Journal of Disability and Oral Health (2011) **12/3** 114-120

A pilot audit of oral health in mechanically ventilated critically ill patients

T E Lloyd[1], P J Frost[2] and J S Rees[3]

[1]Locum Registrar in Maxillofacial Surgery and [2]Consultants in Critical Care Medicine, University Hospital of Wales: [3]Professor of Restorative Dentistry, Cardiff University Dental School, Cardiff, UK

Abstract

Aim and objectives: There is increasing awareness among Intensivists that poor oral hygiene may be associated with ventilator associated pneumonia in intubated patients. The aim of this pilot audit was to assess the oral health status of mechanically ventilated, critically ill patients. The adherence of intensive care nursing staff to local guidelines for the delivery of oral care was also assessed.

Design: Ten patients admitted to the intensive care unit (ICU) were examined during an eight-week period. Oral health on admission was assessed using DMFT scores, a plaque index, BPE and periodontal probing depth. Oral health was also assessed daily following oral care by nursing staff up to the point of extubation.

Results: All patients showed evidence of poor dental health. Half of the sample had untreated decay and seven patients had evidence of moderate to severe periodontal disease. Simple oral hygiene measures carried out by ICU nursing staff generally improved oral health.

Conclusions: This audit highlighted the poor oral health status of patients on admission to the ICU. It also highlighted the vital role of nursing staff in delivering daily routine oral hygiene measures.

Key words: *Oral health status, critical care, mechanically ventilation*

Introduction

Dental plaque is a dynamic biofilm, which may be defined clinically as bacterial deposits that cannot be easily rinsed away. This complex structure harbours many different microbial species with a 1mm^3 volume of plaque containing approximately 100 million bacteria (Thoden Van Velzen *et al*., 1984). In critically ill, mechanically ventilated patients, the mouth is propped open by an endotracheal tube exposing the oral cavity, thereby increasing susceptibility to desiccation. Oral intubation also reduces the self-cleansing action of saliva and impedes the provision of oral hygiene by nursing staff. Patients are also likely to have an impaired cough reflex and an inability to clear secretions that accumulate. Due to a combination of these problems, Intensivists are becoming more aware that dental plaque may play an important role in the aetiology of ventilator-associated pneumonia [VAP] (Fourrier *et al*., 1998; Paju and Scannapieco, 2007).

VAP is a type of hospital-acquired pneumonia that is defined as 'a parenchymal lung infection occurring in a person who is intubated and mechanically ventilated for more than 48 hours'. It is associated with increased morbidity, mortality, length of ICU stay, length of hospital stay and increased cost (Heyland *et al*., 1999; Bercault and Boulain, 2001; Warren *et al*., 2003). In view of these major adverse outcomes and the clinical costs associated with managing VAP, simple strategies that can prevent or reduce its prevalence are highly desirable.

Amongst the critical care literature, documentation of oral health status has focused principally on recording decayed, missing or filled teeth (DMFT) and plaque scoring. To date, the periodontal health of intubated patients has been ignored. This is important because periodontal disease is a bacterial disease caused predominantly by Gram negative anaerobic bacteria (Palmer and Floyd, 2003). Similarly, VAP is also caused by Gram negative anaerobes and this has prompted some Intensivists to suggest that the colonisation of endotracheal tubes by periodontal pathogens is a precursor to the development of VAP. It has been suggested that periodontal disease may drive systemic endothelial dysfunction and impair glucose control, both of which are important in managing critical illness (Tonetti *et al*., 2007; Skamagas *et al*., 2008). However, there is still much debate between clinicians about any causative link between periodontal disease and systemic disease.

The aims of this pilot audit were to:

- Assess the oral health (including periodontal disease) of patients on admission to the ICU
- Compare the level of oral health at point of admission to that at discharge

- Ensure that the local policy on the delivery of daily oral care was being adhered to by intensive care nursing staff.

Method

The patient population for this audit was emergency admissions into the ICU who were ventilated with an oral endotracheal tube. Elective ICU admissions were not included as these patients are usually extubated within days whilst, emergency admissions frequently remain intubated for a week or more. Only dentate adults were included in the audit. The audit was carried out over an eight-week period between October and December 2009. Approval was obtained from the local audit committee following formal submission of a written audit protocol. The gold standard for this audit was that 100% of the ICU nurses would adhere to the local policy for carrying out tooth cleaning.

Data collection

Once patients had been identified using the criteria outlined above, basic demographic information was collected. This included:

- Age
- Gender
- Diagnosis on admission
- Registration with a general dental practitioner and frequency of attendance; this information was obtained by questioning the patients' relatives.

Each patient underwent this oral health screen within 24-hours of admission undertaken by the same clinician (TL). This was performed using a pen torch and overhead lighting for illumination, a mirror, straight fissure probe, basic periodontal examination (BPE) probe and probing depths measured using a William's periodontal probe. Due to the presence of the endotracheal tube, it was only possible to assess the plaque present buccally and interproximally. Similarly, it was only possible to assess any periodontal pocketing present interproximally and buccally.

The oral health screen examined the following:-

- A formal dental charting from which a DMFT score was derived
- Assessment of plaque levels; due to respect for the patients' relatives it was decided not to disclose any plaque deposits. Therefore, only clinically obvious plaque was recorded using the criteria below:-

  0. No visible plaque
  1. Film of plaque present gingivally only visible by removal with a probe
  2. Moderate accumulation of plaque gingivally detectable by the naked eye covering up to one third of the buccal surface
  3. Obvious heavy plaque accumulation covering more than one third of the buccal surface with the interdental regions filled with debris

An overall plaque score was calculated for each patient by dividing the sum of the plaque scores by the total number of sites sampled.

- A Basic Periodontal Examination using the Community Periodontal Index for Treatment Need Index (Ainamo *et al*, 1982)
- A 3 point pocket chart (mesial, distal and mid-buccal sites); a Williams periodontal probe was walked around the buccal surface of each standing tooth from the distal to the mesial interproximal site. However, bleeding sites were not recorded as it was unknown if the patients' smoked, which would have readily masked any gingival bleeding tendency (Kinane and Chestnutt, 2000)
- Establishment of the oral hygiene measures carried out by intensive care nursing staff. The local protocol was for nursing staff to brush the patients' teeth twice daily using a toothbrush and toothpaste. Staff were asked as to the oral hygiene method used. These were recorded as 'none', 'toothbrush with toothpaste' or 'sponge/swab soaked in chlorhexidine'.

Oral health assessments were then repeated on a daily basis up to the point of extubation, death, or discharge from the ICU. The daily oral health screen included:

- Assessment of buccal plaque levels
- Oral hygiene measures carried out by staff.

Results

Due to the strict entry criteria only 10 patients were included in the audit. The sample consisted of seven males and three females with a mean age of 51.6 years and a range of 22-78 years. The diagnosis on admission and co-morbidity data are shown in *Table 1*. The results for this pilot audit are shown in *Tables 2-7*. On admission, the overall DMFT scores (*Table 2*) were relatively high. The mean DMFT was 20.5 with a range of 7 to 29.

Assessment of the periodontal condition (*Tables 3* and *4*) showed that only two out of the 10 patients assessed had a severe periodontal condition with a BPE score of 4. This was also reflected in the probing depths recorded with patients number 3 and 7 having pockets with probing depths in excess of 5.5mm.

The standard of oral hygiene on admission (*Table 5*) was

also relatively poor with the average percentage of tooth surfaces covered with plaque of 70.7% (range; 23-100%) and a mean plaque score of 1.34 (range; 0.35-2.82). Due to the efforts of nursing staff, oral cleanliness improved during mechanical ventilation for nine out of the 10 patients (*Table 5*). At the exit from the audit, the mean tooth surfaces covered with plaque had decreased to 40.1% (range; 17-81%) and the average plaque score was 0.59 (range; 0.28-1.78).

The results for the plaque scores and tooth surfaces covered by plaque were analysed using a two-tailed unpaired t-test. The values for tooth surfaces covered by plaque at the start and end of the audit was statistically significant at the $p<0.001$ level, while the plaque scores were statistically significantly different at the $p<0.05$ level. The methods used to carry out oral hygiene by nursing staff (*Table 6*) also varied widely. The majority of nurses cleaned the teeth using a toothbrush and toothpaste. There was also some obvious variation between the type of cleaning provided by the different nursing teams (notable in patients number 1 and 9). More worryingly, half of the patient sample received no oral hygiene on at least one day during their stay and none of the intensive care nurses were aware of the local guidelines for undertaking oral hygiene twice daily with a toothbrush and toothpaste.

Just over half of this small sample was registered with a GDP (*Table 7*). However, comparison of the DMFT data and current registration showed no obvious trend (*Tables 2* and *7*).

Table 1: Admitting diagnosis, co-morbidity and occupation of the patients included in the study

Patient	**Diagnosis**	**Co-morbidity**
1	Respiratory failure, Pneumonia	Testicular cancer, liver metasteses
2	Cardiac arrest	Nil
3	Respiratory failure, Pneumonia, Septicaemia	Bladder cancer
4	Cardiac arrest, cerebellar infarct	Hydrocephalus, Hypertension, Diverticulitis
5	Paracetamol overdose, liver failure, renal failure, respiratory failure, hypoxic brain damage	Depression
6	Head injury, skull fracture, subdural haematoma, brain contusions	Hypertension
7	Bleeding oesophageal varices, hepatic encephalopathy	Alcoholic, liver cirrhosis
8	Subarachnoid haemorrhage	Depression
9	Fracture of skull, cervical spine, thoracic spine, spinal cord injury, cerebral infarct	Renal dysgenesis
10	Pre-eclampsia, respiratory failure	Hypertension, obesity, asthma

Table 2: DMFT scores

Patient	**No. of teeth present**	**Sound untreated**	**Decayed**	**Missing**	**Filled**	**DMFT score**
1	32	4	28	0	0	28
2	21	3	0	11	18	29
3	18	11	0	14	7	21
4	26	21	2	6	3	11
5	27	15	0	5	12	17
6	10	4	0	22	6	28
7	18	9	5	14	4	23
8	13	4	3	19	6	28
9	28	25	2	4	1	7
10	28	19	0	4	9	13
Mean	**22.1**	**11.5**	**4**	**9.9**	**6.6**	**20.5**

Table 3: BPE scores

Patient	BPE 1	BPE 2-3	BPE 4
1		√	
2		√	
3			√
4		√	
5	√		
6		√	
7			√
8		√	
9	√		
10	√		
Total	**3**	**5**	**2**

Table 4: Highest probing depth recorded

Patient	≤ 3.5 mm	3.5-5.5 mm	5.5-8.5 mm
1		√	
2		√	
3			√
4		√	
5	√		
6	√		
7			√
8		√	
9	√		
10	√		
Total	**4**	**4**	**2**

Table 5: Plaque scores on admission to ICU and at end of study

Patient No.	On admission		Just prior to discharge	
	Plaque score	% surfaces covered by plaque	Plaque score	% surfaces covered by plaque
1	2.82	100	0.17	17
2	1.02	65	0.46	38
3	1.78	81	1.78	81
4	1.04	76	0.96	35
5	0.35	23	0.28	27
6	1.10	70	0.66	63
7	2.30	100	0.33	31
8	1.92	100	0.31	28
9	0.61	54	0.39	36
10	0.42	38	0.54	45
Mean	**1.34**	**70.7**	**0.59**	**40.1**

Table 6: Methods of oral care used in ICU

Patient	Tb + Tp	CHX	Nil	Total
1	7	2	1	10
2	2	0	0	2
3	0	1	0	1
4	4	0	0	4
5	2	1	0	3
6	2	0	0	2
7	2	1	1	4
8	5	2	1	8
9	7	1	1	9
10	1	2	1	4
Total	32	10	5	47

Tb: Tooth brushing
Tp: Toothpaste
CHX: Chlorhexidine

Table7: Dental registration and attendance

	Registration		Attendance	
Patient	**Yes**	**No**	**> 6 months**	**< 6 months**
1		√	√	
2	√		√	
3		√	√	
4		√	√	
5	√			√
6	√			√
7		√	√	
8	√		√	
9	√		√	
10	√			√
Total	6	4	7	3

Discussion

The sample of patients admitted to the ICU had considerable evidence of untreated disease; the patients had a mean of 22.1 teeth of which 11.5 were sound and untreated, 6.6 sound but restored, 4.0 decayed or unsound and 9.9 were missing. The average DMFT score was therefore high at 20.5. It is also worth noting that the individual scores in our sample are also likely to be an underestimate of true disease levels because the conditions under which the examinations were being performed were not clinically ideal. Within the ICU setting it was impossible to dry the teeth completely due to the lack of a dental compressed air supply and the light intensity from the pen torch was inadequate. Therefore, small carious lesions, particularly lingually or palatally, may have been missed.

Periodontal disease continues to be a major concern for dentists and patients throughout the UK and prevalence estimates suggest values for severe disease of around 20% worldwide (Palmer and Floyd, 2003). Five out of 10 of the patients in this audit had a code of 2 or 3 suggesting that home care alone would not be sufficient to improve their periodontal status and some element of intervention would be required by a dental professional. Two out of 10 of the patients had a code 4, which implies significant periodontal disease, which concurs with current prevalence estimates for severe disease. These findings also highlight that seven out of 10 of the patients admitted to the ICU would require a professional intervention to restore them to an acceptable level of periodontal health. This observation is particularly significant because the extent of periodontal disease in critically ill patients has not been previously documented. Furthermore, both periodontal disease and ventilator associated pneumonia are predominantly Gram negative based bacterial infections. This suggests a pos-

sible causal link between the two diseases (Terezakis *et al*, 2011), however a formal prospective longitudinal study with a much larger sample size would be necessary to confirm this suggested link.

Plaque scores on admission were also high and all of the audited patients had plaque present on at least one tooth surface. The average percentage of tooth surfaces covered by plaque on admission was 71%. However, these figures must be interpreted with a certain amount of caution as many of the patients had co-morbidities such as cancer or depression, which could also have a major influence on oral hygiene and gingival/periodontal condition (Genco *et al*, 1999; Wilson and Rees, 2005).

The current protocol within the intensive care unit is for cleaning the oral cavity twice daily cleaning with a toothbrush and toothpaste. However, the actual methods used for mouth cleaning by intensive care staff varied more widely, with some staff using swabs dipped in chlorhexidine mouthwash and on occasions, oral care was forgotten. Nursing staff were asked between the hours of 2pm and 5pm about the method used for that morning's oral cleaning. Assuming that a normal regimen would be for twice daily cleaning, by 2pm each patient should have had the opportunity for one morning cleaning episode. *Table 5* shows the breakdown of cleaning methods utilised per patient. Overall, there were 47 ICU days included in the audit. The data confirm that a toothbrush with toothpaste was used 68% of the time, chlorhexidine solution was used 21% of the time and no cleaning was carried out 11% of the time. Again, these data also need to be interpreted with caution as the nursing staff were aware that an audit about tooth cleaning was taking place and the audit is therefore likely to have acted as a positive motivational factor for the nurses.

Oral health and cleanliness is often given a low priority by nursing staff because it is frequently viewed as a comfort measure rather than a therapeutic intervention to remove potential pathogens (Furr *et al*., 2004). Many nurses are also discouraged from cleaning the mouth because the endotracheal tube makes performing this task difficult and there is a fear of dislodging the tube and precipitating cardiac arrest. Even when procedures are in place, mouth care is often performed poorly or inconsistently (Grap *et al*., 2003). It is therefore possible that the principal reason for the nursing staff to clean with swabs dipped in chlorhexidine is that there is less likelihood of disturbing the endotracheal tube compared to more vigorous tooth brushing.

Local guidance within the ICU is for oral hygiene to be undertaken twice daily using a toothbrush, however unfortunately, none of the intensive care nursing staff were aware of the existence of this document, which highlights the need for additional training.

In spite of ignorance of local guidelines, most teeth cleaning was achieved with tooth brushing and reduced the number of surfaces covered with plaque fell from 71% to 40% (*Tables 5* and *6*). Statistical analysis of these data using a two-tailed unpaired t test found a statistically significant difference with a p value of <0.001. Table 7 shows the number of patients registered with a dentist and the last time they visited the dentist according to the patients' relatives. Half of the patients in this audit were registered with a dentist, but seven of the 10 patients had not visited the dentist in the previous six months. The proportion of dentate adults in the UK who report attending for regular dental check-ups in 2009 was 61% (Steele and O'Sullivan, 2011) which is broadly similar to the patients involved in this audit.

It proved challenging, although it was feasible, to undertake an audit of oral health, including periodontal disease, in mechanically ventilated critically ill patients. The presence of the endotracheal tube undoubtedly impeded the delivery of oral hygiene by nursing staff and also made clinical examination demanding, particularly the lingual and palatal tooth surfaces. This audit also found a high proportion of patients had untreated caries and periodontal disease, requiring intervention from a dental professional to restore them to oral health. Patients' oral cleanliness was also poor at admission, with raised plaque scores and a large number of tooth surfaces covered with plaque. At the end point of the audit, however, oral hygiene had improved even though healthcare staff were not always adhering to local guidelines for the delivery of oral care. As this audit was carried out on a small sample size, these findings need further investigation using a larger sample and to be reaudited.

Conclusion

This audit demonstrated the positive benefit that nursing staff have in maintaining the oral health of ventilated patients. These efforts need to be optimised both nationally and internationally in order to prevent adverse clinical outcomes such as VAP.

Acknowledgement

We would like to express our sincere thanks and gratitude to all of the ICU nurses who took part in this audit.

References

Ainamo J, Barmes D, Beagrie G, Cutress T, Martin J, Sardo-Infirri J. Development of the World Health Organization (WHO) Community Periodontal Index of Treatment Needs (CPITN). *Int Dent J* 1982; **32:** 281-291.

Bercault N, Boulain T. Mortality rate attributable to ventilator-associated nosocomial pneumonia in an adult intensive care unit: a prospective case-control study. *Crit Care Med* 2001; **29:** 2303-2309.

Fourrier F, Duvivier B, Boutigny H, Roussel-Delvallez M, Chopin C. Colonisation of dental plaque: a source of nosocomial infections in intensive care unit patients. *Crit Care Med* 1998; **26:** 301-308.

Furr LA, Binkley CJ, McCurren C, Carrico R. Factors affecting quality of oral care in intensive care units. *J Adv Nurs* 2004; **48:** 454-462.

Grap MJ, Munro CL, Ashtiani B, Bryant S. Oral care interventions in critical care: frequency and documentation. *Am J Crit Care* 2003; **12:** 113-118.
Genco RJ, Ho AW, Grossi SG, Dunford RG, Tedesco LA. Relationship of stress, distress and inadequate coping behavious to periodontal disease. *J Periodontol* 1999; **70:** 711-723.
Heyland DK, Cook DJ, Griffith L, Keenan SP, Brun-Buisson C. The attributable morbidity and mortality of ventilator-associated pneumonia in the critically ill patient. The Canadian Critical Trials Group. *Am J Respir Crit Care Med* 1999; **159:** 1249-1256.
Kinane DF, Chestnutt IG. Smoking and periodontal disease. Crit Rev *Oral Biol Med* 2000; **11:** 356-365.
Paju S, Scannapieco FA. Oral biofilms, periodontitis, and pulmonary infections. *Oral Dis* 2007; **13:** 508-512.
Palmer RM, Floyd PD. *A clinical guide to periodontology*. Second Edition. London: British Dental Journal Books, 2003.
Skamagas M, Breen TL, LeRoith D. Update on diabetes mellitus: prevention, treatment, and association with oral diseases. *Oral Dis* 2008; **14:**105-114.
Steele J, O'Sullivan I. Executive Summary: Adult Dental Health Survey 2009. NHS Information Centre for Health and Social Care, 2011. (www.ic.nhs.uk/statistics-and-data-collections/primary-care/dentistry/adult-dental-health-survey-2009--summary-report-and-thematic-series Accessed 10.6.11)
Terezakis E, Needleman I, Kumar N, Moles D, Aqudo E. The impact of hospitalization on oral health: a systematic review. *J Clin Periodontol* 2011; **38:** 628-636.
Thoden Van Velzen SK, Abraham-Inpijn L, Moorer WR. Plaque and systemic disease: a reappraisal of the focal infection concept. *J Clin Periodontol* 1984; **11:** 209-220.
Tonetti MS, D'Aiuto F, Nibali L, Donald A, Storry C, Parkar M, Suvan J, Hingorani AD, Vallance P, Deanfield J. Treatment of periodontitis and endothelial function. *N Eng J Med* 2007; **356:** 911-920.
Warren DK, Shukla SJ, Olsen MA, Kollef MH, Hollenbeak CS, Cox MJ, Cohen MM, Fraser VJ. Outcome and attributable cost of ventilator-associated pneumonia among intensive care unit patients in a suburban medical centre. *Crit Care Med* 2003; **31:** 1312-1317.
Wilson J, Rees JS. The dental treatment needs and oral side effects of patients undergoing cancer chemotherapy. *Eur J Prosthodont Rest Dent* 2005; **13:** 129-134.

Address for correspondence:
Prof. Jeremy Rees,
Cardiff University Dental School,
Heath Park,
Cardiff
CF14 4XY
Email: reesjs1@cardiff.ac.uk