ORAL HYGIENE IS AN IMPORTANT FACTOR FOR PREVENTION OF VENTILATOR-ASSOCIATED PNEUMONIA

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SUMMARY – Inadequate oral hygiene in intensive care units (ICUs) has been recognized as a critical issue, for it is an important risk factor for ventilator associated pneumonia (VAP). VAP is an aspiration pneumonia that occurs in mechanically ventilated patients, mostly caused by bacteria colonizing the oral cavity and dental plaque. It is the second most common nosocomial infection and the leading cause of complications and death in mechanically ventilated patients. It has been suggested that improvement of oral hygiene in ICU patients could lead to a reduced incidence of VAP. Although diverse oral care measures for ICU patients have been proposed in the literature, there is no evidence that could identify the most efficient ones. Although there are several evidence-based protocols, oral care measures are still performed inconsistently and differ greatly between individual ICUs. This paper lists the oral care measures most commonly performed in ICUs, indicating their advantages and disadvantages. Brushing with regular toothbrush and rinsing with chlorhexidine are considered optimal measures of oral hygiene in critically ill patients. To date, there is no definitive agreement about the most effective oral care protocol, but evidence demonstrates that consistent performance of oral care may lower the incidence of VAP in critically ill patients.

Key words: *Oral hygiene; Intensive care units; Pneumonia, ventilator-associated; Cross infection*

Introduction

Critically ill patients in intensive care units (ICUs) require continuous 24-hour monitoring and adequate nursing care. In the state of critical illness, more attention is often paid to other aspects of nursing care, while oral care is neglected and insufficiently/inappropriately performed. Literature identifies several potential causes of inappropriate oral hygiene in ICUs. The most common are the nursing staff's perception that other aspects of nursing care are more important than consistently performing oral care[1,2], limited and insufficient knowledge regarding importance of oral hygiene in critically ill patients[3], lack of standardized protocols and recommendations for oral hygiene in critically ill[2-7], and insufficient resources allocated for oral hygiene in ICUs. The consequences of inadequate oral hygiene in ICUs manifest both locally, with a higher incidence of caries, periodontal disease and oral mucosal infections[6]; and systemically as bacteremia[8], metastatic infections such as infective endocarditis[9], sepsis and pneumonia[7], chronic obstructive lung disease[10], and other conditions that are caused by increased blood levels of long-range proinflammatory mediators (e.g., accelerated atherosclerosis, glucose intolerance, increased leukocyte count)[11,12]. These conditions further aggravate the health state of ICU patients who are already vitally threatened by their primary disease.

Inadequate oral hygiene in ICUs has been recognized as a critical issue, thus the importance of creating and implementing a standardized oral hygiene

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protocol is increasingly emphasized. Investigations are aimed at finding effective yet easily feasible oral care measures for critically ill patients. Recent efforts to create standardized oral care protocols for ICU patients have resulted in several evidence-based recommendations[13-16]. Despite published recommendations and available protocols, oral care measures are still performed inconsistently and differ greatly between individual ICUs[17]. In many cases, oral care practice is insufficient, compromising both oral and general health of the critically ill.

Ventilator Associated Pneumonia

It is certain that poor oral hygiene affects many aspects of oral and general health of ICU patients. However, most attention is paid to the development of ventilator associated pneumonia (VAP), while research of other health conditions caused by inadequate oral hygiene is scarce and less documented in the literature. Compared with other effects of inadequate oral hygiene that are mostly local and low in acuity, VAP is a serious condition with a high mortality rate. Therefore, prevention of VAP is recognized as the most important objective of oral care in ICUs.

Ventilator associated pneumonia is defined as a nosocomial infection that occurs at least 48 hours after intubation. VAP incidence ranges from 8% to 28% of mechanically ventilated patients and mortality rate is 24%-76%[18]. By its incidence, VAP is the second most common nosocomial infection (after urinary tract infections), and is the leading cause of complications and death in mechanically ventilated patients[6]. Etiologically, VAP is an aspiration pneumonia mostly caused by bacteria that colonize the oral cavity and dental plaque[19].

In oral cavities of hospitalized patients, especially in those mechanically ventilated, microbial flora gradually changes; gram-positive bacteria of low virulence that are predominant at admission (*Streptococcus* spp., *Actinomyces* spp.) are progressively being replaced by the more virulent gram-negative, potentially pathogenic microbial flora. This transition occurs both in dental plaque, which is yet in physiological condition colonized with 200-350 different bacterial species[4,5], and on mucosal surfaces. In dental plaque, the transition occurs by accumulation and maturation of dental plaque enabled by insufficient mechanical cleaning, i.e. poor oral hygiene[20]. In physiological conditions, regular exfoliation and salivary immune mechanisms ensure that oral mucosa is less colonized by bacteria than teeth. However, these protective mechanisms may decline in critically ill patients due to the reduction of salivary secretion, lower levels of salivary local immunity factors, and absence of self-cleaning by chewing. In such conditions, dental plaque and oral mucosa in hospitalized patients may become colonized by (possibly multi-resistant) bacterial species such as *Staphylococcus (S.) aureus, Pseudomonas aeruginosa* and *Streptococcus pneumoniae*, which are identified as potential respiratory pathogens[21]. The shift towards a more pathogenic flora occurs promptly, within 48 hours of admission[22]. Endotracheal tube constantly keeps the glottis open, giving the potential pathogens a pathway to the lower parts of the respiratory tract. Moreover, endotracheal tube may become colonized by bacteria, intubation obstructs physiological cleaning of the upper respiratory tract by coughing, compromises mucociliary transport, and increases mucus secretion[23]. All of the above listed factors make intubated patients more prone to aspiration of bacteria and development of VAP. Therefore, it is reasonable to hypothesize that improvement in oral hygiene and the subsequent reduction of potentially pathogenic bacteria could lead to a reduced incidence of VAP[24].

Oral Hygiene Measures

Available literature suggests diverse oral care measures for ICU patients. Although recent research has yielded recommendations that are supported by evidence, literature still remains equivocal regarding the unique evidence-based protocol. In the absence of such a protocol, oral hygiene practice varies among hospitals and even among individual ICUs within a hospital. Reliable proofs of the efficiency for most of oral care procedures are lacking, so these procedures are carried out in various combinations, mostly unsystematically and superficially[1-7]. The most common oral care agents and procedures, as described in the literature include those described below.

Hydrogen peroxide

Oxidizing antiseptic is used as a mouthwash in concentrations of 1%-3%. Due to its irritating effect,

unpleasant taste and potential genotoxicity[25], it is not recommended for rinsing.

Sodium bicarbonate

Mouthwashes containing aqueous solution of sodium bicarbonate reduce mucus viscosity and therefore make removal of materia alba easier[26]. Moreover, high pH inhibits demineralization of dental hard tissues and protects teeth from caries. However, solutions of higher concentrations may show caustic effect and cause irritation and chemical burns[26]. Research and evidence that may justify usage of sodium bicarbonate solution for oral care in ICUs are lacking[5].

Saline solution

It is a neutral solution used for mouth washing and relief of xerostomia-associated symptoms. Paradoxically, its usage may produce a drying effect on oral mucosa[27], thus rendering it inappropriate for routinely performed oral care of critically ill patients[5].

Water

Plain water can be used for mucosal moistening and symptomatic treatment of xerostomia. Tap water must not be used since it may be contaminated with nosocomial bacteria; therefore, the use of sterile water is recommended[28].

Chlorhexidine

Chlorhexidine (CHX) is a very effective wide-spectrum antiseptic agent with rare occurrence of side effects. It is considered an agent of choice for chemical plaque control, especially when mechanical methods of oral hygiene are difficult to perform[29]. Due to its physicochemical properties, CHX adsorbs to tooth surfaces, enabling extended protection against plaque formation for up to 12 hours following application. For chemical plaque control, solutions of concentration between 0.12% and 0.2% are used for mouth rinsing, swabbing or spraying. CHX gels containing higher concentrations are also available. CHX efficiency in reduction of VAP incidence is still unclear, but there is increasing evidence to support its inclusion in oral hygiene protocols for ICU patients[30-33]. Some authors do not advocate employment of CHX for VAP prevention in critically ill[34-36], whereas others recommend its use only in patients undergoing cardiac surgery[37,38].

Due to its substantivity to clean tooth surfaces, CHX may exert more beneficial and prolonged effect if applied following brushing[39]. This may also explain the non-beneficial effect of CHX in some studies that involved application of CHX without previous brushing[40]. Apparently, further studies are needed to assess the benefits of using CHX for VAP prevention and justify its possible inclusion in standardized oral care protocols.

Topical antibiotics

Topically applied antibiotics covering gram-negative bacteria demonstrated reduced incidence of VAP caused by these bacterial species[41]. There was no development of resistant strains; however, increased growth of *S. aureus* (a potential cause of VAP) was observed[41]. Due to their inability to cover the wide spectrum of bacteria that may cause VAP, the possible change of microbial flora in favor of other pathogenic species, and the risk of resistance development, topical antibiotics are not recommended for oral care in ICU[2].

Citric acid and glycerin

Swabbing with citric acid and glycerin solution stimulates salivation, thereby temporarily relieving the symptoms of xerostomia. Long-term application may exhaust the salivary reflex mechanism, resulting in rebound xerostomia[42]. Moreover, low pH facilitates demineralization of dental hard tissues. Therefore, the use of this solution is not recommended.

Moisturizing agents

Artificial saliva may be used for mucosal moistening and petroleum jelly coating may protect lips from drying. Maintaining moisture of oral mucosa helps preserve its integrity, as damaged mucosa may provide a route for transmission of oral bacteria. Also, moist environment favors physiological oral flora, preventing overgrowth of pathogenic bacteria[24].

Povidone-iodine

Although very effective for skin and mucosal disinfection, povidone-iodine has no effect on the re-

duction of dental plaque. Frequent use is not recommended as it may result in the adsorption of high and potentially toxic amounts of iodine.

Mechanical plaque control

Mechanical biofilm removal is both the most basic and most efficient means of maintaining oral hygiene. In ICU setting, the use of small toothbrushes is recommended, as they can reach the most posterior parts of oral cavity[43]. In order to minimize traumatization of soft tissues, only soft brushes with rounded bristles should be used. Ordinary toothbrushes can also be used for tongue, palate and edentulous ridges cleaning, which are significant microbial reservoirs due to the absence of physiological self-cleansing mechanisms[44]. The benefits of using electric toothbrush are unclear; one study mentions superiority of electric *versus* manual toothbrush[45], whereas another one demonstrated no difference[46]. The former study may have been biased in favor of electric toothbrush because it was used as part of a comprehensive protocol, while manual brushing was performed in a control group, i.e. devoid of other measures that were included in the protocol[45].

Foam swabs are sometimes used as an alternative for toothbrush. Compared to toothbrushes, foam swabs are less efficient in mechanical plaque control[47], since interdental spaces cannot be reached by foam swabs. Also, foam swabs alone cannot generate sufficient pressure to thoroughly remove adherent bacteria.

The standard Bass tooth brushing technique (positioning a soft toothbrush at a 45° angle to the long axis of the tooth and brushing with gentle vibratory motions) is recommended for mechanical plaque control in ICU patients, although other systematic brushing techniques may also be effective. There is no right or wrong way to brush teeth; the final result is more important than the technique itself. The aim of any tooth brushing technique is to achieve as much plaque reduction as possible while avoiding trauma to oral mucosa, especially to marginal gingiva.

The use of toothpaste while brushing is beneficial, although not necessary for plaque removal. A sufficient level of oral hygiene can be achieved by brushing alone; however, brushing with toothpaste provides more thorough cleansing as well as fluoride protection[48]. If CHX is to be applied after brushing, toothpastes without sodium lauril sulfate should be used in order to avoid CHX inactivation[49].

Any tooth brushing presents a theoretical risk of bacteremia. In healthy adult population, transitory bacteremia occurs in 25% of the cases of daily brushing, and in healthy children population, it may occur in up to 40% of the cases[50]. Such transitory bacteremia in healthy subjects is clinically irrelevant, since bacteria are efficiently and promptly neutralized by the reticuloendothelial system[51]. Therefore, the risk of complications caused by transitory bacteremia in ICU patients is negligible, provided they are immunocompetent[52].

Although the benefits of brushing as a measure of VAP prevention are rather intuitive and supported by evidence, some authors indicate the lack of high-level evidence of brushing effectiveness[30,53]. Obviously, more studies are required to elucidate the effect of this simple yet potentially beneficial oral care measure.

Protocol

Despite the various methods and agents for oral hygiene in ICUs aimed at VAP prevention described in the literature, there is still no evidence that could point out the most efficient ones[54]. Although the need of creating a single comprehensive protocol of oral hygiene in critically ill patients is often emphasized in the literature[1-7], and some evidence has been accumulated through clinical research, there is still no consensus regarding the most effective VAP prevention method(s) of oral care that should be integrated in a unique comprehensive protocol. As to date, several protocols have been proposed that are mostly based on mechanical plaque removal, i.e. tooth brushing with regular toothbrush[24,30,54]. CHX use is sometimes included in routine oral care[13,14,31], but there are protocols that limit its use to cardiac surgery patients[38].

Despite recent advances, oral care of the critically ill is performed variously and inconsistently, mostly in accordance with individual staff experience, long 'tradition' of particular methods and available resources[1,17,45,55-58].

The beneficial effect of standardized protocol implementation on lowering VAP incidence was demonstrated in multiple clinical evaluations[31,59], but the protocols employed differed among researchers. How-

ever, this confirms the positive effect of various oral care practices in ICUs, provided they are implemented consistently, i.e. according to the written protocol. Although investigated oral care practices varied, they are predominantly focused on brushing and CHX rinsing, while investigation of other oral care measures is relatively scarce. Results are inconsistent, though supporting the hypothesis that improvement of oral care reduces VAP incidence in the critically ill, besides other local and systemic benefits of maintaining good oral health. Comprehensive oral care protocols have been published[14,16,38,45] and oral care measures are becoming integrated into care bundles for the critically ill[15]. Most of the contemporary evidence-based protocols include tooth brushing and some of them also include CHX rinsing. The American Association of Critical Care Nurses guidelines recommend routine brushing at least twice a day using a soft pediatric or adult toothbrush, but CHX use is limited to cardiac surgery patients[38].

A recently published meta-analysis[60] highlights the lack of high-level evidence for efficiency of tooth brushing as a method of VAP prevention. Moreover, all of the present recommendations are derived from relatively low-level evidence, thus additional studies are needed to verify the efficiency of current protocols and suggest possible improvements.

Conclusion

Although there is no definitive agreement on the most effective oral care protocol, evidence has demonstrated that consistent performance of certain oral care procedures may lower the incidence of VAP in critically ill patients. It should be noted that, besides VAP prevention, quality oral care plays an important role in maintaining local health, and also contributes to the prevention of systemic diseases that may be related to poor oral hygiene. Hence, oral care of the critically ill must be considered as an important part of routine nursing activity, not only as a measure of VAP prevention, but as a crucial treatment with a profound effect on the patient's general health.

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Sažetak

ORALNA HIGIJENA KAO VAŽAN ČIMBENIK U SPRJEČAVANJU PNEUMONIJE POVEZANE S MEHANIČKOMVENTILACIJOM

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Nezadovoljavajuća oralna higijena na jedinicama intenzivnog liječenja (JIL) prepoznata je kao ključno pitanje, jer predstavlja značajan čimbenik rizika za razvoj pneumonije povezane s mehaničkom ventilacijom. Pneumonija povezana s mehaničkom ventilacijom je aspiracijska pneumonija koja se javlja kod mehanički ventiliranih bolesnika i većinom je uzrokovana bakterijama koje koloniziraju usnu šupljinu i zubni plak. Druga je po redu najčešća nozokomijalna infekcija i vodeći je uzrok komplikacija i smrti u mehanički ventiliranih bolesnika. Smatra se kako bi poboljšanje oralne higijene u JIL moglo rezultirati smanjenom incidencijom pneumonije povezane s mehaničkom ventilacijom. Iako su u literaturi predložene razne mjere oralne higijene za bolesnike u JIL, ne postoje dokazi koji bi pokazali koje su od njih najučinkovitije. Iako postoji nekoliko protokola temeljenih na dokazima, mjere oralne higijene se još uvijek provode nedosljedno i razlikuju se među pojedinim JIL. Ovaj rad navodi mjere oralne higijene koje se najčešće provode u JIL i ukazuje na njihove prednosti i nedostatke. Optimalnim mjerama oralne higijene smatraju se četkanje običnom zubnom četkicom i ispiranje klorheksidinom. Iako do danas ne postoji suglasje o najučinkovitijem protokolu oralne skrbi, pokazalo se kako dosljedno provođenje oralne higijene može smanjiti incidenciju pneumonije povezane s mehaničkom ventilacijom u kritično bolesnih pacijenata.

Ključne riječi: *Oralna higijena; Jedinice za intenzivnu skrb; Pneumonija povezana s mehaničkom ventilacijom; Infekcija, hospitalna*