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Using New Technology to Prevent Healthcare-Associated Infection in Pediatric Patients

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Opinion statement

Healthcare-associated infections have a great impact in patients' morbidity and mortality, as well as increasing the length of stay in the hospital and treatment costs. Progresses in the study of epidemiologic health care and researches in its implementation have led to a better comprehension of the effective strategies to prevent the foresaid infections. The objective of this study is to present and discuss the technological innovations in the prevention of healthcare-associated infections. The following data bases were accessed: PUBMED, EMBASE, Scielo, Scopus, and Cochrane, using the key words: healthcare-associated infections, prevention, innovations, innovative, ventilator-associated pneumonia (VAP), catheter-related bloodstream infection (CRBSI). The evidence degree from the Canadian Task Force on Preventive Health Care was used. For every item, the recommendation degree from the Society for Healthcare Epidemiology of America (SHEA/IDSA) was used. Telemedicine, computerized training, realistic training, hand hygiene monitoring technology, chlorhexidine bathing, chlorhexidine-impregnated dressings, antimicrobial-impregnated catheters, high-flow nasal cannula, subglottic aspiration cannula, and silver-coated endotracheal tubes are examples of the new technologies discussed in the article. However, they do not replace cultural measures, such as the healthcare team's education, the establishment and compliance to protocols, and multidisciplinary visits where the need for devices and mechanical ventilation is questioned.

Introduction

Healthcare-associated infections (HAI) have a great impact in patients' morbidity and mortality, as well as increasing the length of stay in the hospital and treatment costs [1–5].

There are various aspects that healthcare-associated infections and infection control interventions have an impact: hospitalization costs (antibiotics, excess length of stay, and intensive care stay), intervention costs (tests costs, gown and glove, nurse and physician time, isolation room), outpatient expenses (physician visits, antibiotics, home health visits, rehabilitation center stay), and patient expenses and outcomes (mortality, morbidity, infections, lost wages, travel expenses) [6].

There is a large body of literature, which has shown that HAI are one of the major causes of patient morbidity and mortality in industrialized countries. Device-associated infections, such as ventilator-associated pneumonia, central venous catheter-associated bloodstream infection, and catheter-associated urinary tract infection have the greatest challenge to hospital safety and quality healthcare in intensive care unit [7].

Progresses in the study of epidemiologic health care and researches in its implementation have led to a better comprehension of the effective strategies to prevent the foresaid infections [8••].

In spite of these advances, there is a great interval between the recommendations and the clinical practices [8••].

Opinion statement

Healthcare-associated infections have a great impact in patients' morbidity and mortality as well as increasing the length of hospital stay and the treatment costs. New technologies for the prevention of healthcare-associated infections need to be combined with cultural measures such as the healthcare team's education, the establishment and compliance to protocols and multidisciplinary visits.

Objective

The objective of this study is to present and discuss the technological innovations in the prevention of healthcare-associated infections.

Methods

The following data bases were accessed: PUBMED, EMBASE, Scielo, Scopus, and Cochrane, using the key words: health-related infections, prevention, innovations, innovative, ventilator-associated pneumonia (VAP), and catheter-related bloodstream infection (CRBSI).

The evidence degree from the Canadian Task Force on Preventive Health Care was used.

For every item, the recommendation degree from the Society for Healthcare Epidemiology of America (SHEA/IDSA) was used [8••].

New technologies for the prevention of health-related infections

Telemedicine

Telemedicine is defined as the provision of long-distance health care, using the telecommunication technology [9].

Lilly et al. studied seven adult intensive care units, with the objective of quantifying the association of telemedicine in mortality, length of stay, complications, and greater compliance to the best clinical practices. The authors observed greater compliance to clinical practices and prevention of VAP, less incidence of VAP, less rates of CRBSI, and shorter length of stay [10]. Later, the same authors studied 56 ICUs and observed better compliance to medical practices after the use of telemedicine [11].

Training (evidence degree II)

Computerized training (e-learning) can be used as a tool to promote training and education, as traditional methods have their limitations in reaching professionals [12]. Its advantages would be the flexibility in time and physical location to access it [13]. Comer et al. applied some pre- and post-tests with e-learning-related questions and observed a greater understating about the risk of CRBSI [14].

Another training option is realistic simulation. Barsuk et al. observed a decrease in CRBSI rates in the unit where the realistic simulation training for central catheter insertion took place. In the unit where this training method was used, the incidence of infection was 0.5 infections/1000 catheter-days. Prior to its implementation, the rate at this unit was 3.2/1000 catheter-days, and in other units that did not use this technology, the rate was 5.03/1000 catheter-days [15].

Khouli et al. studied realistic simulation for central line insertion involving 47 medical residents. They observed a 70 % decrease in the incidence of CRBSI in the group that used the simulation.

Hand hygiene (evidence degree II)

It is extremely important to avoid *Clostridium dificille*-related diseases [8].

Hand hygiene monitoring technology is a potential solution for poor healthcare worker hand hygiene compliance [16, 17]. This technology includes systems that count alcohol-based hand rub or soap dispensing events and complex systems that stimulate the compliance in real time, video cameras, dedicated hand hygiene monitoring systems, and real-time location systems.

Evidence suggests that electronic monitoring is not more accurate than direct observation, but it is related to an improved practice.

Electronic monitoring provides objective information that can be used as feedback with the health professionals. However, this information can be used in a dangerous and unproductive way [16, 18].

The success of these technologies depends on the physical structure and organizational culture of the implementing unit. The success of feedback depends on who provides it and the medium used (e.g., email or face to face meeting) and the specific content, as it can influence the team work culture [18]. Recommendation evidence to provide feedback is degree III [8••].

Chlorhexidine bathing (evidence degree I)

Chlorhexidine bathing is recommended for patients over 2 months of age to prevent catheter-related blood stream infections [8••].

Chlorhexidine gluconate (CHG) is a topical antiseptic that inhibits

organism growth and reduces skin colonization [21]. CHG presents a broad-spectrum activity against *Staphylococcus aureus* and *Enterococcus* species, as it has a residual antibacterial activity [19•]. As hospital-acquired bloodstream infections are often caused by skin organisms, skin decontamination would prevent these infections.

Chlorhedixine bathing is a safe and simple option to prevent the transmission of resistant microorganisms and to decrease hospital-acquired infections [19•, 20]. Milstone et al. conducted a study in children in intensive care units, where they presented a lower incidence of bacteremia and the treatment was well tolerated [21].

Chen et al. did a meta-analysis review of 12 articles in adult patients. Four of them showed a reduction in the risk of infection due to methicillin-resistant *S. aureus* (MRSA) and vancomycin-resistant *Enterococcus* (VRE), a decrease in MRSA infections and in MRSA ventilator-associated pneumonia. As for VRE, skin colonization and infections were reduced [22].

Popp et al. studied 203 thermally injured patients. The median burn area was 25 % of total body surface area. They observed a significant reduction in ventilator-associated pneumonia, catheter-related bloodstream infections, and catheter-associated urinary tract infections [23].

Milstone et al. studied 4947 pediatric patients, older than 2 months, who received daily chlorhexidine bathings. The treatment was well tolerated by the patients. Those who received daily chlorhexidine bathings and had central venous catheters (CVC), showed a 34 % decrease in the risk of bacteremia. The incidence of CRBSI was less in the chlorhexidine group, but without a statistical significance difference [21].

Utilization of chlorhexidine-impregnated dressings to occlude central venous catheter in patients older than 2 months (evidence degree I)

A new chlorhexidine-impregnated dressing was developed (Biopatch®; Johnson & Johnson). Two studies observed a reduction in the colonization of the catheter insertion sites and a 60 % reduction of CRBSI. No resistance to chlorhexidine or adverse reactions was observed [24, 25].

Garland et al. studied 703 patients from 6 neonatal intensive care units. One group received a povidone-iodine skin scrub, and the other a 70 % alcohol scrub followed by placement of a chlorhexidine-impregnated disk over the catheter insertion site. The antimicrobial dressing group had less colonization of CVC tips. Rates of CRBSI and blood stream infections (BSI) without a source did not differ between the two groups. Localized contact dermatitis from the antimicrobial dressing occurred in 15.3 % of the neonates weighing ≤1000 g [26].

Utilization of antimicrobial-impregnated catheters (evidence degree I for adults; evidence degree II for children)

The use of antimicrobial-impregnated catheters is based on the concept of the skin origin of bacteremia [27, 28].

Lai et al. conducted a meta-analysis of 56 studies in adults, with 11 different types of antimicrobial impregnations. Catheter impregnation reduced catheter colonization, but made no statistically significant difference to the rates of

sepsis and all-cause mortality. There were also no statistically significant differences between the groups regarding the rates of adverse effects, including thrombosis/thrombophlebitis, bleeding, erythema, and/or tenderness at the insertion site [29].

There is only one pediatric study, with 98 preterm infants, where a silver-impregnated umbilical catheter was used, and a reduction in CRBSI was observed.

Antimicrobial-impregnated catheters are recommended to prevent CRBSI in adults and the recommendation degree II for children derives from this [8••].

High-flow nasal cannula

Guidelines for VAP recommend that intubation should be avoided using non-invasive ventilation, with a recommendation degree I [8••, 30••]. High-flow nasal cannula (HFNC) could be an alternative to non-invasive ventilation.

Over the last decade, high-flow nasal cannula has increasingly been used in neonatology, gradually replacing nasal continuous positive airway pressure (CPAP) [31].

HFNC administers a heated and humidified mixture of air and oxygen at a higher flow than the patient's inspiratory flow. HFNC diminishes the resistance in the nasal mucosa, "washes out" the gas from the dead space, and creates a 6-cm H_2O pharyngeal pressure. This results in greater comfort and oxygenation for the patient [31].

High-flow nasal cannula can be an alternative to non-invasive ventilation due to a greater tolerance to the interfaces and a lesser need for sedatives [32].

There are still few pediatric studies showing an improvement in respiratory distress and a better oxygenation. However, meta-analysis has not yet demonstrated a statistically significant improvement [32, 33].

Subglottic aspiration cannula (evidence degree III for children and II for adults)

With the insertion of the endotracheal tube, secretions are easily drained and accumulated in the subglottic space. This contaminated secretion slides along the tube and contributes to the occurrence of pneumonia. Therefore, the constant or intermittent aspiration of this secretion could be a strategy [34]. Studies indicate a reduction in VAP in approximately 50 %, reduction in the use of mechanical ventilation, and in the length of stay in intensive care units (ICU). However, there is no evidence of the reduction in mortality.

The obstacles for using subglottic aspiration cannula are its cost, in average, 10 times higher, and also the risk of tracheal injury, with the possibility of a tracheoesophageal fistula and post-extubation laryngitis [34].

Studies were done with adult patients, and the limitations for its use in younger children is the size of the available cannula (size 6 and over), which is indicated for children older than 10 years [30••].

Utilization of silver-coated endotracheal tubes

An effective strategy to reduce VAP is to treat the endotracheal tube with an antiseptic agent to control the formation of biofilm. Biofilm is the bacterial adherence to objects, covered by an exopolysaccharide matrix, which makes it resistant to antibiotic penetration [35]. Biofilm lining is more evident in the distal third of the endotracheal tube and can be formed in the first 60 h of intubation [36].

Silver has antimicrobial properties, and in vitro studies revealed a milder colonization by *S. aureus* and *Pseudomonas aeruginosa* [37, 38].

The recommendations are derived from those in adult patients [30••].

In a meta-analysis, Tokmaji et al. reviewed three randomized controlled trials with a total of 2081 participants. The "risk of bias" assessment indicated a high risk of bias due to lack of blinding of outcomes assessors. There is limited evidence that silver-coated endotracheal tubes reduce the risk of VAP, especially during the first 10 days of mechanical ventilation [39].

There is still no recommendation for this technology.

Conclusions

New technologies are important advances in the prevention of healthcare-associated infections. They are new tools. However, they do not replace cultural measures, such as the healthcare team education, the establishment and compliance to protocols, and multidisciplinary visits where the need for devices and mechanical ventilation is questioned.

Compliance with Ethical Standards

Conflict of Interest

Dr. Schvartsman declares that he has no conflict of interest.
Dr. Medeiros declares that she has no conflict of interest.
Dr. Troster declares that he has no conflict of interest.

Human and Animal Rights and Informed Consent

This article does not contain any studies with human or animal subjects performed by the author.

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