MAJOR ARTICLE

Pressure Ulcer-Related Pelvic Osteomyelitis: A Neglected Disease?

Phani Bodavula,[1,a] Stephen Y. Liang,[1,2,a] Jiami Wu,[1] Paige VanTassell,[1] and Jonas Marschall[1,3]; for the Centers for Disease Control and Prevention Epicenters Program

Divisions of [1]Infectious Diseases, and [2]Emergency Medicine, Washington University School of Medicine, St. Louis, Missouri; and [3]Department of Infectious Diseases, Inselspital, Bern University Hospital, University of Bern, Switzerland

Background. Decubitus ulcers can become complicated by pelvic osteomyelitis. Little is known about the epidemiology of pressure ulcer-related pelvic osteomyelitis.

Methods. We performed a retrospective cohort study of adult patients with pressure ulcer and pelvic osteomyelitis admitted to an academic center from 2006 to 2011. Data on clinical presentation, diagnostic evaluation, and treatment during the index admission were collected. Outcome measures included length of hospital stay and number of readmissions in the subsequent year.

Results. Two hundred twenty patients were included: 163 (74%) were para/quadriplegic and 148 (67%) were male (148; 67%). Mean age was 50 (±18) years. Pelvic osteomyelitis was the primary admission diagnosis for 117 (53%). Fifty-six (26%) patients had concurrent febrile urinary tract infection. Wound cultures collected for 113 patients (51%) were notable for methicillin-resistant *Staphylococcus aureus* (37; 33%), *Streptococci* (19; 17%), and *Pseudomonas* spp (20; 18%). Plain films were obtained in 89 (40%) patients, computed tomography scans were obtained for 81 (37%) patients, and magnetic resonance images were obtained for 40 (18%) patients. Most patients received osteomyelitis-directed antibiotics (153; 70%), 134 of 153 (88%) of which were scheduled to receive ≥6 weeks of treatment. Fifty-five (25%) patients underwent surgery during the index admission; 48 (22%) patients received a combined medical-surgical approach. One third of patients had ≥2 readmissions during the subsequent year. Patients treated with a combined approach were less likely to be readmitted than those who received antibiotics alone (0 [range, 0–4] vs 1 [0–7] readmissions; $P = .04$).

Conclusions. This is one of the largest cohort studies of pressure ulcer-related pelvic osteomyelitis to date. Significant variations existed in diagnostic approach. Most patients received antibiotics; those treated with a combined medical-surgical approach had fewer hospital readmissions.

Keywords. chronic; osteomyelitis; pelvis; pressure ulcer.

Patients with neurological diseases are prone to develop pressure ulcers due to their sensory and motor impairment resulting in immobility. Left untreated, these ulcers can eventually extend to the bone (in which case they are classified as stage IV pressure ulcers [1]) and be associated with infectious complications such as soft tissue infection or osteomyelitis. Osteomyelitis is thought to occur in approximately one third of these ulcers [2]. Stage IV pressure ulcers most commonly affect the tissue overlying the sacrum, ischial bones, and femoral heads, and therefore pressure ulcer-related osteomyelitis is typically found in these locations [3].

Pressure ulcer-related osteomyelitis is challenging to manage for a number of reasons. First, our diagnostic tools are limited, and it can be difficult to differentiate a pressure sore with underlying osteomyelitis from a soft tissue infection surrounding the ulcer, simple microbial colonization of the ulcer, or noninfectious

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[a]P. B. and S. Y. L. contributed equally to this manuscript.

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Correspondence: Stephen Y. Liang, MD, Division of Infectious Diseases, Washington University School of Medicine, 660 S. Euclid Avenue, Campus Box 8051, St. Louis, MO 63110 (sliang@dom.wustl.edu)

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pressure-related bone changes underneath an ulcer [4]. Second, radiological studies are hard to interpret, and they do not necessarily permit a distinction between presence and absence of infection, acute and chronic forms of osteomyelitis, or persistent and resolving infection [5]. Third, patients with spinal cord injury are often unable to report local pain, which is a useful tool for monitoring treatment response in other patient populations. Fourth, chronic osteomyelitis may not be curable with antibiotic treatment alone but may require concomitant surgical measures [6]. Lastly, chronic wounds facilitate the entry of further pathogens and can lead to recurrent episodes of infection.

From an economic viewpoint, there is a significant financial burden associated with stage IV pressure ulcers, particularly in those patients in which ulcers progress to infection of the underlying bone. The average cost for patients with pressure ulcers necessitating 4 consecutive admissions exceeds $100 000 [7]. In addition, the psychological impact of having a smoldering bone infection that may require multiple hospital admissions, treatment courses, and assiduous wound care, all the while threatening slow destruction of tissues has, to our knowledge, never been studied.

Despite the gaps in knowledge, only a few clinical and epidemiological studies have examined pressure ulcer-related pelvic osteomyelitis [2–4, 8, 9]. It is a neglected disease of the developed world. The goal of our study was to describe the epidemiology of pressure ulcer-related pelvic osteomyelitis, including the clinical presentation, diagnostics, management, and outcomes of this understudied condition.

METHODS

Study Design and Setting

We performed a 6-year, retrospective cohort study of patients admitted to Barnes-Jewish Hospital (BJH) between June 1, 2006 and July 31, 2011 and diagnosed with pressure ulcer-related pelvic osteomyelitis. Barnes-Jewish Hospital, a 1250-bed teaching hospital, is the largest hospital in Missouri, with a referral base that draws from the St. Louis metropolitan area, eastern Missouri, and southwestern Illinois. We used a medical informatics database to identify all discharges with ICD-9-CM codes for both pressure ulcers (707–707.9) and osteomyelitis (730–730.9). These discharges were then reviewed to determine whether they met study inclusion criteria defined below. Only the first admission of an individual patient was considered, whereas readmissions were part of the outcomes evaluation. The study was approved by the Washington University Human Research Protection Office.

Inclusion and Exclusion Criteria

Patients ≥18 years old admitted to the hospital with stage IV pressure ulcer present at the time of diagnosis of pelvic osteomyelitis. We excluded pelvic osteomyelitis patients with stage I–III ulcers.

Data Collection and Definitions

We reviewed medical records of all patients who met inclusion criteria. Medical records were examined for demographic information, comorbidities, antibiotic history, presenting symptoms, vital signs, and physical examination findings, imaging studies, diagnostic procedures, microbiology, and both medical and surgical treatment. Laboratory values (such as C-reactive protein and erythrocyte sedimentation rate) and temperature data within 24 hours of admission were also collected.

Length of hospital stay, transfer to the intensive care unit, and crude in-hospital mortality were some of the outcomes of interest. We took the number of readmissions over the following 12 months as the primary endpoint; all patients had at least 12 months of follow-up time to determine this outcome. Cure is a standard clinical outcome; however, it is difficult to ascertain in neurologically compromised patients. In addition, wound documentation over the course of hospitalization(s) was poor; therefore, we chose not to include this in our selection of outcomes.

We defined renal insufficiency as serum creatinine of >2.0 mg/dL. Active malignancy was defined as having received chemotherapy or radiation therapy for cancer in the previous 6 months.

Statistical Analysis

Data entry was performed using Microsoft Access and Excel (Microsoft Corp., Redmond, WA), and we analyzed the data using SPSS 17 (SPSS Inc., Chicago, IL). Univariate comparisons among categorical variables were done with the χ^2 test or Fisher's exact test, as appropriate. Comparisons among continuous variables were performed using Student's *t* test or Mann-Whitney *U* test, as appropriate. We considered a 2-sided *P* value <.05 to be significant.

RESULTS

Patient Characteristics and Clinical Presentation

Of the 270 adult patients with discharge ICD-9-CM codes for pelvic osteomyelitis during the 6-year study period, 220 (81%) were diagnosed with both pressure ulcer and pelvic osteomyelitis and met study criteria (Table 1). The mean age was 50 years (standard deviation ±18). Patients were mostly male (n = 148; 67%) and African American (n = 114; 52%). The median body mass index was 23.6 kg/m^2 (range, 12.3–48.0). Sixteen (7%) patients had been transferred from an outside hospital to our institution; all others were direct admissions.

One hundred seventy (77%) patients were para/quadriplegic, whereas 50 (23%) had no documented neurological dysfunction (ie, they had alternative explanations for their immobility). Of the 170 para/quadriplegic patients, 120 (55%) had traumatic paraplegia; 30 (14%) had a history of cerebrovascular accident;

Table 1. Patient Characteristics and Clinical Presentation in 220 Cases of Pressure Ulcer-Related Pelvic Osteomyelitis

Demographic Variable	n (%)
Age (mean±SD), years	50 (±18)
Male gender	148 (67%)
African American race	114 (52)
Body mass index (median, range), kg/m^2	23.6 (12.3–48.0)
Transfer from outside hospital	16 (7%)
Neurological causes/etiology	
Trauma (history of spinal injury)	120 (55%)
Cerebrovascular accident	30 (14%)
Congenital CNS abnormality	20 (9%)
Nonneurological comorbidity	
Diabetes mellitus	39 (18%)
Chronic renal insufficiency (serum creatinine >1.5)	23 (11%)
Malignancy	18 (8%)
HIV infection	1 (1%)
Reported symptoms	
Back pain	68 (31%)
Weakness	163 (74%)
Fever	95 (43%)
Weight loss	88 (40%)
Sensory loss	156 (71%)
Urine incontinence	155 (71%)
Stool incontinence	144 (61%)
Physical findings	
No documentation of neurological exam	174 (79%)
No documentation of wound exam	113 (51%)

Abbreviations: CNS, central nervous system; HIV, human immunodeficiency virus; SD, standard deviation.

Table 2. Diagnostic Work-Up of 220 Patients With Pressure Ulcer-Related Pelvic Osteomyelitis

Variable	Mean (±SD)	Compatible With Infection (%)
Laboratory data		
WBC count (mean, SD), k/mm^3	13 (7)	
ESR (mean, standard deviation), mm/h	78 (30)	
CRP (mean, standard deviation), mg/dL	116 (83)	
Diagnostic work-up		
Radiology		
Pelvic x-ray	89 (41%)	62%
CT scan	81 (37%)	83%
MRI	40 (18%)	88%
Bone scan	19 (9%)	79%
Any culture	113 (51%)	
Wound culture	64 (29%)	
Deep tissue culture	26 (12%)	
Bone culture	23 (11%)	

Abbreviations: CRP, C-reactive protein; CT, computed tomography; ESR, erythrocyte sedimentation rate; MRI, magnetic resonance imaging; SD, standard deviation; WBC, white blood cell count.

and 20 (9%) patients had a congenital central nervous system abnormality. Diabetes mellitus (18%) and chronic renal insufficiency (11%) were the 2 leading comorbidities among our study patients. Only 117 (53%) patients were primarily admitted for pelvic osteomyelitis; for the remainder, it was a secondary diagnosis. Fifty-six (26%) patients had a concurrent urinary tract infection (UTI), and 32 (15%) had bacteremia. Only 113 (51%) patients had wound documentation; 84 (74%) of these had wound drainage, and 49 (43%) explicitly had purulent drainage from the ulcer. Weakness (74%), sensory loss (71%), and urine incontinence (71%) were the most frequently reported symptoms on admission; subjective fevers (43%) and weight loss (40%) were less commonly disclosed. Most of our patients (n = 174, 79%) did not have a documented neurological exam upon admission. However, 44 (20%) patients had impaired motor strength and 40 (18%) patients had sensory deficits, reflecting their underlying neurological condition.

Diagnostic Evaluation

One hundred sixty-eight (76.4%) patients underwent at least 1 radiological evaluation during their hospitalization. Plain radiography was the most common diagnostic evaluation that patients had undergone in this cohort (n = 89; 40.4%); radiologic evaluations of 55 of these 89 (61.8%) patients were read as consistent with pelvic osteomyelitis. Computed tomography (CT) scans were obtained for 81 (37%) patients, 83% of which were consistent with pelvic osteomyelitis, and magnetic resonance images (MRI) were obtained for 40 (18%) patients (88% consistent with pelvic osteomyelitis). Few patients were classified as having acute pelvic osteomyelitis by the radiologist based on imaging findings (19; 9%).

Basic laboratory values are reported in Table 2. In terms of microbiological work-up, patients had either a superficial, deep tissue, or bone culture (or a combination of these) taken. Of the 113 (51%) patients for which we encountered microbiology results, only 23 (20%) had bone biopsies taken (ie, the gold standard); for 26 (23%) patients, deep tissue cultures were obtained; and for the majority of patients, 64 (57%), wound cultures were submitted. In some instances, samples from multiple sites were taken; in these cases, bone biopsies were valued higher than other specimens. Commonly detected organisms included methicillin-resistant *Staphylococcus aureus* (MRSA) (26; 23%), *Streptococcus* spp (19; 17%), *Pseudomonas* spp (20; 18%), and methicillin-susceptible *S aureus* (MSSA) (11; 10%). In 34 (30%) patients, multiple organisms were identified; in addition, in 29 of 46 (63%) patients with a single organism, work-up elicited additional, mixed flora that was not processed further. Cultures did not reveal microbial growth in 33 (29%) patients (Table 3). Few pathogens were identified from bone

Table 3. Microbiology of 113 Cases of Pressure Ulcer-Related Pelvic Osteomyelitis With Bone Cultures, Deep Tissue Cultures, or Wound Cultures

Organism Detected	Monomicrobial, n (%)
MSSA	6 (5%)
MRSA	15 (13%)
Streptococcus spp	9 (8%)
Escherichia coli	0 (0%)
Pseudomonas aeruginosa	4 (4%)
Enterococcus spp	3 (3%)
Others	9 (8%)
Mixed	34 (30%)
No growth	33 (29%)

Abbreviations: MRSA, methicillin-resistant *Staphylococcus aureus*; MSSA, methicillin-sensitive *Staphylococcus aureus*.

cultures: only 12 of 23 (52%) bone cultures taken revealed a pathogen. For patients who did not undergo imaging nor microbiological sampling, the diagnosis of osteomyelitis was made based on clinical grounds (eg, visible exposure of bone or positive probe-to-bone test).

Management and Outcomes

An Infectious Diseases (ID) consult was obtained to guide the management of pelvic osteomyelitis in 143 (65%) patients during the index hospitalization. The mean time from admission to first positive culture was 2.3 days; the mean time from admission to empiric antibiotic therapy was slightly shorter at 2.1 days. Among those patients with positive bone cultures, 92% received antibiotic therapy, compared with 84% of those with deep tissue or wound cultures ($P = .7$). Most patients received osteomyelitis-directed antibiotics (153; 70%); for 105 patients, this was the only modality used to treat the osteomyelitis. One hundred thirty-four of 153 (88%) patients were scheduled to receive ≥6 weeks of antibiotics. Fifty-five (25%) patients underwent surgery; all underwent surgical debridement and 7 of 55 (12.7%) also received myocutaneous flap coverage. Forty-eight (22%) patients received combined therapy. Almost one third of patients (31.3%) had 2 or more readmissions at our center in the course of the following year; 51 (23.2%) had a single readmission; and 100 (45.5%) did not require readmission at BJH. There was no difference in number of readmissions based on whether patients had been seen by the ID consult service or not (1.3 [±1.7] vs 1.1 [±1.4] readmissions; $P = .5$). In addition, administering an MRI during the diagnostic work-up did not influence this outcome (1.0 [±1.3] vs 1.3 [±1.7] readmissions; $P = .4$). Patients treated with a combined medical-surgical approach were less likely to be readmitted compared with those patients who received antibiotics alone (Table 4). There was no difference in length of hospital stay between the 2 groups (8.5 days [1–94] in those treated with a combined approach vs 7 days [2–84] in those treated with antibiotics alone; $P = .1$).

Table 4. Treatments and Outcomes of Chronic Pressure Ulcer Patients

Treatment	n (%)	Number of Readmissions (Median, Range)	Total Length of Hospital Stay (Median, Range)
Antibiotics only	105 (47.7%)	1 (0–7)	7 (2–84)
Surgical Procedure only	7 (3.2%)	2 (0–5)	
Combined medical-surgical approach	48 (21.8%)	0 (0–4)	8.5 (1–94)
None	60 (27.3%)	1 (0–9)	

DISCUSSION

Pressure ulcer-related pelvic osteomyelitis predominantly affects those patients with traumatic spinal cord injury and a history of cerebrovascular accident. Few studies have attempted to describe the epidemiology of this neglected disease, although it is associated with substantial morbidity and represents a significant economic burden to society. In this study, we report findings from a comparatively large observational study of patients with pressure ulcer-related pelvic osteomyelitis. Wound documentation was poor, which made monitoring the clinical response to wound care, antibiotic treatment, and surgery a challenge. There was considerable variation in diagnostic and treatment approaches, suggesting that there are opportunities for optimizing care.

In this study, pressure ulcers associated with pelvic osteomyelitis were documented in only 51% of cases. To demonstrate changes over time, baseline wound documentation is essential. This becomes most evident when attempting to define treatment success. In light of poor wound documentation not only at baseline but also during the remainder of an admission, we were unable to determine clinical success (expressed as wound improvement) in this retrospective cohort, and therefore we did not include it as an endpoint. In a review of the literature, Rennert et al [2] argue that all affected patients should undergo standardized wound documentation that includes baseline and follow-up wound photography, thereby facilitating outcome studies.

Most patients underwent at least 1 radiographic evaluation during their hospitalization; plain radiography was the most common imaging study used in our institution, but it was only confirmatory of osteomyelitis in approximately 60% of cases. The likelihood of CT and MRI results being consistent with bone infection was higher (82% and 88%, respectively), but these studies focused on smaller subgroups in our cohort.

The role of imaging is poorly defined and has never been scrutinized with regards to cost-effectiveness. It is possible that the most relevant aspect of imaging is to assess the extent of affected bone for the purpose of planning surgical debridement [5]. In contrast, an autopsy-based study suggested that radiology leads to overestimation of affected tissue [10]. In our cohort, obtaining an MRI, the most sensitive imaging tool, did not affect the readmission rate. This is similar to another group's findings [11]. A disadvantage of our cohort was that histopathology, the gold standard for diagnosing osteomyelitis studied elsewhere [12], was not obtained systematically.

Obtaining a microbiological diagnosis is crucial given the need for prolonged antibiotic therapy and the potential for increased cost, toxicity, and other adverse events associated with antibiotic therapy. Few previous studies have collected information on the microbiology of pelvic osteomyelitis [4, 6], but the spectrum seems to be broad and includes Gram-negative bacteria. In our analysis, the most frequently detected organisms were *S aureus* (both MRSA and MSSA), *Streptococcus* species, and *Pseudomonas aeruginosa*. Polymicrobial osteomyelitis and infections where only a single organism was speciated among mixed flora were common. The relative importance of different specimens for optimally guiding therapy has not been determined; in our experience, the available cultures were used irrespective of whether they were obtained from bone, deep tissue, or superficial wound cultures.

The majority of the patients (68%) in our cohort received osteomyelitis-directed antibiotic therapy. One fifth of the patients received a combination of antibiotic therapy and surgical revision; few patients underwent surgery alone. This exemplifies the wide array of approaches pursued in treating pressure ulcer-related osteomyelitis and points to a lack of treatment studies or consensus in the field. Patients treated with a combined approach consisting of antibiotic treatment and surgery, however, were less likely to be readmitted compared with those patients who received antibiotic therapy alone. To our knowledge, this has not been shown before, even though experts have advised combined approaches in earlier studies [13]. In a mechanistic approach, it makes sense that removal of infected and/or dead bone along with systemic antibiotics is accompanied by the highest treatment success rates. Future studies should include additional outcome measures to better document the superiority of combined medical-surgical approaches and consider using propensity score analyses to avoid selection bias. One rare example of evaluating novel approaches is a study by Marriott et al [9], where a short course of antibiotic treatment in conjunction with debridement was shown to be a useful treatment option.

A large proportion of our study population comprised victims of firearms-related injuries. Patients who are confined to wheelchairs or permanently bedridden depend on care delivered by family members, partners, and healthcare providers alike, and they are frequently admitted to healthcare institutions in relatively quick succession, often with suspected infections of unknown etiology. As such, pelvic osteomyelitis is very much a societal problem in our metropolitan region with significant financial implications. The burden to society—in terms of psychological impact, loss of quality of life and residual functionality, involvement of voluntary caregivers, and healthcare cost due to inpatient and outpatient care—should be accurately determined in a future analysis. Pressure ulcer-related pelvic osteomyelitis is, to co-opt a label associated with tropical diseases in developing countries, a neglected infection of the developed world.

There are a few limitations to this study. We used a retrospective cohort of pressure ulcer-related pelvic osteomyelitis with information derived from their first admission during the study period. We did this because readmissions are common in this patient population, and we wanted to avoid including multiple hospital episodes related to the same infection in a given patient. The data are derived from a single academic tertiary care center, which may limit its generalizability. Debridement performed in the operating room was considered a surgical intervention. All patients reported to have undergone surgery had this procedure done. Pressure ulcers and exposed bone may also be surgically debrided at the bedside; documentation of these procedures in the medical record is often lacking based on our clinical experience, yet it is potentially important for treatment success as well. Therefore, the true number of patients that received surgical debridement in our cohort could have been higher than what we identified. Patients included in this study also had to have at least 12 months of follow-up time within our health system, as evidenced by subsequent health encounters documented in our medical record, to examine the primary outcome of readmission. It is possible that we could have inadvertently excluded sicker patients with poor outcomes who may have died before these encounters could take place. Patients also could have received care outside of our medical center, which could have limited the reliability of our assessment of outcomes. Study inclusion was based on ICD-9-CM discharge diagnosis codes; undercoding for pressure ulcers or pelvic osteomyelitis could have resulted in missed cases. Because functional improvement cannot be used as an endpoint in spinal cord injury, we also had to rely on alternative outcome measures, namely hospital readmission, which may not have been specific to complications related to pressure ulcers or pelvic osteomyelitis given the multiple underlying medical comorbidities present in our study cohort.

CONCLUSIONS

This is one of the largest cohort studies of pressure ulcer-related pelvic osteomyelitis to date, and it reveals many gaps in our understanding of this neglected disease and its management.

Concurrent UTI was common, making it difficult to determine the cause for a patient's deterioration and, ultimately, hospitalization, in many cases. Half of all pressure sores were inadequately documented, and significant variation existed in the diagnostic approach to suspected osteomyelitis. Most patients received antibiotic therapy; however, those treated with a combined medical-surgical approach fared better in that they had fewer hospital readmissions over the following year. Future studies should determine the financial and societal impact of pelvic osteomyelitis, develop novel wound documentation tools (eg, colorimetric assays), define reliable and readily measurable outcome parameters, and test multidisciplinary treatment strategies to improve long-term morbidity and prognosis associated with this potentially devastating infection.

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