Morbidity and Cost of Odontogenic Infections

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Sponsorships or competing interests that may be relevant to content are disclosed at the end of this article.

Abstract

Objective. Cost analysis of deep neck space infections from odontogenic origin and review of the morbidity of potentially preventable complications.

Study Design. Case series with chart review.

Setting. Level 1 trauma center and academic safety net hospital.

Subjects and Methods. Patients treated for deep neck space infections due to an odontogenic source between 2001 and 2010 were reviewed. Two hundred patients were included in the study. Ninety-eight patients required inpatient admission. Twelve percent of these patients had difficult airways, and 16% had at least 1 day in the intensive care unit. Cost data were available only for the later 3.5 years of the study period.

Results. The overall cost of treatment for these 71 individuals exceeded $1.1 million.

Conclusion. The cost of treatment for odontogenic infections is staggering. Based on assumptions of the percentage of infections in the metropolitan area captured at Hennepin County Medical Center, extrapolation to the total national cost of inpatient care approaches $200 million annually. This study highlights the importance of access to medical and preventative dental care for the general population and demonstrates the cost benefit that could be achieved through prevention of disease and, therefore, avoidance of its complications.

Keywords
dental infections, health care costs, deep neck infections

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Odontogenic refers to a process arising from the dental system. Descending inflammation is caused by bacterial growth in the gingival recesses in the setting of marginal periodontitis. Soft-tissue infections from odontogenic origin may spread along fascial planes, resulting in deep neck space infections.1 The origin of deep neck abscesses arising from an odontogenic origin is typically the molar teeth of the mandible. Overall, the incidence of deep neck space infections has decreased since the widespread use of antibiotics.2 However, odontogenic origin as the source for deep neck space infections has increased.

Treatment of deep neck space infections typically requires inpatient admission to the hospital, administration of intravenous antibiotics, and surgical debridement.5 Patients with additional comorbidities including HIV and diabetes are at a greater risk for possible complications. Complications resulting from deep neck space infections include mediastinitis, internal jugular vein thrombosis, airway compromise, necrotizing fasciitis, and sepsis.1 These complications lead to prolonged hospital stays, protracted recovery, increased risk of mortality, and exponential increase in the cost of treatment. Improved access to dental care may decrease the incidence of these detrimental outcomes.

This study represents a 9-year experience treating dental infections and their associated complications. Objectives of the study primarily focused on identifying predisposing characteristics, reviewing the extent of disease and therapeutic interventions, and evaluating the overall cost of treatment of odontogenic infections.

Methods

Cases were selected from medical records of patients diagnosed between February 2001 and February 2010 with dental abscesses or deep neck space infections at Hennepin County Medical Center (HCMC), Minneapolis, Minnesota, a large, urban safety net hospital. The study was conducted with approval from the HCMC Human Subjects Research Committee. Charts were selected based on codes from the ninth revision of the International Statistical Classification
of Diseases (ICD-9). The ICD-9 codes used to identify patients were 682.0 (cellulitis and abscess of the face), 682.1 (cellulitis and abscess of the neck), 728.86 (progressive necrotizing infections), 519.2 (mediastinitis), 729.4 (fasciitis unspecified), and 528.3 (cellulitis mouth floor).

A total of 1177 patients were identified on the initial review. Patients with infections caused by non-odontogenic origin were excluded. All patients with presenting complaints of upper respiratory symptoms or localized skin infections were also excluded. Patients with active periodontal disease or patients who had recently undergone dental extraction were included. The final study population consisted of 200 cases. These patients’ medical records were reviewed in detail. Information studied included patient age and gender, location of infection, cause, comorbidities, need for hospitalization, intensive care unit management, treatment, and complications. Radiographic imaging, operative reports, and microbiology reports were used to characterize the patient’s infection. Insurance status was determined by the type of medical insurance and coverage by dental insurance.

The information was entered into a database, and numeric codes were assigned to different groups. Analysis by various subgroups was completed. All case medical record numbers were submitted to the HCMC office of Performance Measurement and Improvement, and all cost data that were available were included. The distribution of cases is shown in Table 1. Statistical analysis was performed using Microsoft Excel and Graphpad to perform t-test, regression analysis, and Fisher exact test. A P value less than .05 was considered significant.

Results

Demographics

There were 112 male patients and 88 female patients, with most patients between the ages of 19 and 50 years (71%). The mean age was 48 ± 13 years (range, 4-83 years) for male patients and 36 ± 15 years (range, 4-95 years) for female patients.

Comorbidities

Multiple comorbidities were identified in the population studied. The most common comorbidity encountered was substance abuse, which was identified in 59 patients (30%). Substance abuse in this study was defined as documented active tobacco use, alcohol abuse, or illicit drug use. The next most common comorbidity encountered was diabetes, affecting 27 patients (14%). Twenty-one patients (11%) had documented medical problems that could adversely affect the immune system. These diseases included HIV, AIDS, autoimmune diseases, chronic kidney disease, and sickle cell anemia. Five (2.5%) patients suffered from significant mental health issues. Figure 1 summarizes patient comorbidities.

Radiology

Ninety patients (45%) had imaging studies. Fifty-four (27%) patients underwent computed tomography (CT) scans. Eighteen patients (9%) had both CT and an orthopantomogram (OPG). Eleven patients (6%) had only an OPG. Three patients underwent ultrasound imaging, and in 4 patients, a plain roentgenogram of the head or lateral neck was obtained. The buccal and submandibular spaces were most commonly involved (Figure 2). Dental caries and other...
dental pathology were identified primarily via imaging, noting evidence of periapical lucencies or cortical erosion.

Microbiology
Of the total 200 patients, only 86 underwent culture. *Streptococcus* was the most common bacteria isolated, appearing in 35 culture results. *Streptococcus viridans* was the most common species isolated, followed by *α*-hemolytic and *β*-hemolytic *Streptococcus*. Ten other *Streptococcus* species were isolated. The next most common culture results were anaerobic bacteria. Of the 21 total culture results positive for anaerobes, mixed anaerobes were the most common results, with no specific species isolated. This occurred in 11 culture results. The most common anaerobic bacteria identified were peptostreptococcus and prevotella. In 7 culture results, *Staphylococcus aureus* was isolated. Methicillin-resistant *S. aureus* (MRSA) was identified in 5 patients. Yeast was identified in only 2 cultures. *Candida* and *Saccharomyces* were isolated. There was no growth of organisms in 39 (45%) cultures taken.

Treatment
Of the 200 patients included in the study, 68 patients were evaluated in the emergency department by emergency department staff and discharged. Thirty-four patients were evaluated by a specialist (oral surgery, dentistry, or otolaryngology) but were not admitted to the hospital. The remaining 98 patients required inpatient admission. Of those admitted to the hospital, about 75% were evaluated by oral surgery or dentistry, about 10% by pediatrics or emergency staff, and 15% by otolaryngology. The average length of inpatient admission was 4.2 days, with a range of 1 to 37 days. Sixteen patients required admission to the intensive care unit. A total of 63 incisions and drainage procedures were performed, not requiring intubation. Incision and drainage with immediate dental extraction were performed in 22 patients.

Fifty-one patients underwent surgical drainage of abscess. Twenty-three of these patients underwent immediate dental extraction. Nine patients underwent awake, fiberoptic intubation, and 3 patients underwent awake tracheostomy because of concern of airway compromise.

Patients developed deep neck spaces abscess in multiple locations as a result of their dental infection. The submandibular space was the most commonly affected space, documented in 48 (24%) patients. The sublingual space was affected in 24 patients. In 20 patients, the parapharyngeal space was affected. Three patients had massesteric abscesses, and in 2 patients, the retropharyngeal space was involved. Thirty-six (18%) patients developed abscesses that extended into more than 1 deep fascial space.

Empiric antibiotic therapy was initiated in all patients on diagnosis of dental infection. The most frequently used antibiotic was oral or intravenous clindamycin (85 patients). In patients who had cultures obtained at time of abscess drainage, antibiotic therapy was subsequently tailored from culture and sensitivity results. Combination antibiotic therapy was implemented in 39 patients.

Outcome and Complications
One mortality resulted from an extensive deep space neck infection in a patient with multiple premorbid comorbidities. Two patients developed mediastinitis, and they were treated with antibiotics and supportive care. Two patients were also diagnosed with necrotizing fasciitis, treated with surgical debridement.

Cost
Patient costs were obtained for patients treated with inpatient admission. Seventy-one of the 98 patients had collectable financial data. The expected cost based on diagnosis-related group was $1,132,627, or $15,952 per patient. Two patients had costs greater than $150,000. Sixteen had costs greater than $10,000. When annualized for the later 3.5 years of the study, when financial data were accessible, the expected cost of treatment at our institution for odontogenic infections exceeds $323,000 per year.

Of the 71 patients, only 12 (16.9%) had dental insurance. In those 12 patients, the mean cost of treatment was $8173 ± $2219. In the 59 patients without insurance, the mean cost of treatment was $17,535 ± $31,539 (not significant by *t* test, *P* = .31). Patients with dental insurance tended to have lower costs for their treatment, whether they had government (medical assistance, Medicare) or commercial health insurance. Costs by these subgroups are shown in Table 2.

### Table 2. Table of subgroups of patients with and without dental insurance by health insurance status.

<table>
<thead>
<tr>
<th>Health Insurance Type</th>
<th>Dental Insurance</th>
<th>Government, $</th>
<th>n</th>
<th>Commercial, $</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
<td>8199</td>
<td>11</td>
<td>7887</td>
<td>13</td>
<td></td>
</tr>
<tr>
<td>No</td>
<td>19,093</td>
<td>41</td>
<td>15,431</td>
<td>13</td>
<td></td>
</tr>
</tbody>
</table>

Not included in Table 2 are 5 patients who were self-pay or used a discounted cash program. One would expect that these patients did not seek routine dental care, but it is possible they opted to not carry insurance but did pay for care. Nonetheless, the average cost of those patients was $10,228 (range, $7683-$19,729), which tends to be lower...
than the group mean and midrange between those with and without dental insurance. The Medicare population was the most expensive group at $37,589 (range, $6459–$175,147) in 6 patients. The average age was 52 years, with all but 1 of the patients younger than 65 years. Therefore, this Medicare group likely had extensive comorbidities and chronic disability.

A subgroup of patients who required the most expensive care was examined with the hope of predicting which patients may require the most preventative care. Sixteen patients had costs greater than $10,000. Of those patients, there were 13 comorbidities in 9 patients. The most common was diabetes or prediabetes in 7 patients. The single patient with the greatest cost was diabetic with end-stage renal disease. There was a high correlation between total cost and length of stay in this group ($R^2 = 0.73$), which was greater than the entire group of 71 patients ($R^2 = 0.53$).

**Discussion**

Prior to the advent of antibiotics, deep neck space infections most commonly originated from the tonsil or pharynx. Today, the most common causes of adult deep neck infections include poor dental hygiene, peritonsillar abscesses, foreign bodies, or intravenous drug abuse. Recent studies at our institution show odontogenic infections as the cause of deep neck infections in nearly 50% of cases. Some studies have shown odontogenic cervical infections to have a similar frequency of multispace infection compared with single-space infections. In this study, 18% of patients developed a multispace infection.

Substance abuse was the most common comorbidity (30%) in our study. Patients who abuse alcohol and tobacco have been shown to adopt poor dental hygiene habits, which can lead to odontogenic infections. The next most common comorbidity identified in our study was diabetes (14%). Diabetes has been frequently shown to be the most common systemic disease associated with deep neck space infections. Hyperglycemia demonstrated in uncontrolled diabetes has been shown to impair both neutrophil function and the complement pathway. Also, 11% of our patients suffered from medical conditions affecting the immune system. Immune dysfunction increases a patient’s risk for complications. For patients with immunosuppression, empiric antibiotics should be expanded to cover all potential pathogens these patients are at risk of contracting.

Most deep neck space infections are polymicrobial. Common aerobic bacteria isolated include *S. viridans*, *Klebsiella pneumonia*, and *S. aureus*. In our study, the most frequently isolated aerobic bacteria was *S. viridans*. *Klebsiella* is frequently found in diabetic patients. Interestingly, none of our patients with diabetes had a positive *Klebsiella* culture. Deep neck space infections caused by MRSA is also increasing. In our study, MRSA affected 5 patients. Common anaerobic bacteria include *Peptostreptococcus*, *Bacteroides*, *Prevotella*, *Fusobacterium*, and *Eikenella* species. Mixed anaerobes were the most common result from our positive anaerobic cultures, followed by *Peptostreptococcus* and *Prevotella*.

Antibiotic therapy should target the most commonly involved aerobic and anaerobic bacteria. Anaerobic bacteria are increasingly producing β-lactamase, therefore making them penicillin resistant. The recommended optimal empiric coverage includes either a penicillin antibiotic in combination with a β-lactamase–resistant antibiotic or a β-lactamase antibiotic in combination with an antibiotic effective against anaerobes. Vancomycin should be considered in intravenous drug abusers, patients at high risk for MRSA infection, and immunocompromised patients. Gentamicin should be considered in diabetics to cover *K pneumonia*. Antibiotic therapy is always tailored following culture results.

Regardless of implementation of appropriate antimicrobial coverage, the mainstay of treatment for deep neck space infections is surgical drainage. Indications include spread of infection, presence of significant comorbidities, absence of clinical improvement, sepsis, and airway compromise. Also of paramount importance is evaluation of the stability of the patient’s airway. The most common cause of death in patients with complicated deep neck space infections is loss of airway. In patients with severe trismus, fiber-optic nasotracheal intubation can be performed. However, severe airway obstruction and significant soft-tissue edema could prevent successful endotracheal intubation, necessitating tracheostomy. Twelve of our patients required urgent intervention to stabilize the airway. Nine patients underwent successful fiber-optic intubation, while 3 patients required urgent tracheostomy. Complications of deep neck space infections include mediastinitis, Lemierre syndrome, and necrotizing fasciitis.

Long-term complications of necrotizing fasciitis and mediastinitis can be considerable and probably involve permanent scarring, dysphagia, tracheal stenosis, and dental abnormalities. We did not complete long-term follow-up on this cohort.

The cost of treatment of deep neck space infections is staggering. Our study demonstrated that the annual cost of treatment at our single institution exceeded $323,000. This does not include outpatient care or ongoing cost and quality of life after treatment for these potentially severe and debilitating infections. Missed days of work, short-term medical leave, and long-term disability add thousands of dollars to each case. As noted, this population is working age, so work issues are important to consider. The average length of hospital stay was 4.2 days, and one can estimate that there was easily 2 weeks of recovery, as well as scar revision surgery and permanent disability due to surgical scarring and resection in cases of necrotizing fasciitis in the tissue.

While HCMC may care for a large proportion of patients without health insurance, many patients who lack dental coverage do have health insurance, as is true of our cohort. Thus, many patients were probably seen at local medical centers or other safety net hospitals in the area. Therefore, it is not likely that HCMC sees all the medical complications of odontogenic infections in the metropolitan area. It is
assumed that, with referrals, HCMC sees 20% of all odontogenic infections (twice the reported HCMC surgical volume of 10% of all metro area surgeries). The cost is more $1,600,000 over the 2.6 million population, which is 62 cents per person. This translates into almost $200 million annually for the United States for inpatient treatment of the medical complications of odontogenic infections (Figure 3). This cost is borne by insurance companies and ultimately is reflected in the insurance premiums in those patients who have insurance and by the hospitals or communities in those patients who do not have medical insurance.

Coverage of an annual dental examination would seem to be a cost-effective strategy for those payers. Many patients had dental care just prior to or during admission for the deep neck infection, but ongoing dental care is probably more likely to result in less morbidity if infection does develop. Indeed, only 1 patient in this cohort of 71 patients had commercial insurance and dental insurance. Using estimates of patients with dental insurance and without dental insurance and extrapolating that to the US population, $100,000,000 could be saved nationally, or about 30 cents per person. (This is less than the total costs because all people with dental insurance do not necessarily seek dental care.) The average cost of a periodic dental examination is about $40 and could be less for discount services (brighter.com), so dental care for all will not be paid by cost savings. Considering that patients with comorbidities tended to have the most expensive treatment, limiting free dental examinations to patients with diabetes may pay for itself. For example, screening the highest risk 1% will result in savings of $30 per year that may pay for routine dental care. As the etiology of deep neck space infections is increasingly odontogenic in origin, many of these infections can be prevented by increasing access to preventative dental care.

Conclusion
The relative incidence of deep neck space infections arising from odontogenic infections is increasing. At our single institution, the expected cost of treatment exceeded $1.1 million in a 3.5-year period. Projected annual inpatient cost is almost $200 million nationally. Additional costs include outpatient care and long-term medical care and disability. This highlights the importance of routine access to medical and preventive dental care for the general population.

Author Contributions
Lindsay Eisler, study concept and design, acquisition of data, analysis and interpretation of data, drafting of manuscript, critical revision of the manuscript for important intellectual content, statistical analysis, administrative, technical, and material support; Kaitlin Wearda, acquisition of data; Kelsey Romatoski, acquisition of data; Rick M. Odland, study concept and design, analysis and interpretation of data, critical revision of the manuscript for important intellectual content, study supervisor.

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References