Clinical Characteristics of Corynebacterium Bacteremia Caused by Different Species, Japan, 2014–2020

Ryosuke Yamamuro, Naoto Hosokawa, Yoshihito Otsuka, Ryosuke Osawa

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Release date: November 17, 2021; Expiration date: November 17, 2022

Learning Objectives

Upon completion of this activity, participants will be able to:

• Describe the proportion of true bacteremia and differences in clinical characteristics of patients with bacteremia from C. striatum, C. jeikeium, and other Corynebacterium species, based on a retrospective medical record review
• Describe differences in mortality and antimicrobial susceptibility in patients with bacteremia from C. striatum, C. jeikeium, and other Corynebacterium species, based on a retrospective medical record review
• Describe clinical implications of differences in clinical characteristics of patients with bacteremia from C. striatum, C. jeikeium, and other Corynebacterium species, based on a retrospective medical record review

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P. Lynne Stockton Taylor, VMD, MS, ELS(D), Technical Writer/Editor, Emerging Infectious Diseases. Disclosure: P. Lynne Stockton Taylor, VMD, MS, ELS(D), has disclosed no relevant financial relationships.

CME Author

Laurie Barclay, MD, freelance writer and reviewer, Medscape, LLC. Disclosure: Laurie Barclay, MD, has disclosed no relevant financial relationships.

Authors

Disclosures: Ryosuke Yamamuro, MD; Naoto Hosokawa, MD, PhD; Yoshihito Otsuka, PhD; and Ryosuke Osawa, MD, have disclosed no relevant financial relationships.
Corynebacterium bacteria are club-shaped gram-positive rods that are ubiquitous in the environment. Because Corynebacterium species other than C. diphtheriae colonize skin and mucous membranes in humans, Corynebacterium is typically considered a clinically nonsignificant contaminant in cultures (1). Recently, the frequency of detecting C. striatum and C. jeikeium as causative agents of severe bloodstream infections (2,3), infective endocarditis, pneumonia, meningitis, and skin and soft tissue infections (SS-TIs) has increased (4). Furthermore, these 2 species have been identified most frequently in cultures of clinical specimens, mainly blood, pus, urine, and pleural effusion (5).

Studies that have identified Corynebacterium infections or bacteremia to the species level are limited, and most are case reports (6). The largest study to date of Corynebacterium bacteremia investigated 98 cases; however, the species were not identified (7). The largest study that identified Corynebacterium species included 30 cases of true bacteremia in 339 patients with positive blood cultures (8). In our study, we aimed to determine the differences in characteristics and clinical presentations for patients with bacteremia caused by C. striatum, C. jeikeium, or other species of Corynebacterium.

Materials and Methods

Study Design
We retrospectively reviewed electronic medical records and clinical microbiology records of patients with positive blood cultures for Corynebacterium spp. in Kameda Medical Center (Chiba, Japan) during January 2014–May 2020. This facility is an 865-bed, tertiary-care general medical center that provides a wide variety of services including general medicine, surgery, oncology, cardiothoracic surgery, hematopoietic stem cell transplantation, and renal transplantation to ≈310,000 persons each year. All patients with blood cultures positive for any organism are automatically referred to the infectious diseases department for consultation. Board-certified infectious disease physicians evaluate the patients and document the consultation report in medical records. The study protocol was reviewed and approved by the Kameda Medical Center Institutional Review Board (reference no. 20-046). The need for written informed consent was waived. The study complied with the principles of the Declaration of Helsinki.

Study Population
We included all patients at the hospital who had blood cultures positive for Corynebacterium spp. during the study period. We collected data about age, sex, underlying conditions, clinical diagnosis, 90-day mortality rates, species of Corynebacterium, and antimicrobial susceptibility. If the same patient had multiple episodes of Corynebacterium bacteremia during the study period, we included only the first episode.

Definitions
We defined a case as true bacteremia when 2 sets of blood cultures from a patient with signs of infection were positive for Corynebacterium spp. or when 1 set of blood cultures and a clinically relevant specimen from another site (e.g., urine or sputum) where the infection was thought to exist (on the basis of signs/symptoms and examination findings) were both positive for the same species of Corynebacterium. For patients with only 1 set of blood cultures in which Corynebacterium spp. were detected and for whom bacteremia was clinically suspected, new blood cultures were performed, and reevaluated as necessary, before antimicrobial agents were initiated. These patients were carefully followed by our infectious disease physicians to ensure the absence of infection. This definition was based on a previous study (9).

Catheter-related bloodstream infection (CRBSI) was considered definite for patients who met 1 of the following 3 criteria: 1) ≥1 set of blood cultures and semiquantitative cultures of a catheter segment (>15 CFUs/plate) were both positive for the same Corynebacterium species; 2) peripheral blood cultures and blood cultures from a catheter lumen were both positive for the same species of Corynebacterium, and its differential time to positivity was >2 hours (10); or 3)
2 sets of blood cultures were positive for *Corynebacterium* species, and signs of inflammation or purulence were present at the catheter insertion site (11). Diagnosis of other focal infections were based on the US Centers for Disease Control and Prevention National Healthcare Safety Network criteria (12).

We classified a case as no focus when physical examination by infectious disease physicians revealed no localized signs of infection, urinalysis was negative for pyuria or bacteriuria, chest images (radiographs or computed tomography scans) showed no infiltrates or masses, and the case still satisfied the criteria for true bacteremia. Chronic kidney disease was defined as being present when serum creatinine level was >2.0 mg/dL. Liver disease was defined as presence of liver cirrhosis or chronic hepatitis B or C.

**Laboratory Methods**

We used RapID CB Plus (Kyokuto Pharmaceutical Industrial Co. Ltd., https://www.kyokutoseiyaku.co.jp) for bacterial identification during January 2014–May 2015. This kit correctly identifies 95% of *Corynebacterium* isolates to the species level (13). Starting in June 2015, we identified strains by using matrix-assisted laser desorption/ionization time-of-flight mass spectrometry and a Bruker MALDI Biotyper (Bruker Daltonics GmbH, https://www.bruker.com). We used score cutoff values according to recommendations proposed by the manufacturer (>2.0). For some cases in which no identification or ambiguous identification was achieved by these methods, we confirmed identification by using 16S rRNA gene sequence analysis. We performed antimicrobial susceptibility tests by broth microdilution, using Clinical and Laboratory Standards Institute (CLSI, https://clsi.org) M45 A2:2ED 2010 during January 2014–December 2016 and CLSI M45 3rd edition from January 2017 on.

**Statistical Analyses**

We used Fisher exact or Pearson $\chi^2$ tests to compare categorical variables. For continuous variables, we used Mann–Whitney U or paired $t$-tests, and for estimating survival probabilities we used Kaplan-Meier curves. We estimated and compared the cumulative incidence of mortality by using the log-rank test and compared differences in antimicrobial susceptibility between *Corynebacterium* species by using Fisher exact or Pearson $\chi^2$ tests. We considered $p<0.05$ to indicate statistical significance. We performed all statistical analyses by using EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan), a graphical user interface for R (The R Foundation, https://www.r-project.org) (14).

**Results**

**Proportion of True Bacteremia Cases**

Of 115 patients in this study, *C. striatum* was detected in 67 (58%), *C. jeikeium* in 14 (12%), and other *Corynebacterium* species in 34 (30%) patients. The category of other consisted of 15 species (Table 1). In total, there were 60 cases of true bacteremia and 55 cases of contamination, resulting in 52% of patients having true bacteremia. Of the 60 patients with true bacteremia, 55 had >2 sets of positive blood cultures with *Corynebacterium* spp.; 5 had 1 set of positive blood cultures but met the definition of true bacteremia in our study. Of 115 patients, >2 genera of bacteria were detected in blood culture from only 1 patient; this patient had diverticulitis and bacteremia caused by *Corynebacterium* spp. and *Escherichia coli*. The patient recovered after receiving treatment.

**Table 1. Patients with Corynebacterium species detected in blood cultures, Japan, 2014–2020**

| Corynebacterium species | Total, n = 115 | True bacteremia, n = 60 | Contamination, n = 55 |
|-------------------------|---------------|-------------------------|----------------------|
| *C. striatum*           | 67            | 47                      | 20                   |
| *C. jeikeium*           | 14            | 10                      | 4                    |
| Other, total            | 34            | 3                       | 31                   |
| *C. accolens*           | 1             | 0                       | 1                    |
| *C. afermentans*        | 6             | 0                       | 6                    |
| *C. amycloatum*         | 4             | 1                       | 3                    |
| *C. aurimucosum*        | 4             | 0                       | 4                    |
| *C. coyleae*            | 1             | 0                       | 1                    |
| *C. glucuronolyticum*   | 1             | 0                       | 1                    |
| *C. minutissimum*       | 4             | 0                       | 4                    |
| *C. mucifaciens*        | 1             | 0                       | 1                    |
| *C. pseudodiptheriticum*| 1             | 0                       | 1                    |
| *C. resistens*          | 2             | 0                       | 2                    |
| *C. riegliei*           | 1             | 1                       | 0                    |
| *C. simulans*           | 3             | 0                       | 3                    |
| *C. singular*           | 2             | 0                       | 2                    |
| *C. tuberculostearicum* | 2             | 0                       | 2                    |
| *C. urealyticum*        | 1             | 1                       | 0                    |
Mortality rates among patients with true bacteremia

Mortality rates among patients with true bacteremia were 34% among those with bacteremia caused by C. striatum, 30% by C. jeikeium, and 0 by other species of Corynebacterium. We observed no significant differences in survival rates between these groups (C. striatum \( p = 0.25 \) and C. jeikeium \( p = 0.32 \)). Six patients experienced a fulminant course of illness that resulted in death within 7 days; all 6 patients, the causative organism was C. striatum.

**Clinical Diagnosis and Underlying Diseases**

Hematologic malignancy was the most common underlying disease (33%), especially in 64% of patients with C. jeikeium bacteremia, followed by solid tumors (24%) and diabetes mellitus (23%) (Table 2). C. striatum and C. jeikeium were more frequently detected than other species in patients with hematologic malignancy (\( p = 0.036 \) and \( p<0.001 \), respectively) and neutropenia (\( p<0.01 \) and \( p<0.001 \), respectively). Of the 60 patients with true bacteremia, 25 (42%) had infection at an unknown site; 17 (28%) had CRBSI; and 18 (30%) had infection at other foci, including SSTI, pyelonephritis, pneumonia, empyema, infective endocarditis, vertebral osteomyelitis, central venous port infection, and spontaneous bacterial peritonitis.

**Mortality Rates**

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**Antimicrobial Susceptibility**

All tested strains of Corynebacterium, regardless of species, were susceptible to vancomycin, linezolid, and minocycline (Table 3). C. striatum and C. jeikeium were less susceptible than other species to penicillin (\( p<0.001 \) for each), ceftriaxone (\( p<0.001 \) for each), meropenem (\( p<0.001 \) for each), erythromycin (\( p<0.01 \) for each), and ciprofloxacin (\( p<0.001 \) for C. striatum and \( p = 0.02 \) for C. jeikeium).

**Discussion**

With regard to the characteristics of Corynebacterium bacteremia at the species level, we report 3 major findings. First, C. striatum and C. jeikeium each caused true bacteremia more frequently than did other Corynebacterium species. Second, hematologic malignancies were the most common underlying disease in patients with Corynebacterium bacteremia (33%).

### Table 2. Clinical diagnosis and characteristics of patients with Corynebacterium species detected in blood culture, Japan, 2014–2020*

| Variable | All, n = 115 | C. striatum, %, n = 67 | C. jeikeium, %, n = 14 | Other species, %, n = 34 | \( p \) values |
|----------|--------------|-------------------------|------------------------|-------------------------|-------------|
| **Age, y** | 71 | 71 | 66 | 77 | 0.055 | <0.001 |
| **Sex** | | | | | | |
| M | 80 (70) | 51 (76) | 13 (93) | 16 (47) | <0.01 | <0.001 |
| F | 35 (30) | 16 (24) | 1 (7) | 18 (53) | <0.01 | <0.001 |
| **Underlying disease, no. (%)** | | | | | | |
| Diabetes mellitus | 27 (23) | 14 (20) | 2 (14) | 11 (32) | 0.309 | 0.292 |
| Chronic kidney disease | 16 (14) | 9 (13) | 2 (14) | 5 (15) | 1 | 1 |
| Liver disease | 4 (4) | 4 (6) | 0 (0) | 0 (0) | 0.299 | NA |
| Solid tumor | 27 (24) | 13 (19) | 4 (29) | 10 (29) | 0.378 | 1 |
| Leukemia† | 20 (17) | 11 (16) | 8 (57) | 1 (3) | 0.056 | <0.001 |
| Malignant lymphoma‡ | 14 (12) | 8 (12) | 3 (21) | 3 (9) | 0.537 | 0.171 |
| Hematologic malignancy§ | 38 (33) | 24 (36) | 9 (64) | 5 (15) | 0.036 | <0.01 |
| **Underlying condition, no. (%)** | | | | | | |
| Neutropenia, <500 cells/mm\(^3\) | 29 (25) | 19 (28) | 8 (57) | 2 (6) | <0.01 | <0.001 |
| Corticosteroid | 8 (7) | 5 (8) | 2 (14) | 1 (3) | 0.661 | 0.2 |
| Chemotherapy, within 3 mo | 41 (36) | 23 (34) | 10 (71) | 8 (24) | 0.377 | <0.01 |
| **Clinical diagnosis, no. (%)** | | | | | | |
| True bacteremia | 60 (52) | 47 (70) | 10 (71) | 3 (9) | <0.001 | <0.001 |
| No focus | 25 (22) | 19 (29) | 6 (43) | 0 | ND | ND |
| CRBSI | 17 (15) | 13 (19) | 3 (21) | 1 (3) | ND | ND |
| Other focus¶ | 18 (16) | 15 (22) | 1 (7) | 2 (6) | ND | ND |
| Contamination | 55 (48) | 20 (30) | 4 (29) | 31 (91) | <0.001 | <0.001 |

*ALL, acute lymphoid leukemia; AML, acute myeloid leukemia; CRBSI, catheter-related blood stream infection; DLBCL, diffuse large B cell lymphoma; MDS, myelodysplastic syndrome; MM, multiple myeloma; NA, not applicable; ND, not done; IVLBCI, intravascular large B cell lymphoma; PTCL, peripheral T-cell lymphoma.

†No. cases: AML, 17; ALL, 3.
‡No. cases: DLBCL, n = 8; PCTL, n = 3; IVLBCI, n = 1; lymphoplasmaclastic lymphoma, n = 1; Burkitt lymphoma, n = 1.
§No. cases: leukemia, n = 20; lymphoma, n = 14; MM, n = 3; MDS, n = 1; myelofibrosis, n = 2.
¶No. cases: pneumocytis, n = 5; skin and soft tissue infection, n = 4; empyema, n = 2; pneumonia, n = 1; prostateitis, n = 1; infective endocarditis, n = 1; osteomyelitis, n = 1; vascular graft infection, n = 1; central venous port infection, n = 1; spontaneous bacterial peritonitis, n = 1.

SYNOPSIS

for E. coli bacteremia alone; Corynebacterium spp. were considered to be contaminants. The percentages of true bacteremia cases caused by C. striatum (70%) and C. jeikeium (71%) were significantly higher than those for other species (9%; \( p<0.001 \) for each) (Table 2).
Third, although the most common sources of infection were of unknown origin and CRBSI, other sources (e.g., pyelonephritis, SSTI, and empyema) accounted for 30% of true bacteremia cases.

The strengths of our study include having had infectious disease specialists assess infection sites and classify cases as true bacteremia to ensure study quality. Furthermore, detailed clinical and microbiological data were available because we included all cases of Corynebacterium bacteremia in our center over 6 years.

A previous study reported that contamination rates varied among species of Corynebacterium and that C. jeikeium caused true bacteremia more frequently than other species (8). The overall contamination rates of 48% in all patients treated in our study approximated those for 2 previous studies in Japan (46% and 42%) (9,15). However, higher contamination rates were reported in a study performed in Sweden (8), where 93% of these cases were considered to be contaminations and C. afermentans accounted for 14%, C. aurimucosum for 7%, and C. amycolatum for 6% of the total Corynebacterium species detected in blood culture. Our study also demonstrated a high contamination rate of 93% for those species, but our frequency of detection was less than that in the previous study; detection rates in our study were 5% for C. afermentans, 3% for C. aurimucosum, and 3% for C. amycolatum. The difference in contamination rates in both studies may be underpinned by regional differences in the epidemiology of Corynebacterium species. It is plausible that the study populations may differ because the study in Sweden was population based, whereas our study was performed in a tertiary-care hospital. Furthermore, indications for blood culture may differ between these studies.

Bacteremia with C. striatum or C. jeikeium, the most frequently identified species in our study, seemed to be more associated with a higher 90-day mortality rate when compared with other species, although we observed no significant difference. Factors associated with a poor prognosis for Corynebacterium spp. bacteremia are mixed infection, chronic kidney disease, and lack of a central venous catheter (16). However, we are unaware of any study that has reported on differences in mortality rate among patients with infections by different species of Corynebacterium. One study reported that C. striatum formed biofilms on polyurethane catheters in vitro and hypothesized that biofilm may contribute to the establishment of hospital-acquired infections (17). Indeed, biofilm formation has been associated with true bacteremia in another study (18). C. jeikeium has also been reported to form biofilm, which can promote opportunistic infections (19). Although further study is needed, the tendency for C. striatum and C. jeikeium to form biofilm and their association with true bacteremia may be a reason for worse outcomes compared with outcomes for infection with other Corynebacterium species.

All strains of Corynebacterium spp. detected in this study were sensitive to vancomycin, minocycline, and linezolid. A previous study reported that most isolates were resistant to penicillin, ciprofloxacin, and tetracycline, and in contrast, all isolates were sensitive to

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**Table 3. Antimicrobial susceptibility testing of Corynebacterium species isolated from blood culture, Japan, 2014–2020**

| Species          | PEN | CRO | MEM | GEN | CIP | MIN | CLI | ERY | VAN | LZD† |
|------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| C. striatum, n = 67 | 14/67 | 5/67 | 17/67 | 59/67 | 3/67 | 6/67 | 8/67 | 13/67 | 6/67 | 4/4 |
| (21)             | (7)  | (25) | (88) | (4)  | (100) | (12) | (19) | (100) | (100) |
| C. jeikeium, n = 14 | 0/14 | 0/14 | 5/14 | 5/14 | 0/14 | 14/14 | 0/14 | 0/14 | 14/14 | 3/3 |
| (0)              | (0)  | (36) | (36) | (0)  | (100) | (0)  | (0)  | (100) | (100) |
| Other species, n = 34 | 27/34 | 22/34 | 31/34 | 30/34 | 10/34 | 34/34 | 6/34 | 16/34 | 34/34 | 2/2 |
| (79)             | (65) | (91) | (88) | (29) | (100) | (18) | (47) | (100) | (100) |
| All, n = 115     | 41/115 | 27/115 | 53/115 | 94/115 | 13/115 | 115/115 | 14/115 | 29/115 | 115/115 | 9/9 |
| (36)             | (23) | (46) | (82) | (11) | (100) | (12) | (25) | (100) | (100) |

*CIP, ciprofloxacin; CLI, clindamycin; CRO, ceftriaxone; ERY, erythromycin; GEN, gentamicin; LZD, linezolid; MEM, meropenem; MIN, minocycline; PEN, penicillin; VAN, vancomycin.

†Antimicrobial susceptibility testing for linezolid was only performed if requested by physicians.
vancomycin (20). In another study, only a few strains of *C. jeikeium* were resistant to doxycycline (21). The results of our study are consistent with those reports.

The most common underlying disease in patients with *Corynebacterium* bacteremia in our study was hematologic malignancy (33%). Among bacteremic patients with hematologic malignancies, the second most common gram-positive bacteria were *Corynebacterium* spp. (22). *C. striatum* was more likely to cause bacteremia in patients with malignancies or neutropenia (15), and *C. jeikeium* also caused bacteremia, frequently in patients with neutropenia or a history of previous antimicrobial treatment (23). The reason for the higher frequency of *Corynebacterium* bacteremia in patients with hematologic malignancies remains unknown. Among patients with hematologic malignancies, the reported rate of skin or rectal colonization with *Corynebacterium* spp. was 41% (24). We hypothesize that skin and mucosal barrier failures resulting from intense chemotherapy, chronic indwelling infusion catheters, and increased colonization may put patients with hematologic malignancies at a higher risk for *Corynebacterium* bacteremia.

Although the most common sources for *Corynebacterium* bacteremia were unknown or CRBSI, other sources accounted for 30% (18/60 cases), including lower respiratory tract infections, urinary tract infections, and SSTIs. Previous studies have reported that *C. striatum* can cause pneumonia (25), urinary tract infections, and intra-abdominal infections (4). Case studies have also reported *C. jeikeium* as being responsible for infective endocarditis (6), pacemaker infections (26), and prosthetic joint infections (27). *Corynebacterium* spp. are often reported as coryneform and not fully identified unless they are from sterile specimens because they colonize the skin and are ubiquitous in the environment. We emphasize the value of actively identifying coryneforms in specimens, even if they are not sterile (e.g., sputum or urine), especially in suspected cases of *Corynebacterium* bacteremia.

The first limitation of our study is that it was a retrospective single-center study. However, we believe that our results can be generalized to other tertiary institutions because the common species of *Corynebacterium* and susceptibility results obtained in our study do not differ considerably from others (9,20); moreover, our hospital is a referral center providing tertiary care in the region. Second, because of the difficulty of separating true bacteremia from contamination when *Corynebacterium* spp. are detected in blood culture, it is possible that we may have missed patients with true bacteremia. For example, we may have missed a patient with prosthetic valve endocarditis when *Corynebacterium* spp. were detected in only 1 set of blood cultures as a result of previous antimicrobial drug use because it did not meet the criteria for true bacteremia in our study. It is also possible that detection of *Corynebacterium* in 2 sets of blood cultures may actually represent contamination. To minimize the risk of incorrectly categorizing *Corynebacterium* bacteremia into true bacteremia or contamination, each case was carefully discussed during daily rounds and cases were routinely closely followed up with repeated blood culture if deemed necessary. Third, the number of cases of infection with the other 15 species of *Corynebacterium* was small, and the sample size was insufficient to describe the clinical characteristics of bacteremia caused by each of these species. Last, we used RapID CB Plus and matrix-assisted laser desorption/ionization time-of-flight mass spectrometry mainly for identification and performed 16s rRNA sequencing analysis for only a subset of cases.

In conclusion, the proportion of cases of true bacteremia caused by *C. striatum* or *C. jeikeium* was higher than that caused by other *Corynebacterium* species, and the mortality rate for true bacteremia was ≤30%. *C. striatum* and *C. jeikeium* were frequently detected in patients with hematologic malignancies and neutropenia. Healthcare providers should give special consideration to these 2 species of *Corynebacterium* and consider the possibility of true bacteremia rather than contamination when they are detected in blood cultures, especially in patients with hematologic malignancies.

**Acknowledgments**

We thank Muneyoshi Kimura and Atsushi Shiraishi for their support with statistical analyses. We also thank the medical technologists in the Kameda Medical Center for their invaluable technical assistance.

**About the Author**

Dr. Yamamuro is a medical doctor at Kameda Medical Center. His primary research interests include opportunistic infections and immune mechanism in hematologic transplant patients.

**References**

1. von Graevenitz A, Pünter-Streit V, Riegel P, Funke G. Coryneform bacteria in throat cultures of healthy individuals. J Clin Microbiol. 1998;36:2087-8. https://doi.org/10.1128/JCM.36.7.2087-2088.1998
2. Elkayam N, Urazov A, Tuneev K, Chapnick E. *Corynebacterium striatum* bacteremia associated with cellulitis in a patient with cirrhosis. IDCases. 2019;17:e00575. https://doi.org/10.1016/j.idcr.2019.e00575
Corynebacterium Bacteremia, Japan

3. van der Lelie H, Leverstein-Van Hall M, Mertens M, van Zaanen HC, van Oers RH, Thomas BL, et al. Corynebacterium CDC group JK (Corynebacterium jeikeium) sepsis in haematological patients: a report of three cases and a systematic literature review. Scand J Infect Dis. 1995;27:581–4. https://doi.org/10.3109/00365549509047071

4. Lee PP, Ferguson DA Jr, Sarubbi FA. Corynebacterium striatum: an underappreciated community and nosocomial pathogen. J Infect. 2005;50:338–43. https://doi.org/10.1016/j.jinf.2004.05.005

5. Bao R, Gao X, Hu B, Zhou Z. Matrix-assisted laser desorption ionization time-of-flight mass spectrometry: a powerful tool for identification of Corynebacterium species. J Thorac Dis. 2017;9:2329–45. https://doi.org/10.21037/jtd.2017.09.69

6. Rezaei Bookani K, Marcus R, Cheikh E, Parish M, Salahuddin U. Corynebacterium jeikeium endocarditis: a case report and comprehensive review of an underestimated infection. IDCases. 2017;11:26–30. https://doi.org/10.1016/j.idcr.2017.11.004

7. Ghide S, Jiayi, Hachem R, Chaftari AM, Raad I. Catheter-related Corynebacterium bacteremia: should the catheter be removed and vancomycin administered? Eur J Clin Microbiol Infect Dis. 2010;29:153–6. https://doi.org/10.1007/s10096-009-0827-0

8. Rasmussen M, Mohlin AW, Nilsson B. From contamination to infective endocarditis—a population-based retrospective study of Corynebacterium isolated from blood cultures. Eur J Microbiol Infect Dis. 2020;39:113–9. https://doi.org/10.1007/s10096-019-03698-6

9. Yanai M, Ogawasawa M, Hayashi Y, Suzuki K, Takahashi H, Satomura A. Retrospective evaluation of the clinical characteristics associated with Corynebacterium species bacteremia. Braz J Infect Dis. 2018;22:24–9. https://doi.org/10.1016/j.bjid.2017.12.002

10. Raad I, Hanna HA, Alakech B, Chatzinikolaou I, Johnson MM, Tarrand J. Differential time to positivity: a useful method for diagnosing catheter-related bloodstream infections. Ann Intern Med. 2004;140:18–25. https://doi.org/10.7326/0003-4819-140-1-200401060-00007

11. Mermel LA, Allon M, Bouza E, Craven DE, Flynn P, et al. Clinical practice guideline for the diagnosis and management of intravascular catheter-related infection: 2009 update by the Infectious Diseases Society of America. Clin Infect Dis. 2009;49:1–45. https://doi.org/10.1086/599376

12. Horan TC, Andrus M, Dudeck MA. CDC/NHSN surveillance definition of health care-associated infection and criteria for specific types of infections in the acute care setting. Am J Infect Control. 2008;36:309–32. https://doi.org/10.1016/j.jic.2008.03.002

13. Hudspeth MK, Hunt Gerardo S, Citron DM, Goldstein EJ. Evaluation of the RapID CB Plus system for identification of Corynebacterium species and other gram-positive rods. J Clin Microbiol. 1998;36:543–7. https://doi.org/10.1128/JCM.36.2.543-547.1998

14. Kanda Y. Investigation of the freely available easy-to-use software ‘EZR’ for medical statistics. Bone Marrow Transplant. 2013;48:452–8. https://doi.org/10.1038/bmt.2012.244

15. Ishiwada N, Watanabe M, Murata S, Takeuchi N, Taniguchi T, Igarashi H. Clinical and bacteriological analyses of bacteremia due to Corynebacterium striatum. J Infect Chemother. 2016;22:790–3. https://doi.org/10.1016/j.jiac.2016.08.009

16. Kimura SI, Gomyo A, Hayakawa J, Akahoshi Y, Harada N, Ugli T, et al. Clinical characteristics and predictive factors for mortality in coryneform bacteria bloodstream infection in hematological patients. J Infect Chemother. 2017;23:148–53. https://doi.org/10.1016/j.jiac.2016.11.007

17. Souza C, Faria YV, San′Anno LO, Viana VG, Seabra SH, Souza MC, et al. Biofilm production by multiresistant Corynebacterium striatum associated with nosocomial outbreak. Mem Inst Oswaldo Cruz. 2015;110:242–8. https://doi.org/10.1590/0074-02760140373

18. Kang SJ, Choi SM, Choi JA, Choi JU, Oh TH, Kim SE, et al. Factors affecting the clinical relevance of Corynebacterium striatum isolated from blood cultures. PLoS One. 2018;13:e0199454. https://doi.org/10.1371/journal.pone.0199454

19. Kwaszezska AK, Brewczyńska A, Szczyzcyk EM. Hydrophobicity and biofilm formation of lipophilic skin corynebacteria. Pol J Microbiol. 2006;55:189–93.

20. Dragomirescu CC, Lixandru BE, Coldea IL, Corneli ON, Fana M, Palade AM, et al. Antimicrobial susceptibility testing for Corynebacterium species isolated from clinical samples in Romania. Antibiotics (Basel). 2020;9:31. https://doi.org/10.3937/antibiotics9010031

21. Soriano F, Zapardiel J, Nieto E. Antimicrobial susceptibilities of Corynebacterium species and other non-spore-forming gram-positive bacilli to 18 antimicrobial agents. Antimicrob Agents Chemother. 1995;39:208–14. https://doi.org/10.1128/AAC.39.1.208

22. Kara Ö, Zarakolu P, Aşıçöglu S, Etiğül S, Uz B, Büyükaşık Y, et al. Epidemiology and emerging resistance in bacterial bloodstream infections in patients with hematologic malignancies. Infect Dis (Lond). 2015;47:686–93. https://doi.org/10.1111/sid.12442.2015.1051105

23. Rozdzinski E, Kern W, Schmeiser T, Kurrle E. Corynebacterium jeikeium bacteremia at a tertiary care center. Infection. 1999;19:201–4. https://doi.org/10.1007/BF01644945

24. Stamm WE, Tompkins LS, Wagner KF, Counts GW, Daniel ED, Meyers JD. Infection due to Corynebacterium species in marrow transplant patients. Ann Intern Med. 1979;91:167–73. https://doi.org/10.7326/0003-4819-91-2-167

25. Shariff M, Aditi A, Beri K. Corynebacterium jeikeium: an emerging respiratory pathogen. J Infect Dev Ctries. 2018;12:581–6. https://doi.org/10.3855/jidc.10406

26. Bechara C, Gousseff M, Passeron A, Pochot J, et al. Corynebacterium jeikeium pacemaker infection associated with antineutrophil cytoplasmic antibodies: a single positive blood culture could be sufficient for diagnosis. J Med Microbiol. 2011;60:249–51. https://doi.org/10.1099/jmm.0.025283-0

27. Cazanave C, Greenwood-Quaintance KE, Hanssen AD, Patel R. Corynebacterium pseudotuberculosis as a cause of infection due to Corynebacterium striatum. J Clin Microbiol. 2012;50:1518–6. https://doi.org/10.1128/JCM.06439-11

Address for correspondence: Ryosuke Yamamuro, Department of Infectious Disease, Kameda Medical Center, 929 Higashi-cho, Kamogawa Chiba, 296-8602, Japan; email: xurrma38@gmail.com