Extensively drug-resistant Alcaligenes faecalis infection

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Research article

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Abstract

**Background:** Alcaligenes faecalis is usually causes opportunistic infections in humans. Alcaligenes faecalis infection is often difficult to treat due to its increased resistance to several antibiotics. The results from a clinical study of patients with Alcaligenes faecalis infection may help improve patients’ clinical care.

**Methods:** We conducted a retrospective analysis of all patients presenting with Alcaligenes faecalis infection from January 2014 to December 2019. The medical records of all patients were reviewed for demographic information, clinical symptoms and signs, comorbidities, use of intravenous antibiotics within the past three months, bacterial culture, antibiotics sensitivity test, and clinical outcomes.

**Results:** Sixty-one cases of Alcaligenes faecalis infection were seen during the study period, including 25 cases of cystitis, nine cases of diabetic foot infection, eight cases of pneumonia, seven cases of acute pyelonephritis, three cases of bacteremia, and nine cases of infection at specific sites. Thirty-seven patients (60.7%) had a history of receiving intravenous antibiotics within three months of the diagnosis. Fifty-one (83.6%) cases were mixed with other bacterial infections. Extensively drug-resistant infections have been reported since 2018. The best sensitivity rate to A. faecalis was 66.7% for three antibiotics (imipenem, meropenem, and ceftazidime) in 2019. Two antibiotics (ciprofloxacin and piperacillin/tazobactam) sensitivity rates to A. faecalis were less than 50%.

**Conclusions:** The most frequent Alcaligenes faecalis infection sites, in order, are the bloodstream, urinary tract, skin and soft tissue, and middle ear. The susceptibility rate of Alcaligenes faecalis to commonly used antibiotics is decreasing. Extensively drug-resistant Alcaligenes faecalis infections have emerged.

Introduction

Alcaligenes faecalis (A. faecalis) is a Gram-negative, obligate aerobic, oxidase-positive, catalase-positive, and nonfermenting bacterium. It is commonly found in soil, water, and in hospital settings, such as in respirators, hemodialysis systems, and intravenous solutions [1-2]. It is a potentially emerging pathogen and usually causes opportunistic infections in humans. The organism has been isolated from a range of clinical materials, such as urine, blood, wound discharge, stool, cerebrospinal fluid, and respiratory secretions [3-6]. A. faecalis has been associated with endocarditis, bacteremia, meningitis, endophthalmitis, skin and soft tissue infections, urinary tract infections, otitis media, peritonitis, and pneumonia [1,2,7-28]. A. faecalis infection is often difficult to treat due to its increased resistance to several antibiotics, such as anti-pseudomonas penicillin, cephalosporins, carbapenems, aminoglycosides, and quinolones [17,23,24,26]. Optimal antibiotic therapy for A. faecalis has not been well established in the literature. We report the results of a clinical study of patients with A. faecalis infection. This study aims to emphasize the emergence of extensively drug-resistant A. faecalis and to provide local susceptibility data for the same.
Materials And Methods

Study design

We conducted a retrospective analysis of all patients presenting with A. faecalis infection who were admitted to Dalin Tzu Chi Hospital from January 2014 to December 2019. Patients were diagnosed with A. faecalis infection when their clinical symptoms and signs indicated infection.

Data collection

The data were obtained from the hospital's clinical information system, microbiology laboratory report system, and medical chart review. We obtained details on all A. faecalis infections (including community-onset infection and hospital-acquired infection), patient demographics, clinical symptoms and signs, details of hospital course, comorbidities, prior intravenous antibiotic use within 90 days, bacterial cultures, antibiotics sensitivity tests, and clinical outcomes.

Antibiotic susceptibility

Antibiotic susceptibility was tested using the VITEK® II system with VITEK® II Gram Negative Susceptibility cards (bioMérieux, Marcy-l’Étoile, France) with Clinical & Laboratory Standards Institute interpretive criteria M100-25. A sterile swab stick was used to transfer a sufficient number of colonies of pure culture and to suspend the microorganisms in 3.0 ml of sterile saline (aqueous 0.45% to 0.50% NaCl, pH 4.5 to 7.0) in a clear plastic test tube. The turbidity was adjusted to 0.50-0.63 McFarland equivalence turbidity standard. The identification cards were inoculated with microorganism suspensions, using an integrated vacuum apparatus. A test tube containing the microorganism suspension was placed into a cassette. One Gram-negative (GN) identification card (offering automated identification of 135 taxa of the most significant fermenting and nonfermenting GN bacilli) and another VITEK II AST-N322 card (for susceptibility testing of aerobic GN bacilli against specified antimicrobials) were placed in the neighboring slots, along with the transfer tube and the corresponding suspension tube. Calculations were performed on raw data and compared to thresholds to determine the reactions for each test. The complete list of antibiotics used in susceptibility testing for A. faecalis, including piperacillin, piperacillin-tazobactam, ceftazidime, cefepime, cefotaxime, ceftriaxone, ampicillin-sulbactam, imipenem, meropenem, gentamicin, amikacin, ciprofloxacin, levofloxacin in our microbiology laboratory which was reference from clinical and laboratory standards institute (30th edition). Our microbiology laboratory susceptibility test report for A. faecalis included piperacillin-tazobactam, ceftazidime, cefepime, imipenem, meropenem, gentamicin, amikacin, ciprofloxacin, and ampicillin-sulbactam. If the susceptibility test showed resistant to all antibiotics, tigecycline susceptibility in A. faecalis would be done by the disc diffusion method.

We also searched PubMed and google scholar for topics related to Alcaligenes faecalis with no language restrictions.

The definition of MDR/XDR cites the literature of Maggiorakos et al. [29]
Study ethics and consent procedure

Our study was a retrospective analysis of medical records. The six-year study represented the lowest risk to the research subjects, and all information was made anonymous before being made available for research. The project was approved by the Buddhist Dalin Tzu Chi General Hospital Research Ethics Committee (Approved IRB No. B10802024), which exempted the study from the requirement for informed consent.

Statistical analysis

Continuous variables were expressed as mean ± standard deviation or median (range), whereas categorical variables were expressed as frequencies and percentages. The trend in change of antimicrobial susceptibility analyzed by linear-by-linear association in chi-square test. All statistical analyses were conducted using the statistical package SPSS for Windows (Version 17.0, SPSS, Inc., Chicago, IL, USA). A p-value <0.05 was considered statistically significant.

Results

Sixty-one cases of A. faecalis infection were identified during the study, including 25 cases of cystitis, nine cases of diabetic foot ulcer with infection, eight cases of pneumonia, seven cases of acute pyelonephritis (APN), three cases of bacteremia, and nine cases of infection at specific sites. There were nine hospital-acquired infections cases, including three cases of diabetic foot ulcer with infection, two cases of pneumonia, one case of pleural empyema, one case of peritonitis, one case of surgical wound infection, and one case of leg burn wound infection. Thirty-one community-onset infection cases (31/52=59.6%) had a history of previous hospitalisation within 90 days. Thirty-seven patients (60.7%) had a history of intravenous antibiotic use within the past 90 days. The most commonly used antibiotics were ceftazidime (11 cases) and levofloxacin (ten cases). There were only two cases of receipt of antibiotics during the same hospitalisation but before the onset of A. faecalis infection, including one case of prolonged mechanical ventilation with pneumonia and one case of peritonitis. The length of stay before A. faecalis isolation of the two cases were 190 days and 22 days, respectively. Fifty-one (83.6%) cases were mixed with other bacterial infections. The most common mixed infection pathogens were Enterococcus species (nine cases), Proteus vulgaris (nine cases), and Pseudomonas aeruginosa (eight cases).

Cystitis with A. faecalis (table 1)

Table 1: Bacteriology and clinical outcome in twenty-five cases of Alcaligenes faecalis infection cystitis
|        | Case 1 | Case 2 | Case 3 | Case 4 | Case 5 | Case 6 | Case 7 | Case 8 | Case 9 |
|--------|--------|--------|--------|--------|--------|--------|--------|--------|--------|
| Year   | 2014   | 2014   | 2014   | 2014   | 2014   | 2014   | 2015   | 2015   | 2015   |
| Catheter related cystitis | No     | No     | Yes    | Yes    | Yes    | Yes    | Yes    | Yes    | Yes    |
| Prior intravenous antibiotic use within 90 days | No     | No     | No     | No     | FEP    | unknown (other hospital) | No     | No     | No     |
| Antibiotic therapy | MXF    | LVX    | LVX    | FEP    | ETP    | CTX    | FEP    | MXF    | CAZ    |
| Outcome | cure   | cure   | cure   | cure   | dead   | dead   | cure   | cure   | cure   |

|                     | GEN | AMK | CAZ | FEP | SAM | TZP | CIP | IPM | MEM | TGC |
|---------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|                     | S   | S   | S   | S   | S   | S   | S   | S   | S   | S   |
| Results of antibiotics sensitivity test of Alcaligenes faecalis | S   | S   | S   | S   | S   | R   | S   | S   | R   | R   |
|                     | S   | S   | S   | S   | S   | S   | S   | S   | S   | S   |
|                     | S   | S   | S   | S   | S   | S   | S   | S   | S   | S   |
|                     | S   | S   | S   | S   | S   | S   | S   | S   | S   | S   |
|                     | S   | S   | S   | S   | S   | S   | S   | S   | S   | S   |
|                     | S   | S   | S   | S   | S   | S   | S   | S   | S   | S   |
|                     | S   | S   | S   | S   | S   | S   | S   | S   | S   | S   |
|                     | S   | S   | S   | S   | S   | S   | S   | S   | S   | S   |
|                     | S   | S   | S   | S   | S   | S   | S   | S   | S   | S   |
|                     | S   | S   | S   | S   | S   | S   | S   | S   | S   | S   |

|                     | GEN | AMK | CAZ | FEP | SAM | TZP | CIP | IPM | MEM | TGC |
|---------------------|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
|                     | S   | S   | S   | S   | S   | S   | S   | S   | S   | S   |
|                     | S   | S   | S   | S   | S   | S   | S   | S   | S   | S   |
|                     | S   | S   | S   | S   | S   | S   | S   | S   | S   | S   |
|                     | S   | S   | S   | S   | S   | S   | S   | S   | S   | S   |
|                     | S   | S   | S   | S   | S   | S   | S   | S   | S   | S   |
|                     | S   | S   | S   | S   | S   | S   | S   | S   | S   | S   |
|                     | S   | S   | S   | S   | S   | S   | S   | S   | S   | S   |
|                     | S   | S   | S   | S   | S   | S   | S   | S   | S   | S   |
|                     | S   | S   | S   | S   | S   | S   | S   | S   | S   | S   |
|                     | S   | S   | S   | S   | S   | S   | S   | S   | S   | S   |

Mixed infection pathogens

| Pathogen                        | V     |
|---------------------------------|-------|
| Enterococcus spp                | V     |
| Proteus vulgaris                | V     |
| Citrobacter koseri              | V     |
| Klebsiella pneumoniae           | V     |
| Providencia rettgeri            | V     |
| Non-fermentative GNB            | V     |

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|                          | Case 10 | Case 11 | Case 12 | Case 13 | Case 14 | Case 15 | Case 16 | Case 17 |
|--------------------------|---------|---------|---------|---------|---------|---------|---------|---------|
| year                     | 2015    | 2015    | 2015    | 2016    | 2016    | 2016    | 2016    | 2016    |
| catheter related cystitis| Yes     | No      | No      | No      | Yes     | No      | Yes     | No      |
| prior intravenous antibiotic use within 90 days | No | LVX | CAZ | CRO | LVX | LVX | NO | No |
| Antibiotics therapy      | CMZ     | SAM     | LVX     | ETP     | CAZ     | LVX     | LVX     | ETP     |
| outcome                  | cure    | cure    | cure    | cure    | cure    | cure    | cure    | cure    |

Results of antibiotics sensitivity test of *Alcaligenes faecalis*

| Drug | Case 10 | Case 11 | Case 12 | Case 13 | Case 14 | Case 15 | Case 16 | Case 17 |
|------|---------|---------|---------|---------|---------|---------|---------|---------|
| GEN  | S       | S       | S       | R       | S       | NIL     | NIL     | S       |
| AMK  | S       | S       | S       | S       | S       | NIL     | NIL     | S       |
| CAZ  | S       | S       | S       | S       | S       | NIL     | NIL     | S       |
| FEP  | S       | S       | S       | S       | S       | NIL     | NIL     | S       |
| SAM  | S       | S       | S       | S       | S       | NIL     | NIL     | S       |
| TZP  | S       | R       | S       | R       | S       | NIL     | NIL     | R       |
| CIP  | S       | R       | S       | R       | R       | NIL     | NIL     | R       |
| IPM  | S       | S       | S       | S       | S       | NIL     | NIL     | S       |
| MEM  | S       | S       | S       | S       | S       | NIL     | NIL     | S       |
| TGC  | NA      | NA      | NA      | NA      | NA      | NA      | NA      | NA      |

Mixed infection pathogens

| Pathogen                  | Case 10 | Case 11 | Case 12 | Case 13 | Case 14 | Case 15 | Case 16 | Case 17 |
|---------------------------|---------|---------|---------|---------|---------|---------|---------|---------|
| Chryseobacterium meningosepticum | V |         |         |         |         |         |         |         |
| Serratia marcescens       |         |         |         |         |         |         |         |         |
| Providencia stuartii      |         |         |         |         |         |         |         |         |
| Escherichia coli          |         |         |         |         |         |         |         |         |
Twenty-five cases of A. faecalis cystitis were seen during the study period, which accounts for 41% of A. faecalis infections in this report. There were ten females and 15 males in our study. The mean age was 76.9 years (range: 25 to 98 years). Sixteen cases (64%) were catheter related cystitis. One patient had no comorbidity, while 24 patients had comorbidities such as diabetes mellitus, hypertension, dementia, cerebrovascular accident and chronic kidney disease (supplement). The most common was neurologic comorbidity (18 cases). Fourteen patients had a history of intravenous antibiotic exposure within the past 90 days. Nineteen patient urine cultures displayed polymicrobial infection. The most common mixed infectious pathogen was Providencia species (five cases). The antibiotics sensitivity test showed no presence of extensively drug-resistant (XDR) A. faecalis. Two patients died from urosepsis. Twenty-three patients were treated with adequate antibiotics therapy and were discharged in excellent condition.

**Acute pyelonephritis (table 2)**
Table 2: Bacteriology and clinical outcome in seven cases of Alcaligenes faecalis acute pyelonephritis

| Year          | Case 1 | Case 2 | Case 3 | Case 4 | Case 5 | Case 6 | Case 7 |
|---------------|--------|--------|--------|--------|--------|--------|--------|
| 2014          |        |        |        |        |        |        |        |
| 2014          |        |        |        |        |        |        |        |
| 2015          |        |        |        |        |        |        |        |
| 2015          |        |        |        |        |        |        |        |
| 2016          |        |        |        |        |        |        |        |
| 2017          |        |        |        |        |        |        |        |
| 2017          |        |        |        |        |        |        |        |

Prior intravenous antibiotic use within 90 days

- No
- Unknown (other hospital)
- No
- ETP
- ETP
- AMC
- ETP
- CFZ

Antibiotics therapy

- SAM
- CIP
- CIP
- LVX
- ETP
- ETP
- TEC
- ERT

Outcome

- cure
- cure
- cure
- cure
- cure
- cure
- cure

Results of antibiotics sensitivity test of Alcaligenes faecalis

| GEN | AMK | CAZ | FEP | SAM | TZP | CIP | IPM | MEM | TGC |
|-----|-----|-----|-----|-----|-----|-----|-----|-----|-----|
| S   | S   | S   | S   | S   | S   | S   | S   | S   | S   |
| S   | S   | S   | S   | S   | S   | S   | S   | S   | S   |
| S   | S   | S   | S   | S   | S   | S   | S   | S   | S   |
| S   | S   | S   | S   | S   | S   | S   | S   | S   | S   |
| S   | S   | S   | S   | R   | S   | S   | R   | S   | S   |

| Mixed infection pathogens |
|----------------------------|
| Proteus vulgaris           | V   | V   |
| Escherichia coli          | V   |     |
| Klebsiella pneumoniae     |     | V   |
| Providencia rettgeri      | V   | V   | V   |
| Enterococcus              |     |     | V   |

Seven patients (six females and one male) with A. faecalis acute pyelonephritis were seen during the study. The mean age was 75.4 years (range: 63 to 85 years). All seven patients had a risk of obstructive uropathy (four cases of cervical carcinoma, two cases of renal stones, and one case of right ureteral cancer). Four patients had a history of intravenous antibiotic exposure within the past 90 days. Six patient urine cultures displayed polymicrobial infection. The most common mixed infectious pathogen was Providencia rettgeri, which affected three patients. The antibiotic sensitivity test showed no presence of XDR A. faecalis. All patients received adequate IV antibiotic therapy, and all were discharged from the hospital in excellent condition.

Diabetic foot ulcer with A. faecalis infection (table 3)

Table 3: Bacteriology and clinical outcome in nine cases of diabetic foot ulcer with Alcaligenes faecalis infection
Six male patients and three female patients had diabetic foot ulcers with A. faecalis infection. The mean age was 57.2 years (range: 41 to 85 years). All patients had other comorbidities. All patients’ foot ulcer lesions were chronic (range: 14 days to 18 months). Two patients had no history of prior intravenous antibiotic use within 90 days. All patients’ wound cultures displayed polymicrobial infection. The antibiotics sensitivity test showed the presence of XDR A. faecalis infection beginning in 2019. All patients required surgical intervention. The wounds did not heal in three patients.

**Pneumonia (table 4)**

**Table 4:** Bacteriology and clinical outcome in eight cases of Alcaligenes faecalis pneumonia
Eight cases (six males, two females) of A. faecalis pneumonia were seen during the study period. The mean age was 70.0 years (range: 51-83 years). All eight patients were at risk of pneumonia (three patients had malignancies, one had end-stage renal disease, and four patients were bed-ridden with neurologic deficits). One patient had no history of prior intravenous antibiotic use within 90 days. Six patient sputum cultures displayed polymicrobial infection. The antibiotics sensitivity test showed the presence of XDR A. faecalis beginning in 2018. Two patients died from A. faecalis pneumonia. Six patients received adequate intravenous antibiotics therapy and were discharged in excellent condition.

**Bacteremia (no concurrent primary site of infection)**

Three patients developed bacteremia during the study period. These three patients included a 78-year-old male, a bedridden stroke survivor; an 81-year-old male, a bedridden dementia; and an 81-year-old female with cholangiocarcinoma and dementia. The two male patients had a history of intravenous antibiotic exposure within the past 90 days. Two patients’ blood cultures displayed polymicrobial infection (one patient had a mixed infection with Enterococcus faecalis, and another patient had a mixed infection with Morganella morganii). Antibiotic sensitivity tests showed no presence of XDR A. faecalis. All patients received adequate antibiotics therapy and were discharged in excellent condition. Nine specific sites of A. faecalis infection cases are shown in Table five. The trend in change of antimicrobial susceptibility
analyzed by linear-by-linear association in chi-square test (Table 6). The susceptibility rate of A. faecalis to commonly used antibiotics (except ciprofloxacin and cefepime) is decreasing year by year.

| Case | Case | Case | Case | Case | Case | Case | Case | Case |
|------|------|------|------|------|------|------|------|------|
| year | 2016 | 2018 | 2017 | 2019 | 2015 | 2016 | 2016 | 2019 |
| prior intravenous antibiotic use within 90 days | NIL | AMC | No | No | CAZ | CIP | MEM | No |
| Antibiotics therapy | MXF | AMC | CAZ | OFX | SXT | CAZ | CFZ | CTB |
| outcome | cure | cure | cure | cure | cure | cure | cure | cure |

Results of antibiotics sensitivity test of Alcaligenes faecalis

| GEN | R | S | S | S | S | S | R | NIL |
|-----|---|---|---|---|---|---|---|-----|
| AMK | S | S | S | S | S | S | NIL | NIL |
| CAZ | R | S | S | S | S | S | R | NIL |
| FEP | R | S | S | S | S | S | R | NIL |
| SAM | R | S | S | S | S | S | R | NIL |
| TZP | R | S | S | S | S | S | R | NIL |
| CIP | R | S | S | R | R | S | NIL | NIL |
| IPM | S | S | S | S | S | S | NIL | NIL |
| MEM | S | S | S | S | S | S | NIL | NIL |
| TGC | NA | NA | NA | NA | NA | NA | NA | NA |

Mixed infection pathogens

| Enterococcus | V |
| Proteus vulgaris | V |
| Enterobacter cloacae | V |
| Pseudomonas aeruginosa | V |
| Acinetobacter baumannii | V |
| Escherichia coli | V |
| Serratia marcesens | V |
| Providencia stuartii | V |
| MSSA | V |
| Streptococcus group D | V |
| Aeromonas hydrophila | V |

Case 1 and case 2: Pleural empyema, Case 3 and case 4: otitis media, Case 5: peritonitis, Case 6: surgical wound infection, Case 7: pelvis abscess, Case 8: scrotum abscess, Case 9: burn wound infection.

Table 6: The trend in change of antimicrobial susceptibility to Alcaligenes faecalis analyzed by linear-by-linear association in chi-square test
| Antibiotics/year (number of patients) | 2014 (12) | 2015 (13) | 2016 (9) | 2017 (9) | 2018 (7) | 2019 (9) | M² | P value |
|-----------------------------------|----------|----------|----------|----------|----------|----------|-----|---------|
| CAZ                               | 100%     | 92.3%    | 77.8%    | 88.7%    | 85.7%    | 66.7%    | 4.063 | 0.044   |
| GEN                               | 100%     | 84.6%    | 55.6%    | 77.8%    | 71.4%    | 55.6%    | 5.144 | 0.023   |
| AMK                               | 100%     | 84.6%    | 100%     | 100%     | 85.7%    | 55.6%    | 5.837 | 0.016   |
| CIP                               | 50.0%    | 61.5%    | 22.2%    | 22.2%    | 42.9%    | 33.3%    | 1.589 | 0.207   |
| IMP                               | 100%     | 100%     | 100%     | 100%     | 85.7%    | 66.7%    | 9.042 | 0.003   |
| SAM                               | 100%     | 84.6%    | 77.8%    | 88.7%    | 85.7%    | 55.6%    | 4.622 | 0.032   |
| FEP                               | 83.3%    | 76.9%    | 77.8%    | 66.7%    | 71.4%    | 55.6%    | 2.028 | 0.154   |
| MEM                               | 100%     | 100%     | 100%     | 100%     | 85.7%    | 66.7%    | 9.042 | 0.003   |
| TZP                               | 100%     | 84.6%    | 33.3%    | 42.4%    | 57.1%    | 33.3%    | 11.713 | 0.001   |

**Discussion And Literature Review**

According to the literature, there were 130 sporadically reported cases of *A. faecalis* infection (table 7) [1,2,7-28,31-46]. The most commonly reported cases involved bacteremia, and most cases occurred in newborns and infants. In 1960, Doxiadis reported 33 cases of bacteremia in newborns, which was the largest case series of *A. faecalis* bacteremia [40]. *A. faecalis* was resistant to sulfonamides, and there were 20 deaths due to *A. faecalis* bacteremia. Fillipe reported 20 cases of chronic otitis media in Angola [19]. The use of bird feces by residents as a traditional remedy to prevent ear discharge was related to these *A. faecalis* chronic otitis media cases. The other infections from *A. faecalis* that have been reported in prior studies, in order of occurrence, were meningitis, skin and soft tissue infection (SSTI), and UTI. In our series, the most frequent cases were, in order of occurrence, UTI, SSTI, and pneumonia. The cases reported in the literature and our cases indicate that the most frequent *A. faecalis* infection sites, in order, are the bloodstream, urinary tract, skin and soft tissue (diabetic foot ulcer accounts for 56.5% of skin and soft tissue infections), and middle ear.

**A. faecalis isolation in mixed culture as a pathogen or contaminant**

In Tena’s report, two out of five skin and soft tissue *A. faecalis* cases were mixed with other bacterial infections [17]. In Filipe's series, all 20 *A. faecalis* otitis media cases were mixed with other bacterial infections [19]. Kahveci reported a case of *A. faecalis* peritonitis and concluded that it was important to view *A. faecalis* as a pathogen rather than a contaminant [15]. Junejo notes that it is evident that any organism found in the culture should not be completely disregarded and marked as a contaminant. [23]. Al-Zakhari explains that serious illnesses and even death can be caused by *A. faecalis*. Therefore, rather than a contaminant, *A. faecalis* should be regarded as a pathogen, because global cases of life-threatening infections caused by *A. faecalis* are emerging [27]. In 2017, Laham reported a clinical sample study of an *A. faecalis* strain isolated from two outpatients and three inpatients, including four wounds cultures and one urine culture [47]. However, this study was only conducted for a three-month period. In
2013, Khajuria reported a total of 15 clinical isolates of A. faecalis specimens such as urine, pus, blood, and body fluids [48]. We believe that many cases of A. faecalis infections cases exist but have not been reported in the literature. Our series of A. faecalis infection cases were about 10 cases every year, which was only a small fraction of the infectious diseases in our hospital. We concur with Junejo and believe A. faecalis to be an infectious pathogen rather than contaminant. In our series, the majority of cultures were mixed with other well-established pathogens. However, one should consider that A. faecalis may be a contaminant in some cases, particularly for those who were cured despite lack of active treatment.

The trend of antibiotic sensitive rate of A. faecalis

In 1997, Bizet first reported that A. faecalis strains were resistant to amoxicillin, ticarcillin, and gentamicin [1]. Amoxicillin-clavulanic acid and cefotaxime provided a successful treatment outcome for patients with A. faecalis infection. In 2000, Pereira reported that a strain of A. faecalis resistant to expanded-spectrum beta-lactamase cephalosporins was isolated from the urine of an inpatient [2]. In 2005, Dubois described the isolation of A. faecalis with ESBL in a patient with a concurrent urinary tract infection [11]. In 2017 and 2018, two cases of XDR A. faecalis pneumonia were reported by Agarwal and Junejo [22,23]. In 2019, Hasan reported that a 60-year-old female with pandrug-resistant A. faecalis bacteremia who was treated with double-dose tigecycline had a successful treatment outcome [26]. Three articles on pandrug-resistant A. faecalis were published in 2020. Al-Zakhari reported a fatal case of cavitary pneumonia caused by pandrug-resistant A. faecalis. The patient died despite the aggressive antibiotic treatment (linezolid and polymyxin B) [27]. Majewski reported a pandrug-resistant A. faecalis hospital acquired urinary tract infection patient; the patient died in hospital [28]. Ngbede identified mobile colistin resistance genes in Alcaligenes faecalis from human clinical samples [30].

In March 2015, the strain A. faecalis exhibited sensitivity only to imipenem and meropenem in a pneumonia patient in our hospital. In May 2018, a strain of XDR A. faecalis susceptible only to tigecycline was isolated from a pneumonia patient. There were four cases with XDR A. faecalis infection in our series, including two cases of pneumonia and two cases of diabetic foot infection.

In view of individual antibiotics, ciprofloxacin revealed a very low susceptibility rate of A. faecalis from 2014 to 2019. Piperacillin/tazobactam was effective in significantly decreasing the susceptibility rate of A. faecalis since 2016. Emerging resistant strains of A. faecalis to imipenem and meropenem have been found since 2018. A high resistance rate of many antibiotics was also found in 2019. The best sensitivity rate to A. faecalis was 66.7% for three antibiotics (imipenem, meropenem, and ceftazidime). In two antibiotics (ciprofloxacin and piperacillin/tazobactam) sensitivity rates to A. faecalis were less than 50%.

Based on our prior experience, we selected an appropriate antibiotic for a susceptible A. faecalis infection patient according to the results of his or her antibiotics sensitivity test. If the A. faecalis organism is an ESBL strain, carbapenem is an appropriate antibiotic. Four articles mentioned that A. faecalis is susceptible to colistin [8,19,22,23]. Data was not available regarding A. faecalis susceptibility to colistin in this study. If the A. faecalis is an XDR strain, we recommend that tigecycline is effective to XDR A. faecalis.
Treatment failure of *A. faecalis* infection cases

Among our reported cases of *A. faecalis* infection, there were seven treatment failure cases, including two cases of pneumonia, two cases of cystitis complicated with sepsis, and three cases of diabetic foot infection. The overall treatment failure rate was 11.5%. *A. faecalis* is a low virulence bacterium. With adequate intravenous antibiotic therapy, patients with *A. faecalis* infection will typically experience a positive treatment outcome.

Patients were cured with non-covering regimens

Four cases were cured with non-covering antibiotics, including two cases of diabetic foot infection, one case of pleural empyema, and one case of surgical wound infection. The four cases had received appropriate wound care, adequate abscess drainage, and surgical intervention which may be crucial for curing of infections.

Limitations

Our clinical study of *A. faecalis* infection was a small case series and therefore can provide only minimal clinical experience. Additional case series reports of *A. faecalis* infection will add to the knowledge of how to treat *A. faecalis* infection. Misidentification of *Acinetobacter baumannii* as *Alcaligenes faecalis* by VITEK II system was reported in the literature [49]. Matrix-assisted laser desorption ionization time of flight mass spectrometry and 16S rRNA sequencing are helpful for the accurate identification between these two species [50]. However, we cannot perform the two methods to confirm the isolates in our hospital. If the culture is XDR *A. faecalis*, matrix-assisted laser desorption ionization time of flight mass spectrometry and 16S rRNA sequencing can be performed. An accurate distinction between *Acinetobacter baumannii* and *A. faecalis* has substantial clinical significance.

Conclusions

*A. faecalis* exhibited decreasing sensitivity rate to commonly used antibiotics in 2019. Extensively drug-resistant *Alcaligenes faecalis* infections have emerged recently. We select an antibiotic for patients susceptible to *A. faecalis* infection based on the results of the antibiotics sensitivity test. With adequate intravenous antibiotic therapy, patients with *A. faecalis* infection will typically experience a positive treatment outcome.

Abbreviations

AMP(ampicillin), SAM(ampicillin-sulbactam), AMX(amoxicillin), AMC(amoxycillin-clavulanic acid), CFZ(cefazolin), CMZ(cefmetazole), CXM(cefuroxime), CRO(ceftriaxone), CTX(ceftaxime), CTB(ceftibuten), CAZ(ceftazidime), FEP(cefepime), GEN(gentamicin), AMK(amikacin), OFX(ofloxacin), CIP(ciprofloxacin), MXF(moxifloxacin), LVX(levofloxacin), ETP(ertapenem), IMP(imipenem), MEM(meropenem), DOR(Doripenem), TZP(piperacillin-tazobactam), OXA(oxacillin), VAN(vancocin)
TEC (teicoplanin), CST (colistin), TGC (tigecycline), SXT (trimethoprim-sulfamethoxazole), MDR (multidrug-resistant), XDR (extensively drug-resistant), PDR (pandrug-resistant), ESBL (extended-spectrum β-lactamase), S (sensitive), R (resistant), I (intermediate), VRE (vancomycin resistant enterococcus), MSSA (methicillin sensitive staphylococcus aureus), MRSA (methicillin resistant staphylococcus aureus), GNB (Gram-negative bacillus), NA (not accessed), NIL (no data available).

**Declarations**

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**Authors’ contributions:**

Chienhsiu Huang designed the study, collected the data, analyzed the data, wrote the manuscript, and reviewed the manuscript.

**Ethics approval**

The project was approved by Buddhist Dalin Tzu Chi general hospital research ethics committee. (Approved IRB No.: B10802024)

**Consent for publication:**

Not applicable.

**Competing interests:**

The authors declare that they have no competing interests.

**Availability of data and materials:**

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Figures
Antibiotics sensitivity rate of Alcaligenes faecalis

Figure 1

Antibiotics sensitive rate of Alcaligenes faecalis

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