Etiology, Characteristics, and Outcomes of Community-Onset Pyomyositis in Korea: A Multicenter Study

Tark Kim,1 Seong Yeon Park,2 Yee Gyung Kwak,3 Jiwon Jung,4,5 Min-Chul Kim,6 Seong-Ho Choi,4 Shi Nae Yu,7 Hyo-Lim Hong,8 Yong Kyun Kim,9,10 Se Yoon Park,11 Eun Hee Song,12, Ki-Ho Park,13 Oh Hyun Cho,14 Sang-Ho Choi,5 and The Korean SSTI Study Group15

1Department of Internal Medicine, Soonchunhyang University Bucheon Hospital, Bucheon, Korea
2Department of Internal Medicine, Dongguk University Ilsan Hospital, Goyang, Korea
3Department of Internal Medicine, Inje University Ilsan Paik Hospital, Goyang, Korea
4Department of Internal Medicine, Ulsan University Hospital, University of Ulsan College of Medicine, Ulsan, Korea
5Department of Infectious Diseases, Asan Medical Center, University of Ulsan College of Medicine, Seoul, Korea
6Department of Internal Medicine, Chung-Ang University Hospital, Seoul, Korea
7Division of Infectious Diseases, Department of Internal Medicine, Soonchunhyang University Cheonan Hospital, Cheonan, Korea
8Department of Internal Medicine, Daegu Catholic University Medical Center, Daegu, Korea
9Department of Internal Medicine, Inje University Haeundae Paik Hospital, Busan, Korea
10Department of Internal Medicine, Hallym University Sacred Heart Hospital, Hallym University College of Medicine, Anyang, Korea
11Department of Internal Medicine, Soonchunhyang University Seoul Hospital, Seoul, Korea
12Department of Internal Medicine, GangNeung Asan Hospital, Gangneung, Korea
13Department of Internal Medicine, Kyung Hee University Hospital, Kyung Hee University School of Medicine, Seoul, Korea
14Department of Internal Medicine, Gyeongsang National University Changwon Hospital, Changwon, Korea
15The Korean Skin and Soft Tissue Study Group, Korea

Received: Aug 26, 2020
Accepted: Nov 29, 2020

Corresponding Author:
Sang-Ho Choi, MD, PhD
Department of Infectious Diseases, Asan Medical Center, University of Ulsan College of Medicine, 88, Olympic-ro 43-gil, Songpa-gu, Seoul 05505, Korea.
Tel: +82-2-3010-3304
Fax: +82-2-3010-6970
E-mail: sangho@amc.seoul.kr

Copyright © 2021 by The Korean Society of Infectious Diseases, Korean Society for Antimicrobial Therapy, and The Korean Society for AIDS
This is an Open Access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (https://creativecommons.org/licenses/by-nc/4.0/) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

ORCID IDs
Tark Kim https://orcid.org/0000-0002-8829-4183
Seong Yeon Park https://orcid.org/0000-0001-8762-7006
Yee Gyung Kwak https://orcid.org/0000-0002-4713-8045
Jiwon Jung https://orcid.org/0000-0003-4333-3270
Min-Chul Kim https://orcid.org/0000-0003-4410-5608
Seong-Ho Choi https://orcid.org/0000-0001-8108-2412

ABSTRACT

Background: Pyomyositis (PM) is a serious soft tissue infection and despite its clinical importance, previous studies have not been able to fully determine the clinical characteristics and microbial epidemiology of PM in Korea, which we therefore aimed to investigate.

Materials and Methods: We retrospectively identified 140 adult patients diagnosed with PM from 13 general hospitals between January 2012 and December 2015. We analyzed the clinical and microbial characteristics of community-onset PM and compared them with community-acquired (CA) and healthcare-associated (HCA) PM.

Results: One hundred eleven organisms were isolated from 96 (68.6%) patients with PM. Staphylococcus aureus (38 patients) was the most common pathogen, followed by streptococci (24 patients), and enteric Gram-negative organisms (27 patients). Methicillin-resistant S. aureus (MRSA) was identified in four (2.9%) patients and in-hospital mortality reached 8.6% (12/140). Enterococci isolates were identified in the HCA PM subgroup only. The proportion of MRSA isolates was not comparable between CA and HCA PM subgroups. In the 83 patients with PM infected by monomicrobial pathogens, isolates of Gram-negative organisms were more commonly found in HCA PM subgroup than in CA PM subgroup (47.6% [10/21] of patients with HCA PM vs. 20.7% [12/58] of patients with CA PM; P = 0.01).

Conclusion: Gram-positive cocci such as S. aureus and streptococci were dominant etiologies in community-onset PM, whereas MRSA appears to an uncommon causative organism of PM.
Etiology of community-onset pyomyositis in Korea

in Korea. Enteric Gram-negative organisms should also be considered as major etiologies, especially in HCA PM patient population in Korea.

**Keywords:** Pyomyositis; Community; Etiology

**INTRODUCTION**

Pyomyositis (PM) is a serious soft tissue infection that is usually accompanied by abscess formation [1]. Pyomyositis is dangerous for patients because it requires long-term treatment with antibiotics and repeated surgical interventions [2]. Despite its clinical importance, previous research has been unable to fully determine the clinical characteristics and microbial epidemiology of PM in Korea. In previous studies conducted across the United States, Gram-positive cocci, such as streptococci, and *Staphylococcus aureus*, were major pathogens of PM [3, 4], and the rate of resistance to methicillin was high [5]. In the guideline published by the Infectious Diseases Society of America, vancomycin is recommended for initial empirical therapy [6]. However, because microbial epidemiology can vary by region, universal application of this guideline may not be appropriate. To establish a unique treatment strategy appropriate for managing PM in Korea, it is necessary to collect and collate our own data on PM in Korea. For these reasons, we conducted a multicenter study to identify the clinical and microbial characteristics of PM in Korea.

**MATERIALS AND METHODS**

1. **Study design and definitions**

Between January 2012 and December 2015, we retrospectively reviewed the medical records of adult patients (>18 years) who had been diagnosed by use of the Korean Standard Classification Disease and Cause of Death codes (M6000 – M6009, M7100 – M7109, and M6500 – M6509) relevant with PM across thirteen teaching hospitals in Korea. A PM diagnosis was confirmed in cases of abscess formation or inflammation in skeletal muscle without fascia involvement in imaging or surgical findings [6]. Patients who did not have compatible findings with PM were excluded from the analysis. PM that had been contracted outside of the hospital, rather than during patient stay, was a prerequisite for eligibility for data usage. Informed consent was waived by the Institutional Review Board of Soonchunhyang University Buceon Hospital, given that this work was a non-interventional, retrospective study and did not involve work on extra clinical specimens (IRB No 2017-01-001).

We categorized cases into healthcare-associated infection (HCA), if any one of the following conditions were satisfied:

(1) Previous admission within 3 months for 2 or more days prior to the episode
(2) Previous intravenous antibiotics, chemotherapy, or nursing care at home within 1 month prior to the episode
(3) Previous hemodialysis within 1 month prior to the episode
(4) Residence in a nursing facility [7]

All other patients were categorized as having a community-acquired (CA) infection.

https://icjournal.org

https://doi.org/10.3947/ic.2020.0102

47
2. Clinical characteristics
We compiled the data on demographics (age and sex), site of infection, and underlying diseases (diabetes mellitus, liver cirrhosis, end-stage renal disease, alcoholism, solid tumor, hematologic malignancy, and immunocompromised state).

We also compiled data on intensive care unit (ICU) admissions and septic shock [8] as the severity indices and on laboratory findings, such as white blood cells, platelets, creatinine, and C-reactive protein. We also investigated surgical intervention as a treatment modality and in-hospital mortality as an outcome indicator.

3. Microbial characteristics
Cultures grown from blood, pus, and intra-surgical specimens were analyzed and the results reviewed. Microorganism identification was conducted using standard methods at each hospital, in which the quality control of microbial tests had passed the evaluation of the accredited institutions. Susceptibility testing was performed using the microdilution method, and results were interpreted according to the National Committee for Clinical Laboratory Standards guidelines [9].

4. Statistical analysis
Statistical analysis was performed using SPSS version 26.0 (SPSS, Chicago, IL, USA). We used a chi-square test or Fisher’s exact test for comparison of categorical variables, and the Mann-Whitney U test to analyze continuous variables. All tests were two-tailed, and differences were considered significant at \( P < 0.05 \).

RESULTS
1. Clinical characteristics
A total of 140 patients with PM were enrolled during the study period. With the exception of 16 (11.4%) patients whose intraoperative findings were indicative of PM, magnetic resonance imaging and computerized tomography were conducted in 80 (57.1%) and 75 (53.6%) patients, respectively. We then categorized 38 (27.1%) patients into the HCA infection group; the median number of enrolled patients at each hospital was 8 (range 2 - 31 patients). The clinical characteristics and laboratory findings of patients with PM are shown in Table 1. The most common underlying disease was diabetes mellitus \((n = 47, 33\%)\), while lower extremity involvement \((n = 76, 54\%)\) was most prevalent. Seventy-three (52.1%) patients with PM received surgical intervention and in-hospital mortality occurred in 12 patients (8.6%). Severity indices, such as ICU admission \((83.3\% \ [10/12] \ of \ patients \ with \ in-hospital \ mortality \ vs. \ 18.8\% \ [24/128] \ of \ patients \ without \ in-hospital \ mortality; \ P < 0.01)\), and septic shock \((58.3\% \ [7/12] \ of \ patients \ with \ in-hospital \ mortality \ vs. \ 7.8\% \ [10/128] \ of \ patients \ without \ in-hospital \ mortality; \ P < 0.001)\) were associated with in-hospital mortality in the univariate analysis.

2. Microbial etiologies
Microbial etiologies of PM are shown in Table 2. We isolated a total of 111 organisms from 96 (68.6%) patients, and found polymicrobial infections in 12 of these 96 (12.5%) patients. We did microbial tests in 131 (93.6%) patients: 118 for blood culture, 66 for intraoperative specimens, and 55 for aspiration or biopsy. The positive rates of culture according to specimen sources were as follows: 78.8% (52/66) from intraoperative specimens, 67.3% (37/55) from aspiration or biopsy specimens, and 28.0% (33/118) from blood cultures.
S. aureus (n = 38 patients, 27.1%) was the most common pathogen, followed by streptococci (n = 24 patients, 17.1%). There were only four (2.7%) of the methicillin-resistant S. aureus (MRSA) isolates identified in all patients with PM and it comprised 10.5% (4/38) of isolates of S. aureus. Four isolates of coagulase-negative staphylococci were considered as pathogens, because these were cultured in sterile aspiration or intra-operative specimens. We identified enteric Gram-negative rods in 27 (19.3%) patients. Of these isolates, 77.8% (21/26), 87.0% (20/23), 87.0% (20/23), and 77.8% (21/26) were susceptible to ceftriaxone, cefepime, piperacillin/tazobactam, and quinolone, respectively.

Isolates of enterococci were found only in HCA PM; there was no difference in the proportion of MRSA isolates in the CA and HCA PM groups. In 83 patients with PM infected by monomicrobial pathogens, isolates of Gram-negative organisms were more commonly found in the HCA PM subgroup than in CA PM subgroup (20.7% [12/58] of patients with CA PM vs. 47.6% [10/21] of patients with HCA PM; P = 0.01).

**DISCUSSION**

Our findings show that S. aureus was the most common etiology in community-onset PM, followed by enteric Gram-negative organisms, and streptococci. MRSA was detected in only
2.9% (4/140) patients with community-onset PM. In hospital mortality occurred in roughly 10% of patients with community-onset PM. This study is the largest multicenter investigation of current microbial etiology, clinical characteristics, and outcomes of community-onset PM in Korea. We expect that this study can be used to develop treatment strategies for community-onset PM in this region.

MRSA is a concerning pathogen in community-onset skin and soft tissue infections; however, in PM, epidemiologic studies are lacking. A retrospective study in the United States, for example, found that MRSA was commonly isolated in patients with PM [5]. Additionally, there have been reports on MRSA-induced PM in the pediatric setting [10]. Based on these experiences, glycopeptides against MRSA are recommended in skin and soft tissue infection guidelines of the Infectious Diseases Society of America. However, with the exception of India, which detected MRSA infection in 12.9% (8/62) of patients with PM [11], MRSA has rarely been identified. For example, a retrospective study conducted in Taiwan found only two MRSA isolates in 32 patients [12], whereas in Brazil, there was no detection of MRSA in a total of 13 adult patients with PM [13]. This study suggests that it may not be appropriate to choose glycopeptides as an empirical regimen for PM in Korea, because MRSA was identified in only 2.9% of the patient population.

When choosing empirical antibiotics, it is important to assess the benefits of administering appropriate antibiotics for improved outcomes against the risk of antibiotic overuse that
could cause antimicrobial resistance and unnecessary adverse drug reactions. In PM, empirical antibiotics against methicillin-susceptible S. aureus and streptococci, rather than against MRSA, should be considered. Moreover, enteric Gram-negative rods should be covered in some situations. While most pathogens in the tropics were S. aureus, Gram-negative rods comprised 30% in temperate regions [3, 4]. Additionally, in a patient with liver cirrhosis, the major pathogen identified was Klebsiella pneumoniae [14]. Older age was also associated with an etiology independent of the S. aureus infection [5]. In our study, Gram-negative rods were more commonly found in HCA PM. It is therefore reasonable to choose cefepime or piperacillin/tazobactam as empirical regimens for PM treatment, as recommended in the skin and soft tissue infection guideline published by the Korean Society for Antimicrobial Therapy [15].

This study has some limitations. First, it is possible that some isolates such as coagulase-negative staphylococci were a wound colonizer rather than pathogens. Second, data on therapeutic investigations such as antibiotics usage were not fully investigated, because this would have fallen outside the scope of the study. Further investigation on the effect of surgical intervention and appropriate use of antibiotics on mortality will be important.

In conclusion, Gram-positive cocci such as S. aureus and streptococci were dominant etiologies in community-onset PM. MRSA appears to be uncommon as a causative organism of PM in Korea; however, enteric Gram-negative organisms should also be considered as major etiologies, especially in HCA PM in Korea.

ACKNOWLEDGMENTS

The list of the membership of the Korean SSTI study group is identical to the list of the authors.

REFERENCES

1. Shepherd JJ. Tropical myositis: is it an entity and what is its cause? Lancet 1983;2:1240-2.
2. Chiedozi LC. Pyomyositis. Review of 205 cases in 112 patients. Am J Surg 1979;137:255-9.
3. Crum NF. Bacterial pyomyositis in the United States. Am J Med 2004;117:420-8.
4. Christin L, Sarosi GA. Pyomyositis in North America: case reports and review. Clin Infect Dis 1992;15:668-77.
5. Burdette SD, Watkins RR, Wong KK, Mathew SD, Martin DJ, Markert RJ. Staphylococcus aureus pyomyositis compared with non-Staphylococcus aureus pyomyositis. J Infect 2012;64:507-12.
6. Stevens DL, Bisno AL, Chambers HF, Dellinger EP, Goldstein EL, Gorbach SL, Hirschmann JV, Kaplan SL, Montoya JG, Wade JC.Infectious Diseases Society of America. Practice guidelines for the diagnosis and management of skin and soft tissue infections: 2014 update by the Infectious Diseases Society of America. Clin Infect Dis 2014;59:e10-52.
7. Friedman ND, Kaye KS, Stout JE, McGarry SA, Trivette SL, Briggs JP, Lamm W, Clark C, MacFarquhar J, Walton AL, Reller LB, Sexton DJ. Health care--associated bloodstream infections in adults: a reason to change the accepted definition of community-acquired infections. Ann Intern Med 2002;137:791-7.
8. Rhodes A, Evans LE, Alhazzani W, Levy MM, Antonelli M, Ferrer R, Kumar A, Sevransky JE, Sprung CL, Nunnally ME, Rochwerg B, Rubenfeld GD, Angus DC, Annane D, Beale RJ, Bellinghan GI, Bernard GR, Chiche JD, Coopersmith C, De Backer DP, French CJ, Fujishima S, Gerlach H, Hidalgo JL, Hollenberg SM, Jones AE, Karnad DR, Kleinpell RM, Koh Y, Lisboa TC, Machado FR, Marini JJ, Marshall IC, Mazuski JE, McIntyre LA, McLean AS, Mehta S, Moreno RP, Myburgh J, Navalesi P, Nishida O, Osborn TM, Perner A, Plunkett CM, Ranieri M, Schorr CA, Seckel MA, Seymour CW, Shieh L, Shukri KA, Simpson SQ, Singer M, Thompson BT, Townsend SR, Van der Poll T, Vincent JL, Wiersinga WJ, Zimmerman JL, Dellinger RP. Surviving Sepsis Campaign: International Guidelines for Management of Sepsis and Septic Shock: 2016. Crit Care Med 2017;45:486-552. [PUBMED] [CROSSREF]

9. Clinical and Laboratory Standards Institute (CLSI). Performance standards for antimicrobial susceptibility testing. Twenty-first informational supplement. CLSI document M100-S21. Wayne, PA: CLSI; 2011.

10. Verma S. Pyomyositis in Children. Curr Infect Dis Rep 2016;18:12. [PUBMED] [CROSSREF]

11. Kumar S, Bhalla A, Singh R, Sharma N, Sharma A, Gautam V, Singh S, Varma S. Primary pyomyositis in North India: a clinical, microbiological, and outcome study. Korean J Intern Med 2018;33:417-31. [PUBMED]

12. Chiu SK, Lin JC, Wang NC, Peng MY, Chang FY. Impact of underlying diseases on the clinical characteristics and outcome of primary pyomyositis. J Microbiol Immunol Infect 2008;41:286-93. [PUBMED]

13. Borges AH, Faraghe B, Laloo DG. Pyomyositis in the upper Negro river basin, Brazilian Amazonia. Trans R Soc Trop Med Hyg 2012;106:532-7. [PUBMED] [CROSSREF]

14. Chang CM, Lee HC, Lee NY, Lee IW, Wu CJ, Chen PL, Lee CC, Ko NY, Ko WC. Community-acquired Klebsiella pneumoniae complicated skin and soft-tissue infections of extremities: emphasis on cirrhotic patients and gas formation. Infection 2008;36:328-34. [PUBMED] [CROSSREF]

15. Kwak YG, Choi SH, Kim T, Park SY, Seo SH, Kim MB, Choi SH. Clinical guidelines for the antibiotic treatment for community-acquired skin and soft tissue infection. Infect Chemother 2017;49:301-25. [PUBMED] [CROSSREF]