- Implement a process of monitoring compliance with recommendations to prevent CLABSI and provide feedback of the monitoring to health care professionals in charge of care of patients (Al-Abdely et al., 2017, Alkhawaja et al., 2020, Alvarez-Moreno et al., 2016, Jaggi et al., 2013, Leblebicioglu et al., 2013b, Rosenthal et al., 2018a, Rosenthal et al., 2010c, Rosenthal et al., 2012d).

ADDITIONAL STRATEGIES

- Apply antibacterial ointment to the sites where hemodialysis catheters are placed (Battistella et al., 2011, Levin et al., 1991, Lok et al., 2003).
- Cover connectors with an antiseptic-containing hub/connector cap/port protector (Oto et al., 2011, Sweet et al., 2012, Wright et al., 2013).
- For long-term CVCs, use antimicrobial lock therapy (Carratala et al., 1999, Labriola et al., 2008, Safdar and Maki, 2006, Wolf et al., 2018).
- Patients receiving hemodialysis through a CVC should use recombinant tissue plasminogen activating factor (rt-PA) once a week following hemodialysis (Hemmelgarn et al., 2011).
- To lower CLABSI rates, use infusion or vascular access teams (Miller et al., 1996, Taylor et al., 2011).
- Use CVCs impregnated with an antiseptic or an antibiotic in patients of all ages (Chong et al., 2017, Gilbert et al., 2016, Lai and Yue, 2021, Wang et al., 2018).

METHODS THAT SHOULD NEVER BE USED IN CLABSI PREVENTION

- Avoid replacing arterial catheters or CVCs on a regular basis (Buetti et al., 2022).

- Do not use antimicrobial prophylaxis for insertion or maintenance of short-term or tunneled catheter (Ranson et al., 1990, van de Wetering et al., 2013).

EPIDEMIOLOGY AND CLINICAL OUTCOMES OF CATHETER ASSOCIATED URINARY TRACT INFECTIONS

- Urinary tract infection is one of the most common HAI. And 70%–80% of these infections are attributable to an indwelling urethral catheter (Saint and Chenoweth, 2003, Weber et al., 2011).
- Twelve to sixteen percent of adult hospital inpatients will have a urinary catheter at some time during admission (Weinstein et al., 1999).
- The daily risk of acquisition of bacteriuria varies from 3% to 7% when an indwelling urethral catheter remains in situ (Saint and Chenoweth, 2003, Weber et al., 2011, Weinstein et al., 1999).
- Morbidity attributable to any single episode of catheterization is limited, but the high frequency of catheter use in hospitalized patients means the cumulative burden of CAUTI is substantial (Burton et al., 2011, Saint and Chenoweth, 2003, Schaeffer, 2003, Tambyah et al., 2002, Weber et al., 2011).
- Infection is the most important adverse outcome of urinary catheter use (Burton et al., 2011, Dudeck et al., 2011a, Dudeck et al., 2011b, Dudeck et al., 2013, Edwards et al., 2008, Edwards et al., 2007, Edwards et al., 2009, Klevens et al., 2008, Nguyen et al., 2017).
- The CAUTI rates reported for facilities reporting to the CDC NHSN were 0.2–4.8 per 1,000 catheter-days for adult inpatient units and 0–1.6 per 1,000 days for pediatric units (Dudeck et al., 2011a, Dudeck et al., 2011b, Dudeck et al., 2013, Edwards et al., 2008, Edwards et al., 2007, Edwards et al., 2009, Klevens et al., 2008, Nguyen et al., 2017).
- International Nosocomial Infection Control Consortium (INICC) surveillance data from January 2013 through December 2018 (664 ICUs in 45 countries) reported a CAUTI rate of 3.16 per 1000 urinary catheter days (Rosenthal et al., 2016, Rosenthal et al., 2020b, Rosenthal et al., 2012b, Rosenthal et al., 2021c, Rosenthal et al., 2010a, Rosenthal et al., 2008b, Rosenthal et al., 2014a).
- At one Veterans Affairs hospital, 0.3% of catheter-days involved symptomatic UTI (Leuck et al., 2012, Trop and Bennett, 1992).

- CAUTI rates from ICUs that reported to CDC NHSN ranged from 1.2 to 4.5 per 1,000 urinary catheter–days in adult ICUs and from 1.4 to 3.1 per 1,000 urinary catheter–days in pediatric ICUs (Dudeck et al., 2011a, Dudeck et al., 2011b, Dudeck et al., 2013, Edwards et al., 2008, Edwards et al., 2007, Edwards et al., 2009, Klevens et al., 2008, Nguyen et al., 2017).
- Symptomatic UTIs in adult ICUs voluntarily reporting to CDC NHSN declined from 1990 to 2007, with a range of an 18.6% decline in cardiothoracic units to a 67% decline in medical-surgical ICUs (Burton et al., 2011).
- A 7% reduction was observed nationally in CAUTI incidence reported between 2009 and 2011, with modest reductions in incidence reported from ward locations but no changes in incidence reported from ICUs (Dudeck et al., 2011a, Dudeck et al., 2011b, Dudeck et al., 2013, Edwards et al., 2008, Edwards et al., 2007, Edwards et al., 2009, Klevens et al., 2008, Nguyen et al., 2017).
- Catheter use is associated with negative outcomes in addition to infection, including nonbacterial urethral inflammation, urethral strictures, mechanical trauma, and mobility impairment.(Hollingsworth et al., 2013, Saint et al., 1999).
- Genitourinary trauma events are reported to occur in 1.5% of catheter-days (Leuck et al., 2012, Trop and Bennett, 1992).
- CAUTI has been reported to be associated with increased mortality and length of stay, but the association with mortality may be a consequence of confounding by unmeasured clinical variables (Clec'h et al., 2007, Chant et al., 2011).
- Inappropriate treatment of catheter-associated asymptomatic bacteriuria promotes antimicrobial resistance and Clostridium difficile infection in acute care facilities (Cope et al., 2009, Pratt et al., 2021, Trautner et al., 2011).

RISK FACTORS OF CATHETER ASSOCIATED URINARY TRACT INFECTIONS

- The duration of catheterization is the most important risk factor for developing CAUTI (Huth et al., 1992, Johnson et al., 1990, Riley et al., 1995).
- Additional risk factors include female sex, older age, and not maintaining a closed drainage system (Hooton et al., 2010).

- Risk factors for developing hospital-acquired urinary tract infection include neutropenia, renal disease, and male sex (Greene et al., 2012).
- The drainage bag of the bacteriuric patient is a reservoir for organisms that may contaminate the environment and be transmitted to other patients through the hands of healthcare personnel (Bukhari et al., 1993).
- Outbreaks of infections associated with resistant gram negative organisms attributable to bacteriuria in catheterized patients have been reported (Jarvis et al., 1985, Kim et al., 2006, Schaberg et al., 1976, Yoon et al., 2005).

SUGGESTED PRACTICE TO PREVENT CATHETER ASSOCIATED URINARY TRACT INFECTIONS

INFRASTRUCTURE SUITABLE FOR PREVENTING CAUTI (Hooton et al., 2010, Loveday et al., 2014, Panknin and Althaus, 2001, Pellowe et al., 2005, Pratt et al., 2007).

- Ensure that catheters are inserted only by qualified, dedicated people.
- Ensure that the materials needed for catheter insertion using an aseptic technique are readily accessible.
- Ensure that there is an adequate number of trained individuals and technological resources to enable surveillance of catheter use and outcomes.
- Establish a system for recording the following information in the patient record: the physician's order for the placement of the catheter, the indications for the catheter's insertion, the date and time of the catheter's insertion, the person's name who did it, the nursing documentation of the placement, the catheter's daily presence and maintenance tasks, and the date and time of the catheter's removal.
- Provide written instructions for catheter insertion, usage, and maintenance, and put them into practice.
- Keep track of the conditions for removal or the reasons for continuous usage.

SURVEILLANCE FOR CAUTI (Hooton et al., 2010, Loveday et al., 2014, Panknin and Althaus, 2001, Pellowe et al., 2005, Pratt et al., 2007).

- Determine the standardized infection ratio (SIR) and/or CAUTI rates for the target groups.

- Compile data on catheter-days, patient-days (denominator data), and catheter insertion indications for each patient in the patient groups or units under observation.
- Take into account offering unit-specific feedback.
- Determine the patient populations or facilities where monitoring should be carried out based on risk assessment, taking into account catheter usage frequency and potential hazard (eg, types of surgery, obstetrics, critical care).
- Implement a process of monitoring compliance with recommendations to prevent CAUTI and provide feedback of the monitoring to health care professionals in charge of care of patients (Kanj et al., 2013, Leblebicioglu et al., 2013a, Navoa-Ng et al., 2013, Rosenthal et al., 2012j)
- Use standardized criteria, such as CDC's National Healthcare Safety Network (NHSN) definitions, to identify patients who have a CAUTI (numerator data).
- Use surveillance methods for case finding that are documented to be valid and appropriate for the institution.

EDUCATION AND TRAINING (Hooton et al., 2010, Loveday et al., 2014, Panknin and Althaus, 2001, Pellowe et al., 2005, Pratt et al., 2007).

- Evaluate HCP competency in catheter care, maintenance, and usage.
- Train medical staff (HCP) who insert, maintain, and care for urinary catheters about CAUTI prevention, including alternatives to indwelling catheters and techniques for catheter placement, management, and removal.

PROPER PROCEDURE FOR INSERTING A CATHETER (Hooton et al., 2010, Loveday et al., 2014, Panknin and Althaus, 2001, Pellowe et al., 2005, Pratt et al., 2007).

- When possible, take into account other bladder management such intermittent catheterization.
- Insert catheters using sterile instruments and aseptic method.
- Only place urinary catheters when absolutely necessary for patient care, and only leave in place for as long as indications still exist.
- perform hand hygiene (according to CDC or WHO recommendations) before and after manipulating the catheter site or apparatus, as well as before and after inserting the catheter.
- To reduce urethral trauma, use a catheter that is as thin as feasible while yet allowing for appropriate drainage.

- When cleaning the urethral meatus, use sterile or antiseptic solution, sterile single-use lubricating jelly packets, and sterile gloves, drapes, and sponges.

MANAGEMENT OF INDWELLING CATHETERS (Hooton et al., 2010, Loveday et al., 2014, Panknin and Althaus, 2001, Pellowe et al., 2005, Pratt et al., 2007).

- Avoid setting the bag on the floor.
- Practice good hygiene.
- It is not required to clean the meatal region with antiseptic solutions.
- Use a different collecting container for each patient and routinely empty the collecting bag.
- Refrain from contacting the collecting container with the draining spigot.
- To collect a small quantity of fresh urine for testing, wipe the needleless sampling port with a disinfectant before aspirating the urine with a sterile syringe/cannula adaptor.
- Prevent kinking of the collection tube and catheter.
- At all times, keep the collecting bag below the bladder's level.
- Maintain a sterile drainage system that is always closed.
- Maintain free-flowing flow of urine.
- Aseptically collect bigger volumes of urine from the drainage bag for specialized tests.
- After insertion, firmly secure indwelling catheters to avoid movement and urethral traction.
- When leaks, disconnections, or breaks in aseptic technique occur, replace the catheter and the collecting system as soon as possible.

SPECIAL INTERVENTION FOR PREVENTING CAUTI (Hooton et al., 2010, Loveday et al., 2014, Panknin and Althaus, 2001, Pellowe et al., 2005, Pratt et al., 2007).

- These unique methods and special interventions are advised for usage in areas and/or populations within the hospital where CAUTI rates or SIRs remain unacceptably high after the application of the fundamental CAUTI prevention measures previously mentioned.
- Evaluate the risk of CAUTI.
- Create a plan for managing postoperative urinary retention that includes bladder scanner use and intermittent catheterization under the direction of a nurse.

- Implement an organization-wide program to identify and remove catheters that are no longer necessary using one or more documented effective procedures.
- Establish a system for assessing and reporting data on catheter use and adverse events from catheter use.

METHODS THAT SHOULD NOT BE CONSIDERED AS USUAL IN CAUTI PREVENTION (Hooton et al., 2010, Loveday et al., 2014, Panknin and Althaus, 2001, Pellowe et al., 2005, Pratt et al., 2007).

- Avoid irrigation of the catheter.
- Avoid routine catheter replacement.
- Antimicrobial/antiseptic-impregnated catheters should NOT be used frequently.
- In catheterized patients, DO NOT test for asymptomatic bacteriuria.
- In catheterized patients, treat asymptomatic bacteriuria ONLY prior to invasive urologic procedures.
- Systemic antimicrobials should NOT be used frequently for prophylaxis.

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