Cost analysis of dental services needed before hematopoietic cell transplantation

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Objective. Streptococcal bacteremia occurs during hematopoietic cell transplantation (HCT), and treatment of active oral disease may reduce this risk. The objective of this study was to determine the type, number, and costs of pre-transplantation dental procedures in this population.

Study Design. Data were collected retrospectively from the records of patients who were to undergo HCT. The type, number, and costs of dental procedures were determined based on median charges of MassHealth (the Medicaid program in Massachusetts) and also on the median “usual and customary” fees charged by dentists in Massachusetts.

Results. A total of 405 patients were evaluated. There were 243 men (60%) and 162 women, with a median age of 53 years. The median and average costs (in US dollars) of dental treatment before HCT were $275 and $384, respectively, for patients covered by MassHealth and $368 and $522, respectively, for those with private insurance, adjusted to 2012 levels.

Conclusions. Dental evaluation before HCT is an economical way for patients to minimize the risk of localized infection and possibly reduce the risk of bacteremia that may prolong the length of hospitalization. (Oral Surg Oral Med Oral Pathol Oral Radiol 2014;117:59-66)

Hematopoietic cell transplantation (HCT) is often used to treat hematologic malignancies including lymphoma, leukemia, multiple myeloma, aplastic anemia, and other bone marrow failure syndromes.1,2 Myeloablative regimens lead to a predictable period of profound neutropenia and frequently result in the loss of mucosal epithelial integrity (ulcerative mucositis), which can permit the entry of organisms from the digestive tract into the blood, resulting in bacteremia.3 In the presence of profound neutropenia, patients become at risk for neutropenic fevers and sepsis.

The oral cavity is host to many types of bacteria, including alpha-hemolytic streptococcal species, particularly viridans streptococci. These organisms are associated with bacteremia and sepsis in patients who undergo induction chemotherapy and myeloablative conditioning in preparation for HCT.4-10 Before 1990, most bloodstream infections in neutropenic patients were caused by gram-negative rods such as Escherichia coli, Pseudomonas aeruginosa, and Klebsiella species. However, since 1990 there has been a shift to gram-positive bacteria such as viridans streptococci.11,12 Approximately 40% of reported cases of sepsis were attributed to gram-positive cocci, whereas 35% to 62% were a result of gram-negative rods.13,14 One of the most important factors contributing to this shift is the use of fluoroquinolones for the prophylaxis of gram-negative bacterial infections among patients undergoing HCT.14,15 The viridans streptococci are typically resistant to these antibiotics, and their use promotes colonization and likely subsequent bacteremia and sepsis.16 The presence of ulcerative mucositis has been shown to increase the frequency of viridans streptococcal bacteremia 3-fold and the length of hospital stay by 6 days.17

Statement of Clinical Relevance

Septicemia results in significant morbidity for patients undergoing hematopoietic cell transplantation. A dental evaluation is an economical way to prevent septicemia from an oral source. This study shows that for <$1000, dental needs can be met in >88% of patients.
Viridans streptococcal bacteremia in neutropenic patients not only leads to increased use of antibiotics but also may result in septic shock and respiratory distress syndrome and is associated with a mortality rate of 11% to 26%. Even with empiric antibacterial treatment, the mortality rate among patients with complicated streptococcal bacteremia is high. Acute dental abscesses are polymicrobial, and a combination of facultative anaerobes such as viridans streptococci and Streptococcus anginosus as well as strict anaerobes are often identified. The US National Institutes of Health consensus statement on oral complications of cancer therapy recognized that “dental foci” are possible sources of systemic infections that need to be “eliminated or ameliorated” by extraction or endodontic therapy. To this end, all patients from the Dana-Farber Cancer Institute scheduled for HCT undergo a formal off-site dental evaluation by their community dentist. This evaluation consists of a full-mouth series of intraoral radiographs and a comprehensive clinical evaluation. An attending oral medicine specialist at Brigham and Women’s Hospital reviews and confirms the findings and treatment plan, and treatment is then performed by the patient’s community or primary dentist.

Medical insurance carriers may reimburse dentists for the dental evaluation of patients who need HCT; however, such carriers usually do not pay for the resulting prescribed dental treatment, because they expect the dental insurance carriers to do so. Furthermore, a survey of patients from 25 states performed in 1997 reported that 44.3% of responders did not have dental insurance. Untreated dental disease puts patients at risk for infection during their hospitalization for HCT, with attendant morbidity and increased economic burden. The cost of restorative treatment was calculated assuming simple extraction based on the number of teeth to be removed, unless the patient’s primary dental provider specified surgical extraction. To estimate the threshold of risk of streptococcal bacteremia at which dental screening and treatment are cost neutral, we computed the average cost per patient, with and without dental screening and treatment, for risks of bacteremia between 0% and 25%. We assumed risk reductions with dental evaluation and therapy between 25% and 90%. Based on the previously published literature, we assumed that patients who developed streptococcal bacteremia would use 3 additional days of hospitalization at a total cost of $14,399. The cost of hospitalization was obtained by adjusting to 2012 US dollars using the health care component of the Consumer Price Index.

PATTERNS AND METHODS
Data for this retrospective study were obtained from the dental records of patients mailed in by dentists and evaluated at the Division of Oral Medicine and Dentistry, Brigham and Women’s Hospital, Boston, MA, USA, from January 2005 to June 2007. Only records that had full radiographic and clinical evaluations were included in this study.

Data collected included age, gender, medical diagnosis, number of carious lesions, number of defective restorations, presence of removable prosthesis, previous endodontic therapy, teeth requiring endodontic therapy, probing depths and periodontal health, degree of plaque and calculus accumulation, and number of extractions required. Only the type and number of dental procedures required to treat caries, periodontal disease, and apical disease from pulp necrosis, as well as to extract nonrestorable teeth (from extensive caries or severe periodontal disease), were used in the analysis. The study was exempted from institutional review board approval, owing to its retrospective nature.

Analysis
Each patient’s dental health care costs were estimated from the payer’s perspective by multiplying the number and type of recommended procedures by the average charges for these services. Two estimates were calculated for each patient. A low estimate of dental costs was calculated using average MassHealth dental reimbursement in 2012, and a high estimate of dental costs was calculated using the median dental reimbursement in 2012 provided by Delta Dental of Massachusetts, a private dental insurance company serving approximately 30% of the population of Massachusetts. The term cost as used throughout this study represents a cost to the payer and not the fee charged by the dentist.

The cost of restorative treatment was calculated by surfaces filled with dental amalgam, unless composite resin was specified. Extraction costs were calculated assuming simple extraction based on the number of teeth to be removed, unless the patient’s primary dental provider specified surgical extraction. To estimate the threshold of risk of streptococcal bacteremia at which dental screening and treatment are cost neutral, we computed the average cost per patient, with and without dental screening and treatment, for risks of bacteremia between 0% and 25%. We assumed risk reductions with dental evaluation and therapy between 25% and 90%. Based on the previously published literature, we assumed that patients who developed streptococcal bacteremia would use 3 additional days of hospitalization at a total cost of $14,399. The cost of hospitalization was obtained by adjusting to 2012 US dollars using the health care component of the Consumer Price Index.

RESULTS
A total of 423 charts were reviewed, and 18 charts were excluded because of incomplete diagnostic criteria such as radiographs and documentation of findings. Of the 423 charts, 405 (95.7%) were complete and evaluable. There were 243 men (60%) and 162 women with a median age of 53 years (range, 18-72). Additional demographic data are presented in Table I.

Our protocol requires that patients receive a dental scaling and prophylaxis within the 3 months preceding
Table 1. Demographics and characteristics of the cohort (n = 405)

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>No. (%)</th>
<th>Median age, years (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male sex</td>
<td>243 (60)</td>
<td></td>
</tr>
<tr>
<td>Underlying diagnosis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-Hodgkin lymphoma</td>
<td>98 (24.2)</td>
<td></td>
</tr>
<tr>
<td>Acute myelogenous leukemia</td>
<td>80 (19.8)</td>
<td></td>
</tr>
<tr>
<td>Multiple myeloma</td>
<td>67 (16.5)</td>
<td></td>
</tr>
<tr>
<td>Hodgkin lymphoma</td>
<td>54 (13.3)</td>
<td></td>
</tr>
<tr>
<td>Myelodysplastic syndrome</td>
<td>32 (7.9)</td>
<td></td>
</tr>
<tr>
<td>Acute lymphocytic leukemia</td>
<td>25 (6.2)</td>
<td></td>
</tr>
<tr>
<td>Chronic lymphocytic leukemia</td>
<td>14 (3.5)</td>
<td></td>
</tr>
<tr>
<td>Chronic myelogenous leukemia</td>
<td>13 (3.2)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>22 (5.4)</td>
<td></td>
</tr>
</tbody>
</table>

their admission. At the time of the dental evaluation, the majority of patients had not had a scaling and prophylaxis performed within the previous 3 months. After the dental evaluation and before admission for HCT, 98.5% of patients had scaling and prophylaxis completed. Therefore, the basic evaluation of obtaining a full-mouth series and panoramic radiographs, clinical evaluation, and completion of scaling and prophylaxis cost $217 for patients on MassHealth dental insurance and $293 for patients with private insurance.

Of the 405 patients in the study, 45.6% required dental restorations, and 20.5% required at least one extraction; 25% of patients required 1 to 2 restorations, and 20.5% required 3 or more restorations (Figure 1). Only 5% required endodontic therapy, and for those with nonrestorable teeth, >90% required no more than 2 dental extractions. For <$500, 318 (78.9%) patients and 275 (68.2%) patients under Medicaid reimbursement and private dental insurance reimbursement, respectively, could have had all their dental treatment completed. For <$1000, the number of patients was 391 (96.5%) and 358 (88.3%), respectively (Figures 2 and 3).

The median and average costs of dental treatment needed before HCT were $275 and $384, respectively, based on MassHealth reimbursement and $368 and $522, respectively, based on the “usual and customary” fees for patients with private dental insurance (Table II).

The risk of streptococcal bacteremia in this population has been reported to be approximately 18%. If dental screening and treatment reduced the risk among Medicaid beneficiaries by 25% (from 18% to ≤11%), the dental interventions would have resulted in cost savings (Figure 4). However, assuming a risk of bacteremia of 5%, monetary savings would accrue only in the case where risk was reduced by 75%. In the case of commercial insurance, the thresholds are slightly higher, owing to the higher costs of dental screening and treatment. Nevertheless, assuming a baseline risk of bacteremia of 18%, small cost savings would be accrued, with risk reductions more than 25% (to about 11%) and savings exceeding $500 per patient if risk was reduced by about half (from 18% to ≤7%; Figure 5).

DISCUSSION

There are very few studies published on dental needs in patients preparing for HCT. In this study, 45.6% of patients needed restorations, and 20.5% needed at least one extraction to treat active disease. In a study by Vaughan et al. in the pediatric population, the prevalence of caries was 23%, and this lower number is to be expected compared with adults. Our figures are slightly lower than those reported by Graber et al., who found that 31 of 42 (67%) presented with dental caries, whereas 47% needed at least one extraction. Akintoye et al. reported that 35.1% and 41.6% required operative procedures and extraction, respectively.

Studies indicate that the incidence of bacteremia varied from 22.0% to 55.8% in all HCT patients. Bacteria may gain access to the patient’s bloodstream through chemotherapy-induced ulcerative stomatitis or from foci of dental infection. Patients are particularly susceptible to viridans streptococcal infection during the pre-engraftment phase, when patients are profoundly neutropenic. Almyroudis et al. found that patients with gram-positive bacterial septicemia (of which 22% had viridans streptococci) had a significantly higher mortality rate and a lower 1-year survival rate than those without septicemia. Similarly, Akintoye et al. demonstrated that during the first 100 days after therapy, 34.8% of the study subjects had positive blood cultures associated with clinical signs of septicemia; 46.9% of cultures were positive for streptococcal bacteria, and, more specifically, 28.6% of cultures were positive for *Streptococcus mitis*. Because viridans streptococci play an important role in bacteremias, a reduction in the number of these organisms in the mouth may reduce the risk of septicemia. One way to accomplish this is by restoring patients to dental health. However, it should be borne in mind that while such streptococci are predominantly inhabitants of the mouth in humans and animals, they may also be isolated from other anatomic organs, including the gastrointestinal and genitourinary tracts.

Based on this study, the average cost to the payer of dental treatment needed before HCT to restore the patient to good dental health was $384 per patient, based on MassHealth reimbursement, or $522 per
patient, based on the “usual and customary” fees for patients with private dental insurance. This cost is minor compared with the overall costs of HCT (autologous or allogeneic) and the costs for identifying and preparing a donor for allogeneic HCT. The median cost for allogeneic HCT for myeloablative and reduced-intensity conditioning HCT are $89,369 (range, $66,894-$130,590) and $21,673 (range, $17,463-$25,929) respectively. The mean cost for autologous HCT has been reported to be $51,312.

For our analysis, we assumed that the monetary cost of treating patients with HCT who become septic is approximately $14,399 for a 3-day hospital stay. However, this cost is probably a low estimate. Jarvis reported that even minimally effective infection control programs are cost effective, because the average hospital stay for bloodstream infections is 7 to 21 days, and the average cost was between $3000 and $40,000 in 1996. Al-Rawajfah et al. reported that the average hospital stay for bloodstream infections was 16 days, with an average cost of approximately $85,000 in 2010, which was $20,000 more than the average in 2003.

Treatment of active dental disease in patients in preparation for HCT does not entail ideal, complex, or
expensive care, because the objective is to reduce the incidence of infection during the period of neutropenia. For the most part, the treatment plans for our patients consisted of scaling and prophylaxis, restorative dentistry, dental extractions, and root canal therapy, and they generally did not include placement of crowns, dental implants, or fixed prosthetics; they also did not include surgical periodontal treatment, unless such therapy had already been started before the evaluation. In this study, only 11 (2.7%) crowns were placed and included in the analysis.

One of the limitations of this study is the retrospective nature of the data. The data are cross-sectional and do not include the actual treatment that each patient received, because in a small number of cases, patients were admitted before the procedures could be completed. The examinations were done by many different dentists in different states, although most were in Massachusetts or the New England area. Differences in diagnostic skills may vary, but having the dentists at our hospital reevaluate the radiographs and discuss complex cases with the dentist helps to provide some uniformity in the treatment plan. Furthermore, the reimbursements provided here are based on dental plans in Massachusetts and would not necessarily apply to other states. Nevertheless, these are fairly routine procedures, and the reimbursements should not vary substantially.

Table II. The cost of each dental treatment provided for adults, dictated by MassHealth and private dental insurance

<table>
<thead>
<tr>
<th>Procedure</th>
<th>MassHealth (US dollars)</th>
<th>Median (commercial) Boston (US dollars)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic first clinical examination</td>
<td>$37</td>
<td>$47.99</td>
</tr>
<tr>
<td>Full-mouth radiograph series</td>
<td>$69</td>
<td>$92.91</td>
</tr>
<tr>
<td>Panoramic film</td>
<td>$62</td>
<td>$85.21</td>
</tr>
<tr>
<td>Scaling and prophylaxis</td>
<td>$49</td>
<td>$67.27</td>
</tr>
<tr>
<td>Single surface amalgam</td>
<td>$58</td>
<td>$75.35</td>
</tr>
<tr>
<td>Two-surface amalgam</td>
<td>$72</td>
<td>$94.95</td>
</tr>
<tr>
<td>Three-surface amalgam</td>
<td>$86</td>
<td>$112.11</td>
</tr>
<tr>
<td>Endodontic treatment, anterior</td>
<td>$375</td>
<td>$599.43</td>
</tr>
<tr>
<td>Endodontic treatment, posterior</td>
<td>$569</td>
<td>$871.12</td>
</tr>
<tr>
<td>Single extraction</td>
<td>$70</td>
<td>$94.95</td>
</tr>
<tr>
<td>Second extraction</td>
<td>Single extraction cost ×2</td>
<td>Single extraction cost ×2</td>
</tr>
<tr>
<td>Anterior crown</td>
<td>$499</td>
<td>$770.14</td>
</tr>
<tr>
<td>Posterior crown</td>
<td>$499</td>
<td>$770.14</td>
</tr>
</tbody>
</table>

MassHealth, the Medicaid program in Massachusetts.
Another drawback is that it is difficult to prove that the rate of bacteremias in a cohort of patients that were restored to optimal dental health would be lower than in those who did not receive dental care. This would entail performing a randomized controlled clinical trial in which one group would receive dental treatment and another no dental treatment, with obvious ethical issues. It is also difficult to determine whether bacteremia in and of itself predicts increased length of hospital stay. Nevertheless, dental evaluation to optimize dental health before HCT is in keeping with the overall context of other pre-HCT testing, which includes pulmonary, cardiovascular, metabolic, and other as-needed evaluations. As noted above, the median dental treatment costs are minimal compared to overall HCT costs. Finally, the estimated cost for an extra 3-day stay in the hospital is probably a low estimate, considering the cost of professional care in an intensive care unit, pain medications and antibiotics, laboratory testing, and nutritional support, even without taking into account the morbidity suffered by the patient.

If we assume that providing dental treatment for patients before HCT may reduce infectious events during the admission for HCT, it is likely to also lead to improved quality of life, reduced length of hospital stay, and reduced use of antibiotics. The expert care provided by a dental specialist before HCT may thus have a substantial impact on reducing the overall cost of medical care.

Fig. 4. Relationship between risk reduction for varying baseline risks of streptococcal bacteremia from dental treatment before hematopoietic cell transplantation and average cost per patient (for MassHealth patients).

Fig. 5. Relationship between risk reduction for varying baseline risks of streptococcal bacteremia from dental treatment before hematopoietic cell transplantation and average cost per patient (for patients with private insurance).
CONCLUSION
Septicemia results in significant morbidity for patients who undergo HCT, and the oral cavity is a reservoir for gram-positive bacteria, which are common pathogens in such septicemias. Because dental infection is a potential source of septicemia, a dental evaluation to identify such sources of infection may be an economical way to reduce or prevent septicemia from an oral source when patients are neutropenic. For less than $1000 in the state of Massachusetts, dental needs for patients can be met in more than 88% of patients, whether they are insured under a government program or have private dental insurance, and such care may result in less septicemia episodes.

REFERENCES
32. Jones JA, Qazilbash MH, Shih YC, Cantor SB, Cooksley CD, Elting LS. In-hospital complications of autologous hematopoietic stem cell transplantation for lymphoid malignancies: clinical and...


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