

Clinical Significance of Bacillus Species other than Bacillus anthracis: A Case Series With Review of Literature

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Case Report

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Abstract

Introduction

Bacillus species (spp.) are Gram-positive bacilli, which are commonly referred to as aerobic spore-forming bacilli (ASB), found as saprophytes in various environmental settings. While these organisms are frequently dismissed as mere contaminants in clinical samples, there is growing evidence highlighting their ability to act as opportunistic pathogens, especially in hospitalized and immunocompromised individuals.

Methods

This case series examines patients admitted to a tertiary care teaching hospital in Karimnagar, Telangana, India, who exhibited clinical signs of sepsis and had blood cultures positive for *Bacillus* spp. Comprehensive clinical information was collected, encompassing demographic details, maternal and perinatal history for neonates, gestational age, mode of delivery, initial symptoms, relevant laboratory results, antimicrobial treatments, and supportive interventions. Culture and antibiotic sensitivity profiles were determined using standard microbiological techniques.

Results

Of the 7 patients, 5 (71.4%) were neonates, 1 (14.3%) was a young adult with type 1 diabetes mellitus (T1DM), and 1 (14.3%) was an elderly postoperative patient. Respiratory distress (100%), hyperbilirubinemia (60%), thrombocytopenia (40%), and coagulopathy (40%) were the predominant clinical features among neonates. All isolates demonstrated susceptibility to standard empiric antimicrobials, including piperacillin-tazobactam, amikacin, meropenem, and vancomycin. Prompt targeted antimicrobial therapy and supportive care yielded favorable outcomes in 6 out of 7 patients (85.7%). One elderly patient left against medical advice. No neonatal mortality was recorded.

Conclusion

Bacillus spp. can cause clinically significant bacteremia and sepsis across diverse age groups. Isolates should not be reflexively dismissed as contaminants. Careful clinical correlation with inflammatory markers and early targeted therapy are vital to optimize patient outcomes.

Introduction

Gram-positive, aerobic or facultatively anaerobic, spore-forming bacilli were first described by Christian Gottfried Ehrenberg and later classified by Ferdinand Cohn under the genus *Bacillus* (*B*). This genus comprises approximately 260 species that inhabit diverse ecological niches, including thermophilic, psychrophilic, acidophilic, alkaliphilic, and halophilic environments. While many species are harmless saprophytes, several are opportunistic pathogens in humans (*B. cereus*, *B. subtilis*, *B. licheniformis*), animals, and insects (*B. thuringiensis*), with *B. anthracis* being the most notable human pathogen. Beyond their pathogenic potential, *Bacillus* species (spp.) are widely exploited in medicine, agriculture, and industry. Spores of *B. stearothermophilus* serve as biological indicators for sterilization efficacy. Besides, multiple species produce clinically important antibiotics (bacitracin, polymyxin, gramicidin); and others yield thermostable enzymes and ribonucleases valuable in molecular biology and biotechnology. Their versatility underscores their dual significance as occasional pathogens and indispensable biotechnological tools [1].

Human infections due to *Bacillus* spp., apart from anthrax, are frequently underrecognized because isolates are often dismissed as contaminants and reported simply as aerobic spore-forming bacilli (ASB). Nevertheless, they have been implicated in a wide spectrum of clinical conditions, including bacteremia, endocarditis, wound and ocular infections, otitis, respiratory and urinary tract infections, gastrointestinal disease, food poisoning, and meningitis. Although most cases occur in immunocompromised or debilitated hosts, such as hospitalized patients, neonates, children, and individuals with hematological malignancies, serious infections have also been documented in immunocompetent individuals, raising concern [1].

Laboratory identification typically relies on biochemical traits such as motility, catalase activity, nitrate reduction, and starch hydrolysis. Virulence factors are well characterized for *B. anthracis* and *B. cereus* but remain poorly defined for other species. Accurate identification and antimicrobial susceptibility testing (AST) are essential to avoid misdiagnosis and guide effective therapy. Recent literature highlights their pathogenic potential in neonates and immunocompromised hosts [2–4], while emerging reports describe multidrug-resistant (MDR) strains and novel virulence mechanisms [5–7]. Distinguishing true and/or opportunistic pathogens from incidental contaminants is therefore critical for appropriate diagnosis and patient management [1]. In this case series, we analyze the demographic characteristics, clinical profiles, laboratory findings, and outcomes of patients with bacteremia due to *Bacillus* spp.

Materials & Methods

Study Design and Setting

This study was conducted as a retrospective case series at a tertiary care teaching hospital in Karimnagar, Telangana, India. The hospital provides advanced neonatal intensive care and adult medical services, making it a suitable setting for evaluating bloodstream infections across diverse patient populations. The study period encompassed admissions April 2018 to March 2019, during which patients presented with clinical features of sepsis and had blood cultures positive for gram-positive bacilli, identified as *Bacillus* spp. Reporting of this case series conforms to the CARE statement and checklist guidelines to ensure comprehensive and transparent clinical reporting (see Appendix 1).

Inclusion and Exclusion Criteria

Patients of all ages admitted with suspected sepsis were screened. Patients with clinical features consistent with systemic infection (e.g., fever, respiratory distress, coagulopathy, thrombocytopenia, seizures, or postoperative sepsis), positive blood cultures with pure growth, for gram-positive bacilli, and ASB identified as belonging to *Bacillus* spp. confirmed by standard microbiological methods were included in the study. Blood cultures yielding *Bacillus* spp. without clinical correlation and patients with inadequate clinical or laboratory records were excluded from the study.

Data Collection

Seven patients who met the inclusion criteria among which five neonates, one young adult, and one elderly postoperative patient were included in the study. Comprehensive clinical and demographic information was extracted from patient records, including maternal and perinatal history, gestational age, mode of delivery, birth weight, and initial symptoms for neonates, and comorbidities, surgical history, and presenting complaints for adults and elderly patients.

Vital signs, laboratory parameters (hemoglobin (Hb), platelet count (PLT), total leukocyte count (TLC), coagulation profile, C-reactive protein (CRP), bilirubin levels), and imaging findings where available were considered for inclusion. Treatment details were documented, including antimicrobial regimens, supportive interventions (oxygen therapy, intravenous (IV) fluids, transfusions), and intensive care measures. Outcomes were assessed at discharge or last follow-up.

Microbiological Methods

Blood cultures were processed using standard aerobic culture techniques. Isolates were identified as *Bacillus* spp. based on colony morphology, Gram staining, and biochemical characteristics including motility, catalase production, nitrate reduction, and starch hydrolysis, following established microbiological protocols [8–11].

AST was performed using the Kirby-Bauer disk diffusion method and the results were interpreted according to the Clinical and Laboratory Standards Institute (CLSI) guidelines [12, 13]. Antibiotics tested included, imipenem (IPM) (10 µg), amikacin (AK) (30 µg), gentamicin (GEN) (10 µg), ciprofloxacin (CIP) (5 µg), ofloxacin (OF), azithromycin (AZM) (15 µg), trimethoprim-sulfamethoxazole (TMP-SMX) (1.25/23.75 µg), piperacillin-tazobactam (PTZ) (30/6 µg), cefepime (CPM) (30 µg), ceftazidime (CAZ) (10 µg), ceftriaxone (CTR) (30 µg), cefotaxime (CTX) (30 µg), cefoxitin (FOX) (30 µg), Cefoperazone+Sulbactam (CSF) (75/30 µg), penicillin (P) (10 µg), linezolid (LZ)(10 µg), erythromycin (E) (15 µg), clindamycin (CD) (2 µg), oxacillin (OX) (1 µg), and vancomycin (VAN) (30 µg). *Escherichia coli* American Type Culture Collection (ATCC) 25922, *Pseudomonas aeruginosa* ATCC 27853, and *Staphylococcus aureus* ATCC 25923 were used as controls.

Ethical Considerations

This study was conducted in accordance with institutional ethical standards. As a retrospective review of anonymized patient records dating back to more than seven years, formal patient consent was waived. Confidentiality was maintained throughout data collection and reporting.

Results

Case 1

An elective lower segment caesarean section (LSCS) was performed at the teaching hospital to deliver a term female infant at 37 weeks of gestation. The infant weighed 2.4 kilograms (kg) at birth and started crying right away. The mother needed two units of packed cell volume (PCV) transfusion at the time of delivery since she was a primigravida, or pregnant for the first time, and had significant anemia in the late third trimester with decreased hemoglobin (Hb). She tested positive for the heterozygous sickle cell thalassemia trait. The pregnancy course of the mother was uneventful. Because of the respiratory distress (RD), the newborn was admitted to the neonatal intensive care unit (NICU) within the first hour of life. The neonate was examined and found to have a heart rate (HR) of 140 beats per minute (BPM), tachypnea with a Downes score of 3/10 owing to increased respiratory rate of 60 beats per minute (BPM), and peripheral blood oxygen saturation (SpO₂) of 95% while on nasal continuous positive airway pressure therapy (CPAP) support with nasal prongs.

The initial laboratory tests indicated a decreased Hb, normal red blood cell (RBC) count, increased total leukocyte count (TLC) with significant neutrophilia, normal platelet (PLT) count, and an increased prothrombin time (PT). C-reactive protein (CRP) was increased, indicating the possibility of early neonatal sepsis. There was an abnormal coagulation profile, with increased serum total bilirubin (TB) and normal direct bilirubin (DB) levels. The ASB, identified as *Bacillus* spp., was found in a blood culture sent on the first day of life (DOL) after admission, supporting the working diagnosis of newborn sepsis. The strain demonstrated acceptable empirical coverage by being susceptible to all routinely used antibiotics on AST.

In addition to intravenous (IV) fluids (10% dextrose with dopamine infusion), antibiotics (PIT and AK), calcium supplements, and feeding assistance as needed, the infant was treated with supportive oxygen via nasal prongs. As the baby's respiratory condition steadily improved, feedings were started as tolerated. With proper hydration and supportive care, bilirubin levels decreased. As the hemodynamic parameters stabilized, the baby's clinical state gradually improved. By day four, the infant was exhibiting clinical stability, tolerating full feed, and maintaining oxygen saturation on room air. Following a four-day stay in the NICU, the baby was discharged in stable condition, given a routine after-birth immunization, and instructed to return to the clinic one week later.

Case 2

A premature male baby of 33 + 5 weeks gestation was born at a tertiary care teaching hospital in Karimnagar, India, via normal vaginal delivery with a birth weight of 2.0 kg. Shortly after birth, the infant was admitted to the NICU due to RD and a bad cry. On inspection, the baby displayed tachycardia, tachypnoea, and chest retractions; he was provisionally identified as preterm with RD syndrome and low birthweight (LBW). The neonate had anemia for their age, with normal/low-normal Hb, increased TLC, decreased PLT count, and a prolonged PT with an increased international normalized ratio (INR), indicating coagulopathy and requiring close monitoring. Additionally, the CRP levels were increased, indicating sepsis. The TB was increased, with a normal DB, showing primarily unconjugated hyperbilirubinemia, which is consistent with newborn jaundice in a premature neonate. The infant received IV fluids, calcium gluconate supplementation, caffeine citrate for the prevention of apnea, and oxygen through nasal prongs while in the NICU. Supportive care for preterm newborns with RD and suspected sepsis risk often included these therapies.

The blood culture from the DOL1 report revealed that *Bacillus* spp. was the causal bacterium for sepsis and was sensitive to all drugs tested. The baby was started on broad-spectrum antibiotics (PIT and AK) and oxygen support, and treatment was based on the AST values, which revealed sensitivity to all the tested antibiotics. Clinically, by DOL 6, the neonate had improved and remained hemodynamically stable on support, with SpO₂ levels around 98–100%. In this case, careful multidisciplinary management led to clinical improvement, gradual respiratory stabilization, and resolution of sepsis signs. The baby recovered and, with normalization of laboratory parameters, was discharged from the NICU on the DOL6 of admission in good condition, with appropriate vaccinations done, and a routine follow-up in the clinic after one week.

Case 3

A term female newborn was delivered at 38 weeks' gestation via an emergency LSCS due to maternal pre-eclampsia at a tertiary care teaching hospital in Karimnagar, India. The baby weighed 2.4 kg at delivery and cried immediately. The mother was a primigravida with several antenatal risk factors, including hypothyroidism (from the second to eighth month), gestational hypertension (HTN) in the last eight months, polycystic ovarian syndrome (PCOS), and a history of febrile sickness (typhoid) in the first trimester. Thick meconium-stained liquor and RD in the newborn at birth necessitated a rapid neonatal examination and NICU admission.

Upon arrival, vital signs indicated a heart rate of 158 BPM, a respiratory rate of 44 per minute, and a SpO₂ of 97% while using nasal CPAP with prongs. The Downes score was 1/10, indicating mild RD. The preliminary diagnosis was a term female newborn with thick meconium-stained liquid and RD. Hyperbilirubinemia with increased TB and normal DB was found in laboratory parameters, which may indicate cholestatic jaundice. Normal/low-normal Hb, decreased PLT count, normal TLC, and a disturbed (prolonged) PT indicative of coagulopathy were among the hematological results. A continuous inflammatory/infectious process in the body was confirmed by an increased CRP. Neonatal sepsis was diagnosed based on blood culture results at DOL1, which showed growth of ASB consistent with *Bacillus* spp. All commonly used antibiotics were effective against the bacterium as evidenced from the AST results. Furthermore, the results of the neurosonogram were normal.

The baby received oxygen via nasal prongs, IV fluids, and broad-spectrum antibiotics such as PIT, AK, and metronidazole. Calcium gluconate supplementation was administered. Fresh frozen plasma (FFP) transfusions were required due to progressive coagulopathy. The baby was diagnosed with meconium aspiration syndrome (MAS), which was worsened by coagulopathy, newborn jaundice, and culture-positive sepsis. The infant showed consistent progress, maintained oxygen saturation, tolerated feeding, and showed clinical parameter stabilization during the NICU stay. The baby was discharged after making a full recovery and receiving all necessary vaccines. After seven days, a follow-up visit to the pediatric out-patient department (OPD) was recommended for routine evaluation and review of biochemical data.

Case 4

A gravida 2 (second pregnancy), parity 2 (two prior children), and living 3 (third live baby) mother gave birth to a preterm female newborn at 35 weeks and 2 days gestational age through an emergency LSCS due to labor not progressing after premature rupture of membrane (PROM) for six hours. The infant weighed 2.6 kg at birth and started crying right away. Upon assessment, the baby's HR was 144 BPM, RR was 49 beats per minute, and SpO₂ was 96%. The infant's Downes score was 2/10, indicating mild RD. Due to RD and premature birth, the infant was admitted to the NICU. Increased Hb, increased RBC count, increased TLC with predominant neutrophilia, and normal PLT count were found in the initial laboratory evaluation. The increased CRP suggests that neonatal sepsis may be present. Serum TB levels were normal, DB levels were increased, and the coagulation profile was normal with a normal PT.

The blood culture obtained at DOL1 revealed ASB, which was identified as *Bacillus* spp. and was susceptible to every antibiotic tested, was the cause of sepsis. Oxygen via nasal prongs, IV fluids, antibiotics (PIT and AK), calcium supplements, and feeding assistance were all part of the baby's supportive care. Feeding was started as tolerated, and the baby's respiratory condition steadily improved. With supportive treatment and proper fluids, bilirubin levels decreased. Following a DOL6 stay in the NICU, the newborn received the necessary vaccinations, was discharged in stable condition, and the parents were instructed to return with the baby to the clinic one week later.

Case 5

A preterm male baby of 30 weeks' gestation was born to a gravida 2 (second pregnancy), parity 1 (one prior kid), live 1 (one live baby), and dead 2 (two deceased children) mother via regular vaginal delivery with PROM lasting more than 12 hours, weighing 1.5 kg. As soon as the baby was born, he began to cry poorly. The infant was admitted to the NICU for premature care and RD. The mother's prenatal history was uncomplicated. Upon assessment, the infant's HR was 150 BPM, RR was 48/min, and SpO₂ 88%, which was maintained 100% while on mechanical ventilation following intubation. Peripheral cyanosis and chest retractions were present in the infant. The baby's scalp was covered in a caput succedaneum. Caput succedaneum is a benign condition in newborns, characterized by scalp swelling (edema) that develops from pressure exerted during a headfirst passage through the birth canal. Decreased Hb, decreased

RBC count, increased TLC with significant neutrophilia, and decreased PLT count were the results of the initial laboratory tests. Increased CRP levels suggested the possibility of early neonatal sepsis.

The bacterial culture of blood performed at DOL1 demonstrated that ASB, identified as *Bacillus* spp., was sensitive to all tested antimicrobials. The baby received normal preterm care for LBW. The child was given IV fluids and antibiotics (PIT and AK) in the right doses, as per the protocol. The baby received calcium supplements and caffeine citrate prophylaxis for prematurity apnea. The baby required continuous ventilatory support for the first 72 hours of his NICU stay due to RD syndrome, after which he was gradually weaned to CPAP and then to oxygen via nasal prongs. His respiratory condition gradually stabilized over the next 10–12 days, with increased air admission and fewer retractions. Serial chest exams revealed improved breath sounds, and SpO₂ remained between 96–100% with minimal oxygen support.

Due to the prematurity and LBW, enteral feedings were started with caution. Initially, the baby was kept nil per mouth and given IV fluids for a few days. Feeding the expressed breast milk was initiated on DOL4 and subsequently increased as the infant tolerated it. By the end of the third week, all enteral feeds were complete. Hematological monitoring revealed persistent decreased platelets (thrombocytopenia) during the first week, which improved gradually without requiring PLT transfusion. Hb levels remained decreased, and the baby required one packed RBC transfusion around the second week of life. CRP levels showed a downward trend by the end of the second week, correlating with the clinical improvement. No bacterial growth was observed in repeat cultures obtained after the antibiotic course. Following NICU procedure, PIT and AK were completed, and no further antibiotics were needed. In the early days, serial liver function tests showed modest unconjugated hyperbilirubinemia (increased TB); phototherapy was administered for 48 hours, and the results were favorable.

The infant was kept under observation for premature apnea during the stay and was given caffeine citrate prophylaxis for the first 10 days. After that, no more occurrences of apnea were noted. Renal values and electrolytes held steady during the hospital stay. At two weeks, a cranial ultrasound revealed no signs of intraventricular hemorrhage, and neurological exams were in line with gestational age. The infant demonstrated steady weight gain, stable cardiorespiratory parameters, and sufficient feeding tolerance by the fourth week of stay. The infant showed appropriate activity for gestational age, had decent suck-swallow coordination, and maintained normal oxygen saturation in ambient air. After a one-month stay in the NICU, the baby had recovered from RD and culture-positive sepsis caused by *Bacillus* spp. With better hematological markers, stable vital signs, and appropriate feeding, the infant was discharged in good condition, with instructions to return for regular check-ups and to continue exclusive breastfeeding.

Case 6

A 25-year-old male presented to the casualty department with chief complaints of a seizure (1 seizure-like episode). The patient, who had been vomiting for four days, had type 1 diabetes mellitus (T1DM) for seven years and was on insulin therapy before being diagnosed with HTN two months back. The patient had vomited immediately after eating four days ago, but for the last two days, he had been experiencing blood-tinged vomitus, which was linked with burning-type epigastric and throat discomfort but not with abdominal pain or loose stools.

On the day of admission, the patient experienced a seizure characterized by unresponsiveness, up rolling of the eyes, and no tonic-clonic movements, foaming, or incontinence. There was no limb stiffness, no head or body injuries, and he has no memory of what occurred during the episode. They proceeded to another hospital and were given midazolam (dosage unknown) before being referred this hospital. He was dazed at first, but regained full consciousness when he arrived. Seizures (new onset) were the initial impression formed throughout examination. The patient has no history of comparable problems. He has been a recognized case of T1DM for 7 years and was treated with insulin. He was diagnosed with de novo HTN two months ago and was being treated with Telmisartan and Cilnidipine. The patient developed pedal oedema and was treated with Torsemide 15 days ago.

During the clinical examination, the patient demonstrated consciousness, coherence, cooperation, and awareness of time, place, and people. With a blood pressure (BP) of 130/80 mmHg, HR of 96 BPM, and SpO₂ of 99% on room air, he was hemodynamically stable. No anomalies were found during the systemic examination: The abdomen was soft and non-tender with no organomegaly; the central nervous system examination was within normal bounds; the respiratory system was clear with bilateral air entry; and the cardiovascular examination revealed normal S1 and S2 with no murmurs. A general examination revealed bilateral pedal oedema, as well as an ulcer on the ventral part of the left foot with slough and hyperpigmentation, which was diagnosed as a trophic ulcer. There was no neurologic impairment. The original working diagnosis was a new-onset seizure, most likely metabolic, with a history of T1DM and recent onset HTN.

During hospitalization, on day two, he was shifted to the cardiology service when he developed new-onset left-sided chest pain, giddiness, and nausea. The vitals showed BP ranging between increased levels, which later decreased, a normal HR, and normal oxygen saturation on room air. Capillary glucose values were markedly increased (deranged) before subsequent improvement with intensive management.

Laboratory testing revealed anemia (decreased Hb), poorly regulated glycemia [increased glycated hemoglobin (HbA1c)], decreased serum albumin (hypoalbuminemia), normal renal function, and increased CRP. The brain computed tomography (CT) indicated no acute intracranial abnormalities. The two-dimensional echocardiography (2D-ECHO) was normal. Upper gastrointestinal endoscopy was conducted, which revealed stomach swelling and an antral ulcer. Blood cultures from day one revealed the presence of ASB, which demonstrated clinically severe *Bacillus* spp.-induced sepsis in a high-risk T1DM patient.

The seizure was initially managed with IV levetiracetam, supportive treatment with IV antiemetics (ondansetron), a proton pump inhibitor (pantoprazole), vitamin supplements (Optineurin), and regulated IV fluids with dextrose-normal saline. He was treated for T1DM and HTN with basal insulin, oral metformin, telmisartan-H combination once daily, and frequent glucose monitoring, with instructions to supplement with dextrose only if blood glucose levels fell below a specified threshold. Cardiac care includes low-dose aspirin (Ecosprin), clopidogrel, atorvastatin, nicardipine/nifedipine (Nicardia Retard), and low-molecular-weight heparin (enoxaparin), in line with therapy for non-ST-elevation myocardial infarction (STEMI) and vasospastic angina in younger patients.

Blood cultures drawn at admission isolated *Bacillus* spp., which was resistant to clindamycin, azithromycin, erythromycin, cefotaxime, and ceftazidime, but remained fully sensitive to all other agents tested, including vancomycin and meropenem. The patient was given the first round of broad-spectrum IV antibiotics, such as VAN and MER. Regular dressings, pressure off-loading, and glycemic optimization were employed in the conservative management of the diabetic foot ulcer, resulting in a gradual local improvement without the need for surgery. In the days that followed, seizures did not recur, nitroglycerin infusion reduced chest pain by over half, BP was better managed, glycemic indices stabilized, and there were no more episodes of hematemesis or sepsis.

Case 7

An 85-year-old male patient was admitted to the emergency room with major complaints of abdominal pain lasting five days. The pain was diffuse, intermittent, and of a squeezing character. The patient has not passed stools or had flatus in the last five days. There had been a 5-day history of appetite loss and abdominal distention. His medical history revealed that he has had HTN for the past five years and is taking amlodipine regularly. He had surgery 10 years ago to correct bilateral inguinal hernias with mesh placement. He didn't have any recognized medical allergies.

During the clinical examination, the patient showed signs of consciousness, coherence, cooperation, and good time, place, and person orientation. He had a reasonable build and diet. A noticeable pallor was present. The HR was 76 BPM, the RR was 22/minute, the BP was 130/80 mmHg, and the patient was afebrile. A swollen abdomen with stiffness and no bowel noises was seen during the per abdomen examination. As normal sphincter tone was observed, the per-rectal examination was carried out with an empty rectum and no discernible bulk. The respiratory system was clear with bilateral air entry, and the cardiovascular examination revealed normal S1 and S2 with no murmurs.

Laboratory testing revealed anemia (decreased Hb), normal renal function (normal serum creatinine and urea), and an increased CRP. A tentative diagnosis of acute small bowel blockage was given. He had an emergency exploratory laparotomy, resection, and anastomosis of the small bowel, as well as a loop ileostomy, all performed under general anesthesia. The patient was hemodynamically stable, and the surgery went smoothly. Following surgery, frequent dressings were applied to the incision site, and appropriate supportive therapy and post-operative antibiotic prophylaxis were continued.

Blood cultures obtained on Day 1 revealed the growth of ASB. Sepsis due to *Bacillus* spp. was confirmed, and AST by disk diffusion demonstrated a distinct resistant profile. The isolate showed clear susceptibility to piperacillin-tazobactam, amikacin, gentamicin, cotrimoxazole (trimethoprim-sulfamethoxazole), cefepime, ceftriaxone, cefotaxime, cefoperazone, ciprofloxacin, ofloxacin, linezolid, tetracycline, vancomycin, meropenem, and novobiocin. In contrast, complete resistance was observed to ceftazidime, oxacillin, erythromycin, clindamycin, and penicillin. (Fig. 1)

(A) Irregular, flat, grayish-white colonies with a rough, ground-glass appearance and wavy margins on blood agar, demonstrating characteristic spreading growth. (B) High-magnification surface view of *Bacillus* colonies showing typical colony textures with accompanying beta-hemolytic clearance zones. (C) Gram-stained smear under light microscopy (400X) revealing large, rectangular, Gram-positive bacilli arranged in elongated, interlocking chains. (D) Oil-immersion light microscopy field (100X) highlighting robust Gram-positive rods with early formation of non-swelling central or subterminal endospores. (E) Antimicrobial susceptibility testing by disk diffusion demonstrating substantial zones of bacterial growth inhibition and clearing around piperacillin-tazobactam (PIT), ciprofloxacin (CIP), ofloxacin (OF), amikacin (AK), gentamicin (GEN). (F) Disk diffusion testing further showing prominent inhibition zones for linezolid (LZ), vancomycin (VA), contrasted with complete resistance and uninhibited growth up to the disk margins for ceftazidime (CAZ), clindamycin (CD), and erythromycin (E)

This image has been created by the authors

The patient was initiated on broad-spectrum IV antibiotics, including vancomycin and meropenem. However, the patient left against medical advice (LAMA), requesting oral antibiotics, most likely due to financial constraints. A detailed summary of the clinical and laboratory profiles of the cases included in this study is presented in Table 1 and Table 2. Table 1

Table 1
Case-by-case summary including clinical presentations, treatment, and outcome

Case (Age/sex)	Risk factors	Clinical presentation	Blood culture	Antibiotic susceptibility pattern	Treatment given	Outcome
Case 1 (2 days, female)	Maternal anemia, LSCS	Respiratory distress	<i>Bacillus</i> spp.	Sensitive to all tested antimicrobials	PIT + AK, IV fluids, oxygen, NICU supportive care	Recovered
Case 2 (5 days, male)	Prematurity, LBW	RD, poor cry	<i>Bacillus</i> spp.	Sensitive to all tested antimicrobials	Broad-spectrum antibiotics, oxygen, NICU supportive care	Recovered
Case 3 (7 days, female)	Maternal pre-eclampsia, MAS	RD, jaundice	<i>Bacillus</i> spp.	Sensitive to all tested antimicrobials	PIT + AK, FFP transfusions, NICU supportive care	Recovered
Case 4 (10 days, female)	Prematurity, PROM	Mild RD	<i>Bacillus</i> spp.	Sensitive to all tested antimicrobials	PIT + AK, oxygen, NICU supportive care	Recovered
Case 5 (14 days, male)	Prematurity, PROM > 12h, LBW	Severe RD	<i>Bacillus</i> spp.	Sensitive to all tested antimicrobials	PIT + AK, ventilatory support, NICU supportive care	Recovered after prolonged NICU stay
Case 6 (25 years, male)	Type 1 diabetes, chronic foot ulcer	Seizure, sepsis, GI bleed	<i>Bacillus</i> spp.	Resistant to azithromycin, erythromycin, and ceftazidime	VAN + MER, glycemic control, wound care	Recovered
Case 7 (85 years, male)	Advanced age, postoperative state	Abdominal pain, sepsis	<i>Bacillus</i> spp.	Resistant to ceftazidime, oxacillin, erythromycin, clindamycin, and penicillin	VAN + MER, postoperative supportive care	Left against medical advice (LAMA)

LSCS: lower segment caesarean section; LBW: low birth weight; RD: respiratory distress; MAS: meconium aspiration syndrome; PROM: premature rupture of membrane; NICU: neonatal intensive care unit; FFP: fresh frozen plasma; PIT: piperacillin-tazobactam; AK: amikacin; VAN: vancomycin; MER: meropenem; GI: gastrointestinal; LAMA: left against medical advice; T1DM: type 1 diabetes mellitus

Table 2

Table 2
Hematological and biochemical indices of the cases

Case	Hb; Normal value: 12–20 g/dL	TLC; Normal value: 4000–11000/mm ³	Platelets; Normal value: 150,000 to 450,000/mm ³	CRP; Normal value: <0.6 mg/dL	TB; Normal value: 1.0–12.0 mg/dL	DB; Normal value: 1.0–1.5 mg/dL	Coagulation profile; Normal value (PT = 11–13.5 seconds, INR = 0.8–1.1)
1	6.0	22,000	260,000	2.4	5.7	1.2	PT = 15 seconds
2	13.9	15,200	45,000	2.4	11.4	1.2	PT = 28 seconds, INR 2.2
3	14.3	10,000	100,000	9.6	11.1	1.0	PT = 18 seconds
4	20.4	18,900	330,000	4.8	2.0	1.9	PT = 12 seconds
5	10.5	19,200	91,000	2.4	11.0	NA	Persistent thrombocytopenia
6	10.5	NA	NA	1.2	9.0	1.1	PT = 11 seconds
7	11.0	NA	NA	1.2	3.0	1.0	PT = 13 seconds

Hb: Hemoglobin; TLC: total leukocyte count; CRP: C-reactive protein; PLT: platelet count; PT: prothrombin time; INR: international normalized ratio; TB: total bilirubin; DB: direct bilirubin; NA: data not available

Discussion

In the context of human disease, *Bacillus* spp. demonstrate a spectrum of pathogenic potential that extends beyond the classical anthrax agent. *B. anthracis* remains the only obligate pathogen, producing cutaneous, intestinal, and pulmonary anthrax through its capsule and tripartite toxin complex. However, *B. cereus* has emerged as a clinically significant organism, not only as a cause of foodborne illness but also as an opportunistic pathogen responsible for severe systemic infections including bacteremia, meningitis, and endocarditis. Its pathogenicity is mediated by a range of toxins and enzymes such as cereolysin and phospholipases. Other *Bacillus* spp., including *B. subtilis*, *B. licheniformis*, *B. pumilus*, and *B. thuringiensis*, though traditionally regarded as environmental or commensal organisms, have been implicated in opportunistic infections of wounds, the respiratory tract, and the urinary tract, particularly in immunocompromised hosts. Collectively, these observations underscore that while anthrax remains the archetypal *Bacillus* infection, the broader genus increasingly contributes to clinically relevant disease, warranting greater recognition of non-anthrax *Bacillus* spp. in diagnostic and therapeutic considerations. [2, 14–16]. Table 3

Table 3
Clinical and microbiological characteristics of *Bacillus* species

Species	Type of human infections	Predisposing factors	Virulence factors	Morphology (Microscopy)	Cultural characters (Colony/Growth)
<i>B. anthracis</i>	Cutaneous, pulmonary, intestinal anthrax [14]	Contact with infected animals/products, inhalation of spores, ingestion of contaminated meat [14]	Obligate pathogen; virulence via capsule and tripartite toxin [14]	Large Gram-positive rods, non-motile, square ends, central spores (non-swelling) [14]	Non-hemolytic colonies, "Medusa head" appearance, sticky consistency [14]
<i>B. cereus</i>	Food poisoning (emetic and diarrheal), bacteremia, meningitis, endocarditis, wound/ocular infections [1, 14]	Contaminated food (rice, meat, dairy, vegetables), immunocompromised hosts [1, 14]	Produces enterotoxins, cereolysin, phospholipases; frequent opportunistic pathogen [1, 14]	Gram-positive rods, motile, central/subterminal spores [1, 14]	Large, rough, spreading colonies, β -hemolytic [1, 14]
<i>B. subtilis</i>	Food poisoning, wound infections, respiratory/urinary tract infections [1]	Opportunistic in immunocompromised individuals [1]	Generally environmental, but can act as secondary invader [1]	Gram-positive rods, motile, oval spores [1]	Dry, rough colonies, often pigmented, β -hemolytic [1]
<i>B. licheniformis</i>	Food poisoning, opportunistic infections (wounds, respiratory tract) [1]	Immunocompromised state, contaminated food [1]	Can produce toxins and enzymes interfering with therapy [1]	Gram-positive rods, motile, spores present [1]	Colonies often pigmented (brownish), irregular edges [1]
<i>B. thuringiensis</i>	Rare systemic infections, wound infections [1]	Immunocompromised patients [1]	Closely related to <i>B. cereus</i> ; shares virulence traits [1, 14]	Gram-positive rods, motile, spores with parasporal crystals [1, 14]	Colonies resemble <i>B. cereus</i> , β -hemolytic [1, 14]
<i>B. pumilus</i> , <i>B. coagulans</i> , <i>B. circulans</i> , <i>B. brevis</i> , <i>B. alvei</i>	Opportunistic infections (abscesses, septicemia, wounds) [1, 14]	Immunocompromised hosts, secondary invaders [1]	Rare but documented; may worsen preexisting infections [1]	Gram-positive rods, motile, spores present [1]	Colonies variable, often pigmented or irregular [1]

B: *Bacillus*

In our series, neonates accounted for 71.4% (n = 5) of *Bacillus* spp. cases. Major risk factors included prematurity (n = 3, 60%), low birth weight (n = 4, 80%), maternal anemia (n = 2, 40%), prolonged rupture of membranes (n = 1, 20%), and meconium aspiration (n = 1, 20%). These findings are consistent with established contributors to neonatal sepsis [17]. Outbreaks of *Bacillus cereus* in NICUs have reported mortality rates of 30–50% among preterm infants [18].

Recent NICU surveillance provides further context. In a French cohort of 1,000 neonates, 26% carried multidrug-resistant organisms (MDROs), while 15% carried *B. cereus* [7]. Carriage of *B. cereus* was transient (median 7 days) and rarely progressed to infection, whereas MDRO carriage persisted longer (median 21 days) and was more strongly associated with subsequent bloodstream infections [7]. These data suggest that *B. cereus* colonization is often environmentally acquired, though infection remains possible in high-risk neonates.

Beyond neonates, *Bacillus* spp. sepsis was observed in a young adult with T1DM and a chronic diabetic foot ulcer, and in an elderly postoperative patient. Diabetes increases bloodstream infection risk by 2-3-fold, particularly in the presence of chronic wounds [19]. In a prospective 19-month orthopedic ward study, *B. cereus* was isolated from 24 patients with postoperative or post-traumatic wound infections. Of these, 21 exhibited clinical signs: 9 had mild symptoms (e.g., increased wound secretion), 10 developed moderate manifestations (fever or pronounced local reactions), and 2 suffered severe necrotic infections. Notably, *Bacillus* spp. were implicated in one-fourth of wound complications following total hip arthroplasty, with infected patients requiring significantly longer hospital stays compared to controls (p = 0.0042) [20]. These findings underscore that *Bacillus* spp. should not be dismissed as contaminants but recognized as clinically relevant pathogens in surgical and trauma settings.

The clinical significance of *Bacillus* spp. remains debated. A retrospective review of blood cultures at North Carolina Memorial Hospital (1981–1985) documented a rising incidence of *Bacillus* isolation: from 4.97 per 10,000 admissions in 1981 to 12.5 in 1985, and from 1.12 to 2.33 per 1,000 blood cultures over the same period. Among 95 patients with positive cultures, 78 (82%) had records available; isolates were classified as clinically significant in 5 cases (6.4%), possibly significant in 33 (42.3%), and nonsignificant in 40 (51.3%). Underlying conditions among clinically significant cases included burn trauma (n

= 2), leukemia (n = 1), carcinoma (n = 1), and gastrointestinal hemorrhage (n = 1). Importantly, all clinically significant and most possibly significant isolates were identified as *B. cereus*. These findings suggest *Bacillus* spp. account for clinically significant bacteremia in approximately 5–10% of cases, with increasing incidence over time, and highlight burn trauma as a notable predisposing factor [21]. In our series, correlation between *Bacillus* isolation, elevated CRP (> 10 mg/L), and clinical features of sepsis strongly supports pathogenicity. Recent NICU studies further emphasize the diagnostic challenge: while *B. cereus* carriage was frequent (15%), only 0.5% progressed to bloodstream infection, underscoring the role of environmental contamination [7]. Careful clinical correlation remains essential.

Resistance patterns in our isolates were noteworthy. All were susceptible to vancomycin and meropenem, but resistance to other agents was not uncommon, consistent with prior reports [22]. Increasing reports of MDR *Bacillus* strains, coupled with NICU surveillance data showing MDRO carriage in 15–26% of neonates [22], highlight the importance of routine AST. Table 4

Table 4
Comparative summary of *Bacillus* sepsis cases in neonates and adults

Parameter	Neonatal cases (our series and literature)	Adult/elderly cases (our series and literature)
Proportion of cases	71.4% (5/7 patients) [our series]	28.6% (2/7 patients) [our series]
Risk factors	Prematurity (60%), low birth weight (80%), maternal anemia (40%), prolonged rupture of membranes (20%), meconium aspiration (20%) [17, 18]	Diabetes mellitus (1 case, chronic foot ulcer) [19]; postoperative abdominal surgery (1 case) [20]
Carriage prevalence (NICU cohort)	<i>B. cereus</i> carriage: 15%; MDRO carriage: 26% [7]	Not applicable
Carriage duration	<i>B. cereus</i> : median 7 days; MDROs: median 21 days [7]	Not applicable
Progression to infection	<i>B. cereus</i> : ~0.5% of carriers developed bloodstream infection [7, 18]	True bloodstream infections documented in diabetics and postoperative patients [19, 20]
Mortality risk	30–50% in NICU outbreaks; >40% if treatment delayed [18]	Variable; higher in elderly postoperative patients due to comorbidities [20, 21]
Inflammatory markers	CRP > 10 mg/L in all septic neonates [our series]	Elevated CRP and clinical sepsis in both adult cases [our series]
Antimicrobial resistance	Penicillin resistance: 71.4%; Cephalosporin resistance: 57.1%; susceptible to vancomycin and meropenem [22]	Similar resistance profile; escalation required to vancomycin/meropenem [22]
Clinical outcome	Favorable with early recognition, broad-spectrum antibiotics, and NICU supportive care [17, 18]	Favorable with escalation to vancomycin/meropenem; comorbidities increased risk [19, 20]

B. Bacillus; NICU: neonatal intensive care unit; MDRO: multidrug resistant organisms; CRP: C-reactive protein

Our findings, combined with recent cohort studies, reinforce that *Bacillus* spp. should not be routinely dismissed as contaminants. In neonates, mortality can exceed 40% if treatment is delayed [18]. Early recognition, appropriate antimicrobial therapy, and supportive care are essential. In adults and elderly patients, comorbidities amplify risk. NICU surveillance data suggest *Bacillus* spp. including *B. cereus* carriage is often transient and environmentally acquired, but infection control measures remain justified given its pathogenic potential [7]. Ultimately, careful clinical correlation and AST are critical to avoid both underestimation and overtreatment.

Study limitations

The primary limitation of this study lies in its retrospective design and the absence of species-level identification using modern molecular or automated techniques. Methods such as 16S ribosomal RNA (rRNA) gene sequencing, matrix-assisted laser desorption/ionization time-of-flight (MALDI-TOF) mass spectrometry, or automated bacterial identification systems like VITEK were not employed. Instead, isolates were classified broadly at the genus level (*Bacillus* spp.) based solely on conventional phenotypic biochemical profiles. As a result, species-specific clinical correlations could not be established.

Conclusions

This case series highlights that *Bacillus* spp., although frequently regarded as contaminants, can act as opportunistic pathogens in both neonates and adults. The neonatal cases underscore the vulnerability of this population, where prematurity, maternal factors, and perinatal complications create a fertile ground for invasive infection. The adult and elderly cases demonstrate that comorbidities such as diabetes and postoperative status also predispose individuals to bloodstream infections caused by *Bacillus* spp. other than *B. anthracis*. AST patterns observed in our isolates emphasize the importance of performing susceptibility testing rather than assuming contamination and relying solely on empirical therapy. Clinical correlation with inflammatory markers and sepsis features strongly supported the potential pathogenic role of these organisms in our patients. Overall, the findings reinforce that *Bacillus* spp. should not be dismissed outright as contaminants. Careful clinical assessment, timely initiation of appropriate antimicrobial therapy, and supportive care are essential for favorable outcomes. Future studies with larger cohorts are needed to better define risk factors, resistance trends, and optimal management strategies for *Bacillus* infections.

Declarations

Ethics and Consent to Participate

This study was approved by the Institutional Ethics Committee prior to commencement. For the retrospective evaluation of de-identified medical records, the requirement for formal participant consent was waived by the institutional review board.

Consent to Publish

Written informed consent was obtained from all adult patients. In the case of minors, consent was provided by their parents or legal guardians for publication of this case report and any accompanying images. A copy of the signed consent is available for review by the Editor-in-Chief of this journal.

Availability of Data and Materials

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

Competing Interests

The authors declare that they have no competing interests.

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Authors' Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

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References

1. Kandi V: Clinical significance of *Bacillus* species other than *Bacillus anthracis*. *J Med Microb Diagn*. 2016, 5:130. 10.4172/2161-0703.1000e130
2. Lotte R, Chevalier A, Boyer L, Ruimy R: *Bacillus cereus* invasive infections in preterm neonates: an up-to-date review of the literature. *Clin Microbiol Rev*. 2022, 35:0008821. 10.1128/cmr.00088-21
3. Gaur AH, Patrick CC, McCullers JA, et al.: *Bacillus cereus* bacteremia and meningitis in immunocompromised children. *Clin Infect Dis*. 2001, 32:1456–62. 10.1086/320154
4. Little JS, Coughlin C, Hsieh C, et al.: Neuroinvasive *Bacillus cereus* infection in immunocompromised hosts: epidemiologic investigation of 5 patients with acute myeloid leukemia. *Open Forum Infect Dis*. 2024, 11:ofae048. 10.1093/ofid/ofae048
5. Ramarao N, Sanchis V: The pore-forming haemolysins of *Bacillus cereus*: a review. *Toxins (Basel)*. 2013, 5:1119–1139. 10.3390/toxins5061119
6. Okutani A, Okugawa S, Fujimoto F, Ikeda M, Tsutsumi T, Moriya K, Maeda K: Genetic diversity and virulence of *Bacillus cereus* group isolates from bloodstream infections. *Microbiol Spectr*. 2025, 13:e0240724. 10.1128/spectrum.02407-24
7. Camphuis MA, Vincent M, Dauwalder O, Dananché C, Pastor-Diez B, Masclef-Imbert M, Picaud JC: Multidrug-resistant organisms and *Bacillus cereus* colonization in a neonatal intensive care unit: a cohort study. *Pediatr Infect Dis J*. 2025, 44:798–803. 10.1097/INF.0000000000004773
8. Logan NA, Vos PD: *Bacillus*. *Bergey's Manual of Systematics of Archaea and Bacteria*. Trujillo ME, Dedysh S, DeVos P, Hedlund B, Kämpfer P, Rainey FA, Whitman WB (ed): John Wiley & Sons, Inc., Hoboken, New Jersey, USA; 2015. 1–163. 10.1002/9781118960608.gbm00530
9. Ehling-Schulz M, Lereclus D, Koehler TM: The *Bacillus cereus* group: *Bacillus* species with pathogenic potential. *Microbiol Spectr*. 2019, 7:10.1128/microbiolspec.gpp3-0032-2018. 10.1128/microbiolspec.GPP3-0032-2018
10. Celandroni F, Vecchione A, Cara A, Mazzantini D, Lupetti A, Ghelardi E: Identification of *Bacillus* species: implication on the quality of probiotic formulations. *PLoS One*. 2019, 14:e0217021. 10.1371/journal.pone.0217021
11. Hafezi A, Khamar Z: The method and analysis of some biochemical tests commonly used for microbial identification: a review. *Compr Health Biomed Stud*. 2024, 3:e160199. 10.5812/chbs-160199
12. Kirby-Bauer disk diffusion susceptibility test protocol. (2009). Accessed: May 31, 2026: <https://asm.org/getattachment/2594ce26-bd44-47f6-8287-0657aa9185ad/kirby-bauer-disc-diffusion-susceptibility-test-pro...>

13. Clinical and Laboratory Standards Institute (CLSI). Performance standards for antimicrobial disk susceptibility tests (CLSI document M02). (2024). Accessed: March 26, 2026: <https://clsi.org/standards/products/microbiology/documents/m02>.
14. Turnbull PCB: *Bacillus*. Medical Microbiology. Baron S (ed): University of Texas Medical Branch at Galveston, Galveston (TX); 1996.
15. Logan NA: *Bacillus* and relatives in foodborne illness. J Appl Microbiol. 2012, 112:417–429. 10.1111/j.1365-2672.2011.05204.x
16. Bottone EJ: *Bacillus cereus*, a volatile human pathogen. Clin Microbiol Rev. 2010, 23:382–398. 10.1128/CMR.00073 – 09
17. Stoll BJ, Hansen N, Fanaroff AA, et al.: Late-onset sepsis in very low birth weight neonates: the experience of the NICHD neonatal research network. Pediatrics. 2002, 110:285–291. 10.1542/peds.110.2.285
18. Sliman R, Rehm S, Shlaes DM.: Serious infections caused by *Bacillus* species. Medicine (Baltimore). 1987, 66:218–223. 10.1097/00005792-198705000-00005
19. Shah BR, Hux JE: Quantifying the risk of infectious diseases for people with diabetes. Diabetes Care. 2003, 26:510–513. 10.2337/diacare.26.2.510
20. Akesson A, Hedström SA, Ripa T: *Bacillus cereus*: a significant pathogen in postoperative and post-traumatic wounds on orthopaedic wards. Scand J Infect Dis. 1991, 23:71–77. 10.3109/00365549109023377
21. Weber DJ, Saviteer SM, Rutala WA, Thomann CA: Clinical significance of *Bacillus* species isolated from blood cultures. South Med J. 1989, 82:705–709.
22. Kotiranta A, Lounatmaa K, Haapasalo M: Epidemiology and pathogenesis of *Bacillus cereus* infections. Microbes Infect. 2000, 2:189–198. 10.1016/S1286-4579(00)00269-0

Figures

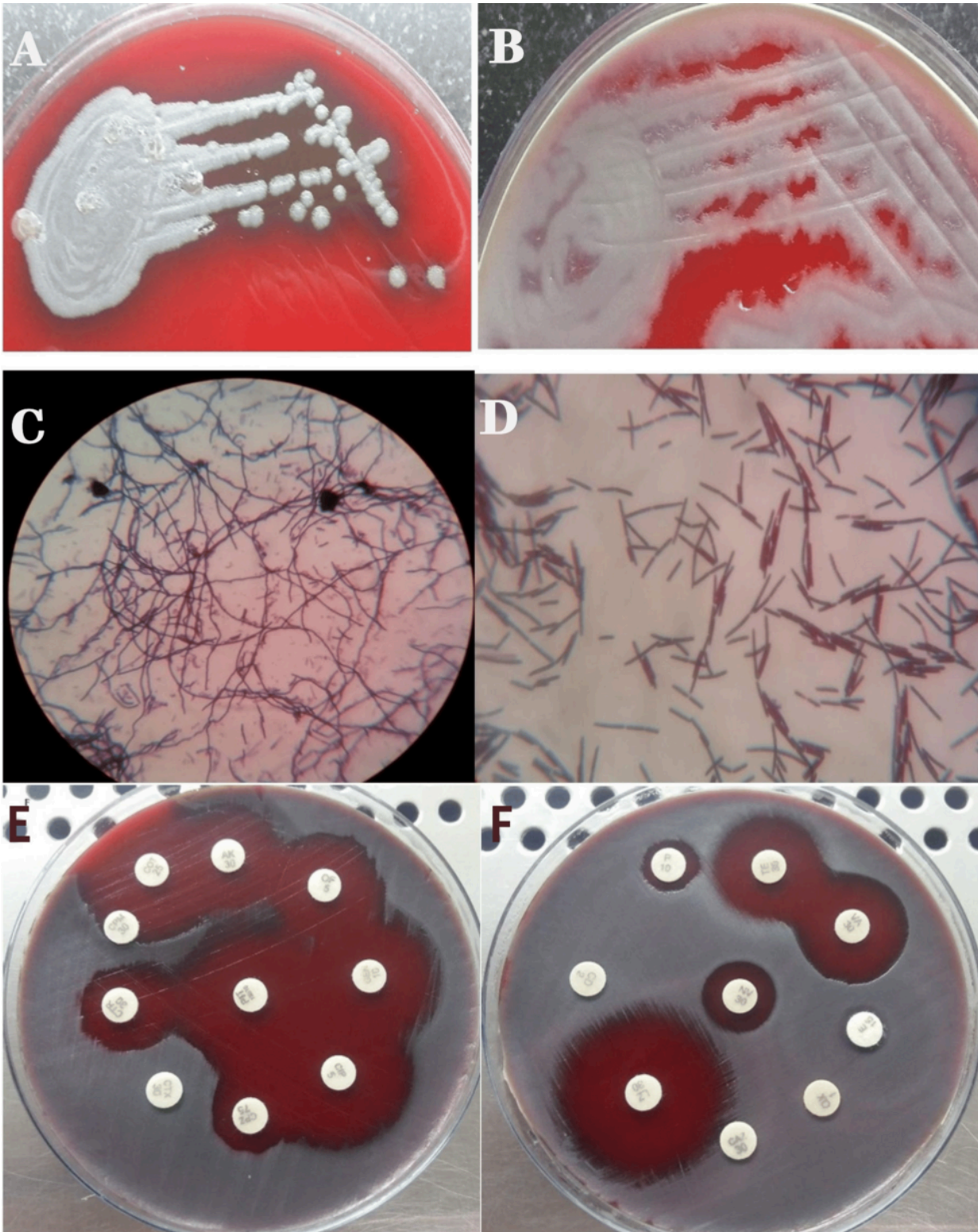


Figure 1

Phenotypic, microscopic, and antimicrobial susceptibility profiles of *Bacillus* species isolated from the blood culture of case 7

(A) Irregular, flat, grayish-white colonies with a rough, ground-glass appearance and wavy margins on blood agar, demonstrating characteristic spreading growth. (B) High-magnification surface view of *Bacillus* colonies showing typical colony textures with accompanying beta-hemolytic clearance zones. (C) Gram-stained smear under light microscopy (400X) revealing large, rectangular, Gram-positive bacilli arranged in elongated, interlocking chains. (D) Oil-immersion light microscopy field (100X) highlighting robust Gram-positive rods with early formation of non-swelling central or subterminal endospores. (E) Antimicrobial susceptibility testing by disk diffusion demonstrating substantial zones of bacterial growth inhibition and clearing around piperacillin-tazobactam (PIT), ciprofloxacin (CIP), ofloxacin (OF), amikacin (AK), gentamicin (GEN). (F) Disk diffusion testing further showing prominent

inhibition zones for linezolid (LZ), vancomycin (VA), contrasted with complete resistance and uninhibited growth up to the disk margins for ceftazidime (CAZ), clindamycin (CD), and erythromycin (E)

Supplementary Files

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