Oral health care for the critically ill: a narrative review

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Abstract

Background: The link between oral bacteria and respiratory infections is well documented. Dental plaque has the potential to be colonized by respiratory pathogens and this, together with microaspiration of oral bacteria, can lead to pneumonia particularly in the elderly and critically ill. The provision of adequate oral care is therefore essential for the maintenance of good oral health and the prevention of respiratory complications.

Main body: Numerous oral care practices are utilised for intubated patients, with a clear lack of consensus on the best approach for oral care. This narrative review aims to explore the oral-lung connection and discuss in detail current oral care practices to identify shortcomings and offer suggestions for future research. The importance of adequate oral care has been recognised in guideline interventions for the prevention of pneumonia, but practices differ and controversy exists particularly regarding the use of chlorhexidine. The oral health assessment is also an important but often overlooked element of oral care that needs to be considered. Oral care plans should ideally be implemented on the basis of an individual oral health assessment. An oral health assessment prior to provision of oral care should identify patient needs and facilitate targeted oral care interventions.

Conclusion: Oral health is an important consideration in the management of the critically ill. Studies have suggested benefit in the reduction of respiratory complication such as Ventilator Associated Pneumonia associated with effective oral health care practices. However, at present there is no consensus as to the best way of providing optimal oral health care in the critically ill. Further research is needed to standardise oral health assessment and care practices to enable development of evidenced based personalised oral care for the critically ill.

Keywords: VAP, Oral health, Chlorhexidine, Oral bacteria, Pneumonia

Introduction

The oral cavity houses the second largest microbiota in the human body and includes bacteria, fungi, viruses, and archaea [1]. The majority of micro-organisms within the oral cavity are found within biofilms consisting of mostly commensal bacteria that are considered beneficial for the host. However, dysbiosis of the microbial biofilm can lead to dental diseases such as periodontitis and tooth decay [2]. Periodontitis is a chronic inflammatory disease affecting the supporting tissues of the teeth and is generally caused by oral anaerobic bacteria in a susceptible individual. The disease is highly prevalent, with severe forms affecting 10% of the population [3]. Tooth decay, on the other hand, is caused by acid produced by oral bacterial fermentation of dietary carbohydrates. Untreated dental caries is the 2nd most common chronic disease, with 2.4 billion individuals affected worldwide [4]. Untreated caries can ultimately lead to the death of the tooth and subsequent abscess formation in the underlying tissues.

Localised oral diseases, including periodontitis and caries-induced infections, have previously been shown to
have systemic connections [5]. Oral bacteria commonly gain entrance to the circulation through ulcerated gingiva crevicular tissue that surrounds the teeth [6]. Invasion of the cariogenic Gram positive bacterium *Streptococcus mutans* into vascular endothelial cells is considered an exacerbating factor in infective endocarditis [7]. Additionally, oral bacteria including *Staphylococcus aureus*, *Streptococcus sanguis*, *Enterococcus faecalis*, and others have been implicated in the pathogenesis of infective endocarditis [8]. Poor oral hygiene in this regard, has been shown to be associated with an increased risk for infective endocarditis [9]. Gram negative oral bacteria and the local inflammatory response associated with periodontitis, can contribute to systemic inflammation and the initiation and progression of chronic inflammatory based diseases, including cardiovascular disease [10], diabetes [11] and respiratory disease [12].

This narrative review aims to provide an overview on the links between oral health and respiratory disease with particular consideration to the critically ill. We also consider the roles oral health assessment and oral care interventions have in the critically ill. A comprehensive search of the published English literature was conducted in PubMed, Medline, and Scopus until March 2021, using the following keywords: (“oral health” OR “oral disease” OR “periodontitis”* OR “caries” OR “oral health assessment” OR “oral health care” OR “oral prophylaxis”) AND (“critically ill” OR “critical care” OR “intensive care” OR “VAP”). Two of our investigators independently searched the databases (IEK and LW) and reviewed each of the retrieved articles.

### Oral health and respiratory disease

The airway, including upper and lower segments, is a continuum of the oro-nasopharynx. Secretions of the upper airways are normally heavily contaminated with microorganisms originating from the oro-nasopharynx region. The lower airways, however, maintain a more sterile-like state supported by the cough reflex, the action of tracheobronchial secretions, mucociliary transport of inhaled microorganisms, and immune defence factors (cell-mediated immunity, humoral immunity, and neutrophils). In individuals with underlying chronic health problems, aspirated oral secretions containing potential pathogens are not always cleared effectively [13]. In these cases, pathogenic changes to the normal commensal microflora of the respiratory system, and more specifically potential infections that are derived from the oral cavity, represent a mechanistic pathway for an association with oral health.

The oral microbiome is comprised of over 600 prevalent taxa at the species level, with distinct subsets predominating in various oral habitats [1]. Dental caries and periodontitis are the most common oral diseases and are major causes of tooth loss [3]. Despite different aetiologies, caries and periodontal disease represent dysbiotic states of the oral microbiome [14]. In the absence of effective oral hygiene, initial dental plaque formation on a clean tooth surface will occur within 48 h. As the biofilm matures, its composition reflects the oral environment. If the pH in the oral cavity is low, then a cariogenic microflora may predominate (Gram-positive bacteria and *Candida albicans*), whereas if the gums are inflamed a periodontopathic microbiota is likely to predominate (anaerobic Gram-negative bacteria). Immunocompromised patients and individuals with low salivary flow rates will generally tend to be more susceptible to bacterial and fungal colonisation of the oral cavity. As well as leading to oral disease these pathogenic oral bacteria may be transported to the lungs where they have the potential to cause respiratory infections [15]. One cubic millimetre of dental plaque contains about 100 million bacteria [16], and may serve as a persistent reservoir for potential pathogens. Micro-aspiration of oral bacteria is common and frequently occurs during sleep. Studies have shown that typical aspirated volumes are of an amount likely to contain bacterial pathogens [17].

Amongst the associations between oral health and various respiratory diseases, the association with pneumonia has received much attention due to the strength of biological plausibility. Oral colonisation by respiratory pathogens, fostered by poor oral hygiene, has been associated with hospital-acquired pneumonia [12, 18]. Hospital-acquired pneumonia is typically caused by bacteria that are not normally residents of the oropharynx but enter this milieu from the environment. These include Gram-negative bacilli, *Pseudomonas aeruginosa*, *Staphylococcus aureus*, and enteric species (such as *Escherichia coli*, *Klebsiella pneumoniae*, *Serratia species*, *Enterobacter species*). In ventilator-associated pneumonia (VAP), the placement of an endotracheal tube can transport oropharyngeal organisms into the lower airway [19]. The growth of a biofilm resistant to host defences and antibiotics, on the surface of the tube represents a further problem [20]. Recently, in an in vitro study, we showed that the opportunistic oral pathogen *C. albicans* enhanced bacterial numbers of the VAP pathogens; *E. coli*, *S. aureus* and MRSA in dual-species biofilms [21]. Studies have also linked community acquired pneumonia with poor oral hygiene [22, 23].

There have been several systematic reviews that have aimed to investigate the association between oral health and pneumonia. Khadka et al. [24] performed a systematic review which included studies investigating pathogenic microorganisms in oral specimens of older people with aspiration pneumonia. Based on twelve studies (four
isolated from the lung are often genetically indistinguish-
confirmed previous findings that respiratory pathogens
risk patients. was associated with a reduction in the risk for hospital
were identified which found that good oral health care
procedures in reducing hospital-acquired pneumonia
El-Rabbany et al. [26] focus was given to reviewing RCTs
(95% CI 1.68–3.86). In a systematic review conducted by
ırntime in ICU and this is particularly problematic for those
in ICU subjects serve as reservoirs for respiratory patho-
gen colonization, with the pathogens causing pneumo-
ating to first colonize the dental plaque on teeth or dentures, rather than soft tissues [34]. In intubated
patients with poor baseline dental health, such as peri-
odontal disease and tooth decay, the dysbiotic plaque is
likely to be mature and its removal requires special con-
siderations. Oral health assessment prior to provision of
oral care is therefore important to identify oral disease
and subsequently target specific oral care needs. Oral
health assessment is a descriptive health measurement
needed to establish the patient’s baseline oral health sta-
tus, changes in oral health during the course of care, and
response to interventions [35]. An oral health assessment
should include a general observation and an intra-oral
examination to detect changes in the oral cavity, includ-
ing, teeth, soft tissues and saliva [36]. The oral assessment
should be performed frequently as part of a systematic
patient assessment and should be used to identify those
at increased risk of oral complications.

Despite the obvious benefits, an oral health assess-
ment is not routinely performed for critically ill patients
[37, 38], as the process is considered time-consuming
and requires the training of nursing staff to identify oral
disease. Furthermore, the tools that are available for
oral assessment are variable, mostly not validated and
are mostly developed for oral health assessment in dif-
ferent settings but adapted for use in ICU (Table 1). It
is therefore not surprising that wide variability in oral
care assessment practices exists [39]. In a recent con-
sensus paper, the British Association of Critical Nurses
(BACCN) emphasised the importance of oral assessment
and identified the need for further research [36]. Oral
care protocols that were based on an oral health assess-
ment were previously found to be more cost-effective and
resulted in a significant reduction of VAP [40–42]. As the
provision of oral care for the critically ill and in particu-
lar those who are mechanically ventilated is complex and
demanding, oral health assessment prior to provision of
oral care to identify the oral disease and subsequent tar-
ged oral care interventions could result in more clini-
cally and cost-effective care [40, 41].

Oral health assessment
The oral health of intubated patients deteriorates with
time in ICU and this is particularly problematic for those
with pre-existing dental disease. Several studies have
verified that teeth and other oral surfaces of patients in
ICU subjects serve as reservoirs for respiratory patho-
gen colonization, with the pathogens causing pneumo-
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Oral care interventions for the critically ill
The importance of adequate oral care has been recog-
nised in guideline interventions for the prevention of
VAP [43]. Different oral practices have been adopted
for intubated patients, including toothbrushing and the
use of oral care solutions such as antiseptic mouthwash.
However, the most effective way to achieve good oral
care in the ICU is not known, and there is currently a lack of consensus [44].

Among oral care solutions, the oral antiseptic chlorhexidine digluconate was reported as the most widely used antiseptic for oral hygiene in European ICU patients [45]. Multiple systematic reviews including both randomised and non-randomised clinical trials have reported the effectiveness of chlorhexidine (CHX) in reducing VAP and mortality (Table 2). A recent Cochrane review performed a meta-analysis based on 18 RCTs and found that CHX reduced the risk of VAP compared to placebo or usual care from 24% to about 18% (RR 0.75, 95% confidence intervals (CI) 0.62–0.91, \( P = 0.004 \)) [46]. Despite this, the use of CHX has been brought into question by the finding that a possible (non-significant) increase in mortality was reported [44, 47, 48]. It is not clear, however how CHX increases the risk of mortality which has led to calls for further research to investigate its safety in critical care settings [49, 50]. CHX exhibits broad-spectrum antimicrobial activity and is considered stable, safe and effective in reducing plaque formation [51]. However, it has some disadvantages including, tooth discolouration and mucosal ulcerations when used in high concentrations, as well as emerging evidence of microbial resistance [52]. Furthermore, CHX has limited antimicrobial activities on established biofilms and therefore mechanical plaque removal, such as tooth brushing, is required prior to supplemental use of CHX [53, 54]. Future studies should be designed with these limitations in mind. Within the critical care context, the method of application of chlorhexidine is also worthy of consideration, as the use of gels may be safer than solutions, to reduce the risk of microaspiration.

Although the adjunct use of chemical plaque control may be useful, effective control of dental plaque biofilm requires physical disruption with mechanical devices such as toothbrushing. Control of dental plaque and oral disease using mechanical means alone is well documented in the general population [55, 56]. In the critically ill, mechanical plaque control is widely used, but its efficacy in reducing the incidence of VAP is debatable. A systematic review of four RCT that included 828 patients showed toothbrushing did not significantly reduce the incidence of VAP (RR, 0.77; 95% CI 0.50–1.21) and mortality (RR, 0.88; 95% CI 0.70–1.10) [57]. On the other hand, Zhao et al., showed in a combined meta-analysis of five studies (910 participants), that toothbrushing reduced the incidence of VAP (RR 0.61, 95% CI 0.41–0.91, \( P = 0.01 \)) [46]. In addition, toothbrushing compared to CHX was found to significantly reduce the duration of mechanical ventilation (MD \(-1.46\) days, 95% CI \(-2.69\) to \(-0.23\) days, \(P = 0.02\)) and ICU stay (MD \(-1.89\) days, 95% CI \(-3.52\) to \(-0.27\) days, \(P = 0.02\)), but had no effect on mortality (RR 0.86, 95% CI 0.70–1.05, \(P = 0.14\)). It is important to note here that the efficacy of toothbrushing in reducing plaque in these studies was reported in only one study [58] where the reduction in plaque scores was associated with a reduction in VAP.

Toothbrushing combined with antiseptics is a commonly used oral hygiene practice and showed efficacy in controlling plaque and periodontal disease [59]. In their meta-analysis Zhao et al. combined two studies (649 participants), investigating toothbrushing with chlorhexidine compared to chlorhexidine alone and no difference in the incidence of VAP (RR 0.74, 95% CI 0.50–1.09, \(P = 0.13\)), or mortality (RR 0.87, 95% CI 0.68–1.12, \(P = 0.28\)) was found [46]. Another systematic review compared CHX alone to oral hygiene protocols involving mechanical removal of biofilm (toothbrushing, scraping) together with chlorhexidine [60]. Their meta-analysis of six studies (1276 patients) showed a reduction in the incidence of VAP in oral care protocols that combined mechanical plaque removal and CHX (risk difference: \(-0.06\) (95% CI \(-0.11\) to \(-0.02\); \(P = 0.007\)). CHX is known to be

### Table 1  Oral health assessment tools commonly used in ICUs

| Tool | Content | Measurement | Validation | Other |
|------|---------|-------------|------------|-------|
| Beck Oral Assessment Score (BOAS) Beck [66] | lips, tongue and mucosa, gingiva, teeth and saliva | 5 items each with a four-point scale 1–4 Max score 20 | No | Developed for assessment of stomatitis post chemotherapy and adopted with modification for ICU |
| Bedside oral exam (BOE) Prendergast et al. [42] | lips, tongue, saliva, mucous membranes, gingiva, teeth and odour | 8 Items each with a three-point scale 1–3 Max score 24 | Yes | Modified from the Oral Assessment Guide (OAG) developed for assessment of mucositis post radiation therapy and adopted with modification for ICU |
| Mucosal Plaque Score (MPS) Henriksen et al. [67] | Plaque | Bleeding, redness, ulceration, saliva, halitosis, external factors, and debris | No | Developed to assess oral care in the elderly |
| The BRUSHED Assessment Model Hayes and Jones [68] | Mucosa | 1–4 Point scale for each item Max score 8 | No | Its use in ICU is not well documented |


deactivated if used immediately following toothbrushing with toothpaste containing anionic surfactants [61] and it is not clear from these studies whether such considerations were taken into account.

**Other oral care interventions**

Several other oral care solutions are used in ICU in addition to CHX. These include antiseptics such as povidone iodine, Listerine and triclosan as well as non-antiseptics such as saline and bicarbonate. In their systematic review, Zhao et al. compared povidone iodine rinse with a saline rinse or placebo in a meta-analysis of three studies (356 participants). They showed evidence of a reduction in VAP in the povidone iodine group (RR 0.69, 95% CI 0.50–0.95, \( P = 0.02 \)). On the contrary, their meta-analysis of 4 studies, which compared a saline rinse with a saline-soaked swab, found that saline rinse may reduce the incidence of VAP (RR 0.47, 95% CI 0.37–0.62, \( P < 0.001 \)) [46]. A recent systematic review investigating the effectiveness of novel herbal oral care products in the prevention of VAP reported comparable affects to CHX [62]. However, with only a limited number of studies investigating these products, further studies are required.
It is apparent from the discussion above that there is no clear consensus on the most clinically relevant and cost-effective oral care intervention. In an attempt to define the most effective oral care intervention for the prevention of VAP, Sankaran and Sonis [64] exploited the existing meta-analysis data of a Cochrane systematic review [63], and performed a network meta-analysis (NMA) to compare different oral care interventions across different studies and rank the efficacy of each in the context of all of the interventions studied. The NMA included 25 studies (4473 subjects), 16 treatments, 29 pairwise comparisons, and 15 designs. The results based on the NMA most frequent ranking probability scores (P) showed that tooth brushing (P fixed-0.94, P random-0.89), tooth brushing with povidone-iodine (P fixed-0.90, Random-0.88), and furacillin (P fixed-0.88, P random-0.84) were the best three interventions for preventing VAP. CHX of 0.2% concentration (P score fixed of 0.65, P score random of 0.65) ranked as the second-best intervention in the network along with Biotene (P score fixed of 0.59, P score random 0.54) and potassium permanganate (P score fixed of 0.53, P score random 0.54). The NMA demonstrated the superiority of toothbrushing or mechanical cleaning and when combined with a mouthwash, NMA showed that tooth brushing is superior to a mouthwash alone and toothbrushing with povidone iodine is superior to any other mouthwash. The results of this NMA are however based on a mix of low risk and high risk of bias studies and are not recommended for clinical treatment needs. High quality clinical trials are needed taking into account the outcome of this NMA to determine the best intervention taking into account patient-specific oral care needs. A further consideration, relates to potential barriers in the implementation of oral care protocols. An ethnographic investigation found that the complexity of performing oral care in ICU setting is underestimated and undervalued [65]. Technical barriers included oral crowding with tubes and aversive responses by patients such as biting. Contextual impediments to oral care included time constraints, lack of training, and limited opportunities for interprofessional collaboration.

**Conclusion**

The contribution of poor oral hygiene and oral bacteria to the development of pneumonia is well established. Within the context of critical care, however, controversy exists as to the best practice to achieve optimal oral health care and whether this is reflected in better overall outcomes for ICU patients. Further research is needed to standardise oral care practices and personalise individuals’ oral health needs within the ICU.
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