

First Report of *Scedosporium aurantiacum* Endocarditis in an Immunocompetent Chinese Male and Literature Review

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Background: *Scedosporium aurantiacum* is a rare opportunistic pathogen distributed worldwide. *S. aurantiacum* can cause invasive infections in both immunocompromised and immunocompetent individuals following exposure to contaminated environments. The risk associated with wastewater exposure is an important public health concern. Owing to its multi-drug resistance, the treatment of *S. aurantiacum* infection is very challenging.

Case Presentation: We report a case of a 44-year-old Chinese male with disseminated infection and endocarditis caused by *S. aurantiacum* after falling into a nearly dry wastewater pool. *S. aurantiacum* isolated from blood cultures was identified using nanopore sequencing technology of internal transcribed spacer 1 (ITS1) and matrix-assisted laser desorption ionization/time-of-flight mass spectrometry (MALDI-TOF MS). In vitro antifungal susceptibility testing indicated that voriconazole was the most active agent with a minimum inhibitory concentration (MIC) of 0.5 µg/mL. Despite receiving appropriate antifungal therapy, the patient died 12 days after fungal isolation because of uncontrolled infection and systemic organ failure.

Conclusion: This is the first reported clinical case of *S. aurantiacum* endocarditis in China. This case highlights that even in immunocompetent patients, *S. aurantiacum* infection should be considered. For clinicians, understanding a detailed history of the contaminated environments that the patient has been exposed to is crucial for early diagnosis. Nanopore sequencing offers a new option for identifying *S. aurantiacum*. Drug susceptibility testing is essential for determining the most appropriate antimycotic agent.

Keywords: *Scedosporium aurantiacum*, immunocompetent patient, disseminated infection, infective endocarditis, nanopore sequencing technology, multi-drug resistance

Introduction

Scedosporium species are saprophytic filamentous fungi broadly distributed in soil, sewage, and sludge that can cause asymptomatic colonization or localized or disseminated infection in immunocompromised patients, especially following aspiration of contaminated water or traumatic inoculation.¹ *Scedosporium aurantiacum*, one of the main species responsible for scedosporiosis, is a rare and life-threatening opportunistic pathogen that has intrinsic resistance to multiple antifungals, presenting significant challenges to the processes of diagnosis and treatment.² *S. aurantiacum* had a high incidence in respiratory specimens of cystic fibrosis patients in Australia, and a relatively low incidence in Europe.³ The clinical isolates of *S. aurantiacum* from China were described for the first time in 2022,⁴ but so far there has been no clinical case report of *S. aurantiacum* endocarditis in China. Herein, we report the fatal case of a previously healthy Chinese patient with disseminated infection and endocarditis, which was found to be caused by *S. aurantiacum* using fungal culture, MALDI-TOF MS, and nanopore sequencing technology. We also provide a literature review on *S. aurantiacum* infections.

Case Presentation

A 44-year-old previously healthy Chinese male presented to our hospital with progressive back pain and limited functional activity of the left lower limb for one month. He reported no history of immunosuppressive medication, corticosteroid, or intravenous drug addiction. On admission, he was conscious, and his vital signs and physical examination findings were unremarkable, except for a lumbosacral examination, which revealed tenderness in the interspinous and bilateral paravertebral muscles, accompanied by radiating pain in his left lower limb. The complete blood cell count showed a white blood cell count (WBC) of $13.36 \times 10^9/\text{L}$ with neutrophils 80.1%, hemoglobin (Hb) 94 g/L, and platelets (PLT) $870 \times 10^9/\text{L}$. Elevated inflammatory marker levels included high-sensitivity C-reactive protein (hsCRP) 277.77 mg/L, erythrocyte sedimentation rate (ESR) 88 mm/h, interleukin-6 (IL-6) 53.1 pg/mL and procalcitonin (PCT) 204.27 ng/mL. HIV-1/-2 antibody test results were negative.

Lumbar magnetic resonance imaging revealed inflammation of the L4/5 disc and ruled out the possibility of an intraspinal tumor. He immediately underwent an aggressive surgical debridement and etiological investigation, but no pathogenic bacteria, including *Brucella* and mycobacteria, were identified. Subsequently, histopathological of the L4/5 nucleus pulposus revealed granulomatous inflammation. His serum (1-3)- β -D-glucan antigen assay (BG assay) and serum aspergillus galactomannan antigen assay (GM assay) came back negative. Piperacillin/tazobactam and vancomycin were empirically administered. However, the symptoms did not improve. Even worse, his body temperature increased to 40 °C, accompanied by new symptoms of chest tightness and dyspnea. Therefore, the indicators of cardiac troponin T (cTnT) and N-terminal pro B-type natriuretic peptide (NT-pro BNP) were investigated. The results showed that the values significantly increased, reaching 40.52 pg/mL and 2379 pg/mL, respectively. Then, echocardiography was performed and revealed new-onset vegetation measuring 13×12 mm over the native mitral valve, with severe mitral regurgitation (Figure 1A). Based on the unusual finding, a detailed interview was conducted once more with the patient. We learned that he had a history of falling into a nearly dry wastewater pool after exposure to hydrogen sulfide gas while working at a sewage treatment plant three months ago. Accordingly, serum BG assay was re-examined and found to be positive with 126.59 pg/mL (normal <70 pg/mL), whereas GM assay remains negative. Therefore, fungal endocarditis was clinically suspected.

According to the diagnostic protocol for infective endocarditis (IE), two sets of aerobic and anaerobic blood cultures (from veins of the left lower extremity and the right upper extremity, respectively) were collected, and four days apart two other sets

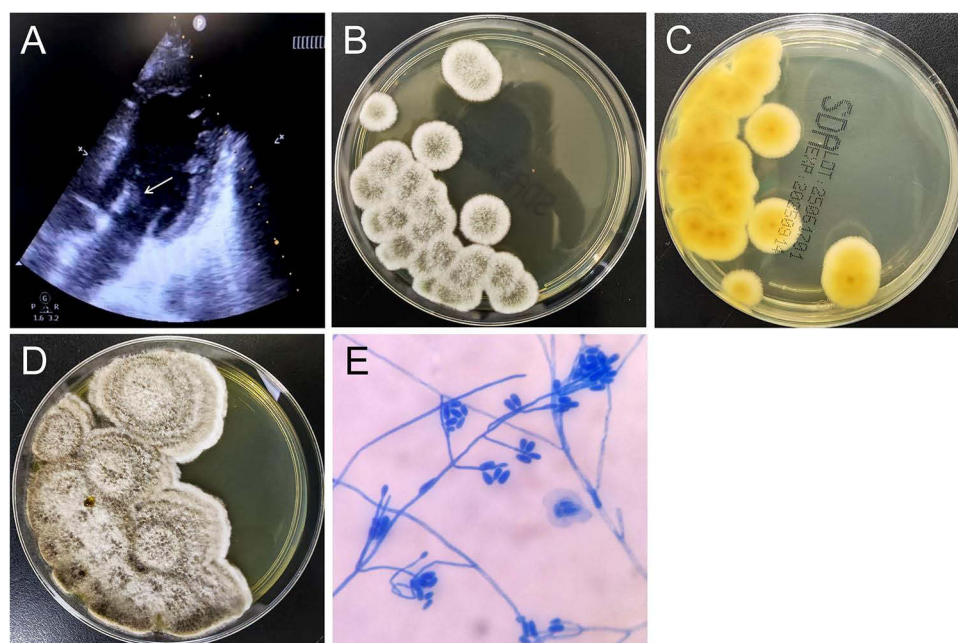


Figure 1 (A) Echocardiography showing a large vegetation over the native mitral valve (white arrow). *S. aurantiacum* cultured on Sabouraud dextrose agar after 3 days at 35 °C: (B) front view and (C) reverse view. (D) Phenotypic characterization of *S. aurantiacum* colonies on Sabouraud dextrose agar after 5 days at 35 °C. (E) Lactophenol cotton blue stain (×1000) of *S. aurantiacum* showing septate hyphae with obovoid and thick-walled conidia.

(from the right femoral vein and the left femoral artery, respectively) were collected. As expected, branching hyphae were found in all aerobic blood culture smears. At 35 °C, the colonies appeared mold-like and greyish-white on Sabouraud dextrose agar (SDA) after 3 days of incubation (Figure 1B), and a brown orange center with a distinctive light-yellow pigment appeared on the reverse side of the SDA plate (Figure 1C). Moreover, a concentric growth pattern and white margins of the colonies were observed after 5 days of incubation (Figure 1D). Lactophenol cotton blue staining of the mold revealed septate hyphae with branching at acute angles and lateral cylindrical or slightly flask-shaped conidiogenous cells bearing obovoid and thick-walled conidia singly or in small groups (Figure 1E), morphologically consistent with *Scedosporium* species.⁵ By using matrix-assisted laser desorption ionization/time-of-flight mass spectrometry (MALDI-TOF MS) (Bruker Daltonics GmbH Microflex LT/SH, USA), the fungus was identified as *Scedosporium aurantiacum* with 2.012 points (Figure 2). Nanopore sequencing targeting the fungal internal transcribed spacer 1 (ITS1) region was conducted using the Oxford Nanopore Technologies (ONT) platform. The fungal sequences showed 100% sequence identity with those of *S. aurantiacum* (accession number: KP132662), and the sequences were deposited in GenBank (accession number: PX279226) (<https://www.ncbi.nlm.nih.gov/nuccore/PX279226.1/>). In addition, the lumbar drainage fluid was subjected to prolonged incubation and the fungi grew, but only a single colony. The patient was diagnosed with disseminated *S. aurantiacum* infection and endocarditis, meeting two major criteria and one minor criterion of the 2023 European Society of Cardiology modified diagnostic criteria for IE.⁶

In vitro antifungal susceptibility testing was performed by a broth microdilution assay according to the Clinical and Laboratory Standards Institute guidelines.⁷ The minimum inhibitory concentrations were as follows: voriconazole, 0.5 µg/mL; itraconazole, 1 µg/mL; posaconazole, 2 µg/mL; isavuconazole, 4 µg/mL; caspofungin, 8 µg/mL; anidulafungin, >8 µg/mL; amphotericin B, >16 µg/mL; micafungin, >16 µg/mL; fluconazole, 32 µg/mL and 5-flucytosine, >64 µg/mL.

Owing to his poor clinical status, which manifested as septic shock, multiple organ failure, and a low PLT count of $27 \times 10^9/L$, he was considered unsuitable for surgical management. Intravenous voriconazole (400 mg on day 1 and 200 mg daily thereafter) combined with amphotericin B (Lipid Complex) (200 mg once daily) and other supportive treatments were initiated; however, his condition continued to deteriorate, and he died 12 days after the fungus was isolated. The patient's family refused autopsy.

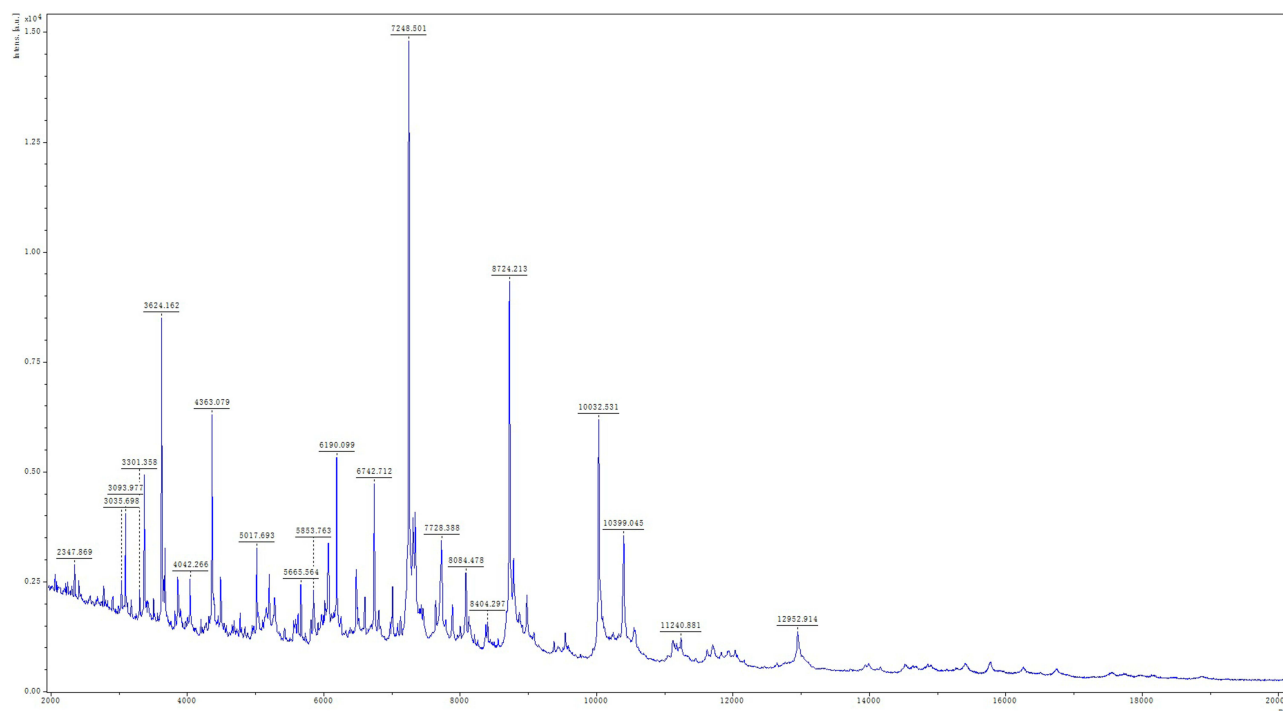


Figure 2 MALDI-TOF MS analysis of the isolate.

Discussion

Although IE due to *Scedosporium* species is quite rare, it is the most common pathogen in fungal IE caused by non-*Aspergillus* filamentous fungi.⁸ The pathology of *Scedosporium* species varies widely, ranging from respiratory colonization in cystic fibrosis patients and localized subcutaneous tissue infections to life-threatening disseminated infections.³ Because clinical symptoms, histopathology, and imaging features of scedosporiosis are easily confused with other mycoses, such as aspergillosis and fusariosis, the diagnosis of scedosporiosis is difficult, resulting in delayed optimal treatment and increased mortality.

Among the 71 Australian clinical isolates of *Scedosporium* species associated with colonization and infection, *Scedosporium apiospermum* accounted for 59.2% and *Scedosporium aurantiacum* for 40.8%.⁹ However, among the 45 clinical isolates of *Scedosporium* infection in China, *Scedosporium boydii* was the most prevalent species at 48.9%, followed by *S. apiospermum* at 40%, *S. aurantiacum* at 8.9%, and *Scedosporium dehoogii* at 2.2%.⁴ This distribution is similar to that observed in patients with cystic fibrosis (CF) in France and in patients with CF or immunocompromise in Northern Spain.^{10,11} Among the 28 cases of immunocompetent patients reported globally who were deeply infected with *Scedosporium* species, *S. apiospermum* was the most common species at 75%, followed by *S. boydii* at 17.9% and *S. aurantiacum* at 10.7%.¹²

Based on the initial laboratory investigations and epidemiological studies described above, *S. apiospermum* was the first pathogen to be identified in our patient. However, *S. aurantiacum* was identified based on macroscopic characteristics, including the production of a distinctive light-yellow pigment and growth at 45 °C, as well as microscopic features manifested as mostly obovoid conidia, and by MALDI-TOF MS and nanopore sequencing of ITS1. Additionally, the assimilation of d-ribose, but not sucrose, is the key characteristic for discriminating *S. aurantiacum* from *S. apiospermum*.¹³

Since *S. aurantiacum* was proposed as a new phylogenetic species in 2005,¹⁴ there has been an increase in *S. aurantiacum* cases involving local or invasive infections. Based on case reports available in PubMed, we identified and analyzed 15 cases of *S. aurantiacum* infection from 2005 to 2025, after including our case, as summarized in Table 1.^{15–26}

Among the 15 patients, there were 7 males and 8 females. The age of these patients ranged from 4 to 82 years. There were 10 cases in Asia, two in America, two in Europe, and one in Australia. *S. aurantiacum* infection in these patients was associated with a diversity of risk factors and initial events, including trauma (5 cases, 33.3%), organ transplantation (4 cases, 26.7%), near-drowning experience (3 cases, 20%), diabetes (2 cases, 13.3%), malignant lymphoma (1 case, 6.7%), lung cancer (1 case, 6.7%), acute myeloid leukemia (1 case, 6.7%), chronic bronchiectasis (1 case, 6.7%), history of nontuberculous mycobacterial infection (1 case, 6.7%), neutropenia (1 case, 6.7%), and anti-neutrophil cytoplasmic antibody-associated systemic vasculitis (1 case, 6.7%). The interval from the initial event to onset among the 8 cases ranged from 0 days to 3 months. Fever was the most common systemic symptom (7 cases, 46.7%), followed by altered consciousness (5 cases, 33.3%) and respiratory distress (5 cases, 33.3%). The main sites of infection were the lungs (7 cases, 46.7%), brain (5 cases, 33.3%), blood and eye (each accounted for 3 cases, 20%). Other affected sites included the bones, subcutaneous tissues, and transplanted kidney (each accounted for 2 cases, 13.3%), and the native heart and transplanted heart (each accounted for 1 case, 6.67%). Five patients (33.3%) had a disseminated disease. Among them, three patients had a history of organ transplantation, 1 case involved trauma, and 1 case involved near-drowning.

There were eight immunocompromised patients (53.3%) and seven immunocompetent patients (46.7%). Generally, immunocompromised patients are thought to be predisposed to opportunistic *Scedosporium* infection; however, this review revealed a high incidence of *S. aurantiacum* infection in immunocompetent patients due to prior trauma (4 cases, 26.7%) and near-drowning (3 cases, 20%). This finding suggests the need to maintain a high index of clinical suspicion in patients with a history of exposure to contaminated environments, even if they are immunocompetent. In the current case, our patient was previously healthy. Despite extensive investigation, there was no evidence of immunosuppression and immunodeficiency in our patient. We presumed that the source of his disseminated infection and endocarditis was through traumatic inoculation in his lumbar after exposure to wastewater. The incidence of lung infections in immunocompromised patients (4 out of 8, 50%) was higher than that in immunocompetent patients (2 out of 7, 28.6%). Immunocompromised patients (3 out of 8, 37.5%) were also more likely to develop disseminated infection than immunocompetent patients (2 out of 7, 28.6%). To date, there have been no reported cases of subcutaneous soft tissue infection in immunocompetent patients.

Table 1 Summary of Reported Cases of *Scedosporium aurantiacum* Infection 2005–2025

Reference/ Year	Age/ Sex	Country	Initial Events	Risk Factors	Clinical Findings	Pathological Changing	Period After the Initial Event	Types of Infections	Specimen Source	Method of Identification	Antifungal Treatment	Treatment Duration	Outcome
Kooijman CM et al, 2007 ¹⁵	36/M	The Netherlands	Trauma	None	Femoral pain	Femoral abscess, fistula	15 weeks	Localised	Femoral fragment	Culture, sequencing	VCZ	12 weeks	Improved
Tintelnot K et al, 2008 ¹⁶	51/F	Germany	Near- drowning	None	Fever, altered consciousness	Brain abscess, hydrocephalus	61 days	Localised	Brain abscess	Culture, sequencing	VCZ	6 months	Improved
Nakamura Y et al, 2013 ¹⁷	68/F	Japan	Near- drowning	None	Fever, altered consciousness, short of breath, double hemiplegia	Brain abscess, hydrocephalus, pneumonia	0 days	Disseminated	Bronchoalveolar lavage fluid	Culture, Sequencing, PCR	VCZ, ABLC	215 days	Improved
Kim SH et al, 2015 ¹⁸	19/M	Korea	None	Heart transplantation	Fever, weakness, mutism, altered consciousness	Acute intracerebral hemorrhage, cerebral infarction, vegetation formed in the transplanted heart	NA	Disseminated	Blood	Culture, PCR	AmB	5 days	Death
Kim SH et al, 2015 ¹⁸	56/M	Korea	None	Kidney transplantation	Fever, oliguria, altered consciousness	Pulmonary multiple nodules and consolidations, pleural effusion, cerebral ischemia	NA	Disseminated	Urine, wound, blood	Culture, PCR	ITRA, ABLC	4 days	Death
Kim SH et al, 2015 ¹⁸	57/F	Korea	None	Kidney transplantation	Weakness, pyuria, hematuria, altered consciousness	Renal abscess, endophthalmitis	NA	Disseminated	Wound	Culture, PCR	VCZ, CAS	24 days	Death
Kondo M et al, 2018 ¹⁹	82/M	Japan	Trauma	Malignant lymphoma, diabetes	Decreased activity	Subcutaneous abscess	0 days	Localised	Subcutaneous abscess	Culture, PCR	None	None	Improved
Kim H et al, 2019 ²⁰	70/F	Korea	Trauma	None	Ocular discomfort	Scleritis, corneal ulcer	10 days	Localised	Necrotic tissue	Culture, sequencing	VCZ, AmB	3 months	Improved
Mizusawa M et al, 2021 ²¹	35/F	USA	None	Lung cancer	Cough, wheezing, chest tightness	Obstructive pneumonia	NA	Localised	Endobronchial lung biopsy, bronchoalveolar lavage fluid	Culture, sequencing	VCZ	12 days	Improved
Amin S et al, 2021 ²²	52/F	Australia	None	Kidney transplant, chronic bronchiectasis	Dyspnea, fatigue, peripheral edema	Pulmonary alveolar proteinosis	NA	Localised	Whole lung lavage fluid	Culture, sequencing	VCZ	5 weeks	Death
Ghasemian R et al, 2021 ²³	67/F	Iran	Near- drowning	None	Fever, ARDS	Aspiration pneumonitis	0 days	Localised	Bronchoalveolar lavage fluid	Culture, sequencing	VCZ, ABLC	6 days	Death
Carnovale S et al, 2022 ²⁴	4/F	Argentina	Trauma	None	Penetrating trauma of the eye	Endophthalmitis	0 days	Localised	Vitreous humor	Culture, sequencing	VCZ, AmB	Not mentioned	Improved
Kitahara M et al, 2024 ²⁵	69/M	Japan	None	Acute myeloid leukemia, nontuberculous mycobacteria infection history, neutropenia	Fever, chills, cough, chest pain	Pneumonia, pleural effusion	NA	Localised	Lung lesion	Sequencing	ABLC	4 days	Death

(Continued)

Table 1 (Continued).

Reference/ Year	Age/ Sex	Country	Initial Events	Risk Factors	Clinical Findings	Pathological Changing	Period After the Initial Event	Types of Infections	Specimen Source	Method of Identification	Antifungal Treatment	Treatment Duration	Outcome
Kashiwada- Nakamura K et al, 2024 ²⁶	78/M	Japan	None	ANCA associated systemic vasculitis, diabetes	Mass of the hand	Subcutaneous abscess	NA	Localised	Subcutaneous abscess	Culture, sequencing	VCZ, PCZ	10 weeks	Improved
This study	44/M	China	Trauma	None	Back pain, fever, chest tightness, dyspnea	Lumbar disc inflammation, vegetation in the native valve, respiratory failure, cerebral embolic infarcts	3 months	Disseminated	Lumbar drainage fluid, blood	Culture, sequencing, MALDI-TOF MS	VCZ, ABLC	12 days	Death

Abbreviations: M, Male; F, Female; ARDS, Acute Respiratory Distress Syndrome; ANCA, Anti-neutrophil cytoplasmic antibody; NA, not available; PCR, polymerase chain reaction; MALDI-TOF MS, matrix-assisted laser desorption ionization/time-of-flight mass spectrometry; ABLC, Amphotericin B (Lipid Complex); AmB, Amphotericin B deoxycholate; ITRA, Itraconazole; VCZ, Voriconazole; CAS, Caspofungin; PCZ, Posaconazole.

Of note, only our patient's native heart valves were affected, while the other patient was a heart transplant recipient who acquired *S. aurantiacum* through donor-derived transmission.¹⁸ Furthermore, *S. aurantiacum* endocarditis may have a poor prognosis. Previous studies have shown that in mouse models, the virulence of *S. aurantiacum* is stronger than that of other *Scedosporium* species and is comparable to that of *Lomentospora prolificans*, which has a high mortality rate of 81% in patients with endocarditis.^{27,28} In this review, the overall mortality of *S. aurantiacum* infection was 46.6% (7 out of 15), but the mortality in patients with disseminated infection can reach up to 80% (4 out of 5). Hence, the clinical outcomes of disseminated infections caused by *S. aurantiacum* are discouraging.

Voriconazole is recommended by the European Federation of Medical Mycology as a first-line antimycotic drug for the treatment of *Scedosporium* infections.²⁹ Although voriconazole was used within the recommended dose in our patients, we did not monitor the serum voriconazole concentrations periodically during the course of intravenous therapy. However, this is an essential procedure for ensuring individualized medication, maximizing therapeutic efficacy and minimizing toxicity. In this case, we used voriconazole combined with amphotericin B (Lipid Complex) to combat *S. aurantiacum* infection. This combination therapy is a first-line alternative treatment for scedosporiosis. However, the optimal therapy remains unknown and data on treatment is anecdotal. Several case reports have added to the evidence that the combination therapy with voriconazole and terbinafine may be synergistic and effective for the treatment of scedosporiosis.^{30–32} So far, there have been no reports on the use of voriconazole in combination with terbinafine for the treatment of *S. aurantiacum* infection. Goldman et al reported a case of cutaneous *S. apiospermum* infection, and the patient partially recovered through the combination therapy of voriconazole plus micafungin and granulocyte macrophage colony-stimulating factor (GM-CSF).³³ In this review, only one patient recovered through skin puncture of a subcutaneous abscess, but without using antifungal drugs.¹⁹ Among the remaining 14 patients who received antifungal treatment, 11 patients were administered voriconazole (11 out of 14, 78.6%), and most of them (7 out of 11, 63.6%) had improved outcomes, while all 3 patients who did not use voriconazole died.

Among the 7 improved cases, the treatment duration ranged from 12 to 215 days. Nine patients (9 out of 15, 60%) underwent in vitro antifungal susceptibility testing of *S. aurantiacum*. The results showed that voriconazole was the most active agent with a minimum inhibitory concentration (MIC) range from 0.25 to 1 µg/mL, followed by a MIC range of 0.5–>16 µg/mL for posaconazole, 0.5–>16 µg/mL for itraconazole, 2–>16 µg/mL for amphotericin, 2–>16 µg/mL for terbinafine, 2–>16 µg/mL for isavuconazole, 4–>8 µg/mL for micafungin and 4–>16 µg/mL for caspofungin.

Because of the variability in virulence and antifungal susceptibility patterns among different species, accurate identification of *Scedosporium* species at the species level is very important for clinical practice.^{2,34} Although little is known about the pathogenesis and virulence of *Scedosporium* species, recent studies have shown that the biofilms serves as a protective role, and the ability to form biofilms enhances virulence in *Scedosporium* species.^{35,36} The biofilms formed by *S. aurantiacum* were more robust and had a greater biomass than those formed by *S. apiospermum*, and the clinical *S. aurantiacum* isolate was also more virulent in a larvae *Galleria mellonella* infection model.³⁵ By comparing the clinical presentation of *S. aurantiacum* and *S. apiospermum* in immunocompetent patients, we found that apart from fever and local pain, which were the most common clinical presentation for both, dyspnea and altered consciousness occurred more common in patients infected with *S. aurantiacum* compared to those infected with *S. apiospermum*, while haemoptysis and lethargy occurred more common in patients infected with *S. apiospermum* compared to those infected with *S. aurantiacum*.¹² In immunocompetent individuals, patients infected with *S. aurantiacum* may have a poorer clinical prognosis than those infected with *S. apiospermum*, with the mortality rates being 28.6% and 23.8%, respectively.

Currently, culture remains the main method for detecting pathogens in clinical samples. Although it is difficult to distinguish these species in terms of morphology, molecular biological methods, such as polymerase chain reaction (PCR) for use on tissue specimens and sequencing of ITS1, ITS2, β-tubulin, and calmodulin for use in cultures, are widely used for the identification of *Scedosporium* species with extremely high sensitivity and precision.³⁷ Clinically, MALDI-TOF MS is a reliable tool that can rapidly and accurately identify *Scedosporium* species.³⁸ Nanopore sequencing technology, as an important auxiliary diagnostic method for difficult-to-cultivate pathogens and uncommon pathogens, has the advantages of short turnaround time, high sequencing length, precise results, and applicability to various clinical samples.³⁹

Conclusion

Herein, we report the first case of *S. aurantiacum* endocarditis in China. This case highlights that, even in immuno-competent patients, fungal origin should be suspected, especially in those with a history of exposure to a contaminated environment. Adequately obtaining the exposure history of contaminated environments is an important aspect of clinical practice, which could assist clinicians to avoid delayed diagnosis. Nanopore sequencing offers a new option for identifying *S. aurantiacum*. It is crucial for clinical laboratories to identify *Scedosporium* spp. to the species level and perform drug susceptibility testing to determine the most appropriate antimycotic agent. Accurate diagnosis and rational treatment are associated with low mortality rate.

Ethics Approval and Informed Consent

This study was reviewed and approved by the Ethics Committee of Public Health Clinical Center Affiliated to Shandong University (No. GWLCZXC-SOP-K-2025-157) and was conducted in accordance with the principles of the Declaration of Helsinki. Institutional approval was not required for publication of the case details as it does not involve sensitive patient information. Written informed consent to have the case details and any accompanying potentially identifiable images or data published has been obtained from the patient's family.

Consent for Publication

Written informed consent was obtained from the patient's family for publication of this report and any accompanying images.

Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; have drafted, revised or critically reviewed the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors report no conflicts of interest in this work.

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