

Disseminated nocardiosis caused by *Nocardia otitidiscaviarum* in an immunocompetent host: A case report and literature review

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Abstract. The aim of the present study was to summarize the clinical characteristics of nocardiosis caused by *Nocardia otitidiscaviarum* in order to improve the knowledge of nocardiosis. A case of dissemination nocardiosis caused by *N. otitidiscaviarum* in an immunocompetent host is reported and the associated literature reviewed. Informed consent for publication of this case report was provided by the patient. The present patient was a young immunocompetent man suffering from disseminated nocardiosis induced by infection with *N. otitidiscaviarum*. Following a poor response to β -lactam antibiotic, a combination of sulfonamide with minocycline was administered, which successfully ameliorated the symptoms. Previous studies published in English were retrieved from PubMed with 'Nocardia otitidiscaviarum' used as the search keyword. A total of 23 articles were retrieved from the PubMed database, supporting the assertion that *N. otitidiscaviarum* is a rare *Nocardia* species. Among these 23 cases, there were 11 cases of lymphocutaneous (48%), 5 of pulmonary (22%), 2 of brain (9%) and 1 of pyothorax (4%) infection, and 4 cases of disseminated infections (17%). Analysis of the immune state of these patients demonstrated that 9 were immunocompetent (39%), 7 of whom had cutaneous infections (30%) with a predominant history of trauma (6/7), and 14 were immunosuppressed, 9 of whom were treated with prednisolone. Microbiology and histopathology were necessary in all cases for definite diagnosis. Among the 13 cases who underwent drug susceptibility testing, 10 cases were sensitive to trimethoprim-sulfamethoxazole (TMP-SMX) and 12 cases were sensitive to aminoglycoside. In conclusion, although *N. otitidiscaviarum* is one of the less commonly isolated species of *Nocardia*, it is capable of inducing localized or disseminated infection, even in an immunocompetent

host. The majority of cases respond well to TMP-SMX and aminoglycoside, but the therapeutic action of cephalosporin is weak. Identification of bacteria and drug sensitivity tests for *Nocardia* is critical for guiding clinical treatment.

Introduction

Nocardia spp. are gram-positive aerobic bacteria, which are commonly found in soil, water and air (1). Contaminated dust, soil and food can enter the body through the respiratory tract, gastrointestinal tract and skin and proceed to cause corresponding symptoms, such as coughing, expectoration, hemoptysis and skin abscesses, which are considered as nocardiosis (2). Nocardiosis is a vital, but often ignored, infectious disease in immunocompromised hosts, which is particularly serious in the absence of timely diagnosis and therapy. Nocardiosis can be caused by various *Nocardia* spp., including *Nocardia asteroides*, *Nocardia brasiliensis*, *Nocardia cyriacigeorgica*, *Nocardia farcinica* and *Nocardia otitidiscaviarum* (3). As compared with the other *Nocardia* spp., *N. otitidiscaviarum* appears to be rare (3%) which was first recognized in samples taken from a Sumatran cavy or guinea pig with ear disease (3). The present case report describes a case of disseminated nocardiosis induced by infection with *N. otitidiscaviarum* in an immunocompetent host. Furthermore, in order to summarize the clinical features of this disease and improve understanding, a review of the existing literature of the disease induced by this species is also presented.

Case report

A 37 year-old Chinese man presented at Beijing Shijitan Hospital (Beijing, China) with an intermittent cough with little sputum, which had lasted 50 days, and a mass on the right side of his neck, which had first presented 1 month previously. The patient initially attributed the neck pain to a neck sprain, however the mass gradually increased in size over a period of 30 days. The patient complained of a 2-month history of unintentional weight loss (≥ 8 kg) and mild pallor of the conjunctiva, skin and palms was detected. No fever, fatigue or night sweats had been experienced since the onset of disease. The patient had no past history of tuberculosis, diabetes mellitus or steroid therapy. The right-hand side of the patient's neck exhibited a

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marked swelling (12x8 cm; Fig. 1), the temperature of which was slightly elevated; however, no cervical or supraclavicular lymphadenopathy was detected. Following examination, percussion dullness was detected in the patient's chest from the first to sixth intercostal spaces on the right mid-clavicular line with a faint expiratory wheeze on the right. The heart rhythm of the patient was regular with no gallops or murmurs and abdominal examination raised no concerns.

Laboratory examination detected mild anemia with a hemoglobin concentration of 6.9 g/dl (reference, 130-175 g/dl), in addition to the following: Red blood count, 3.89×10^{12} cells/l (reference, $4.3\text{--}5.8 \times 10^{12}$ cells/l); mean corpuscular volume, 65.8 fl (reference, 82-100 fl); mean hemoglobin content, 18 pg (reference, 27-34 pg); mean hemoglobin concentration, 270 g/l (reference, 316-354 g/l); and white blood cell (WBC) count, 8.91×10^9 cells/l (reference, $3.5\text{--}9.5 \times 10^9$ cells/l). Serum tumor marker levels were: Cancer antigen-125, 68.3 U/ml (reference, 0-35 U/ml), Cyfra21-1, 4.19 ng/ml (reference, 0-3.3 ng/ml); and neuron-specific enolase, 49.78 ng/ml (reference, 0-17 ng/ml). Abnormal thyroid function was detected: Serum total thyroxine (T4), 6.65 $\mu\text{g/dl}$ (reference, 5.1-14.1 $\mu\text{g/dl}$); total triiodothyronine (T3), 85.3 ng/dl (reference, 80-200 ng/dl); thyrotropin, 9.68 IU/ml (reference, 0.27-4.2 g/dl); free T3, 1.67 pg/ml (reference, 2-4.4 pg/ml); and free T4, 0.94 ng/dl (reference, 0.93-1.7 ng/dl).

Ultrasound investigation (ACUSON Sequoia 512; Siemens Healthineers, Erlangen, Germany) indicated that the right-hand side of the patient's neck was hyperechoic and computed tomography (CT) of the chest (Somatom Definition AS; Siemens Healthineers) demonstrated a mass in the upper lobe of the right lung, multiple nodules in both lungs and pleural effusion in the right lung (Fig. 2).

The initial diagnosis was right upper pulmonary neoplasm with right cervical lymph node and pleural metastases; therefore, an ultrasound-guided right cervical mass biopsy was performed. Histopathological analysis of the aspiration tissue (Santa Cruz Biotechnology, Inc., La Jolla, TX, USA) demonstrated granulation tissue and abscess formation (Fig. 3A). A modified acid-fast stain-positive organism was detected with smooth and granular colonies (Fig. 3B and C). Subculture and microscopy demonstrated the organism was a branching gram-positive rod; thus, *Nocardia* was confirmed. The cutaneous, soft tissue lesion and lung symptoms were diagnosed as nocardiosis.

As the patient presented with nocardiosis with the characteristics of dissemination, further examinations were performed. Firstly, routine and chemical testing of pleural effusion was performed, demonstrating the effusion was pH 7.4, and positive for Rey's reaction, which indicates exudate. The proportion of pleural fluid was 1.025, and the WBC count was significantly elevated at 1.8×10^9 cells/l, with 91% monocytes and 9% polymorphonuclear cells. Protein concentration of the hydrothorax was 32.5 g/l, and the concentrations of glucose, lactate dehydrogenase and adenosine deaminase were 2.1 mmol/l, 468 U/l and 27 U/l, respectively. These results confirmed a parapneumonic effusion. Contrast-enhanced CT of the abdomen indicated multiple low-density lesions in the right lobe of the liver, which, with ring-enhancement, were consistent with the imaging features of an abscess (Fig. 4). MRI scanning of the head (Magnetom Avanto 1.5T; Siemens

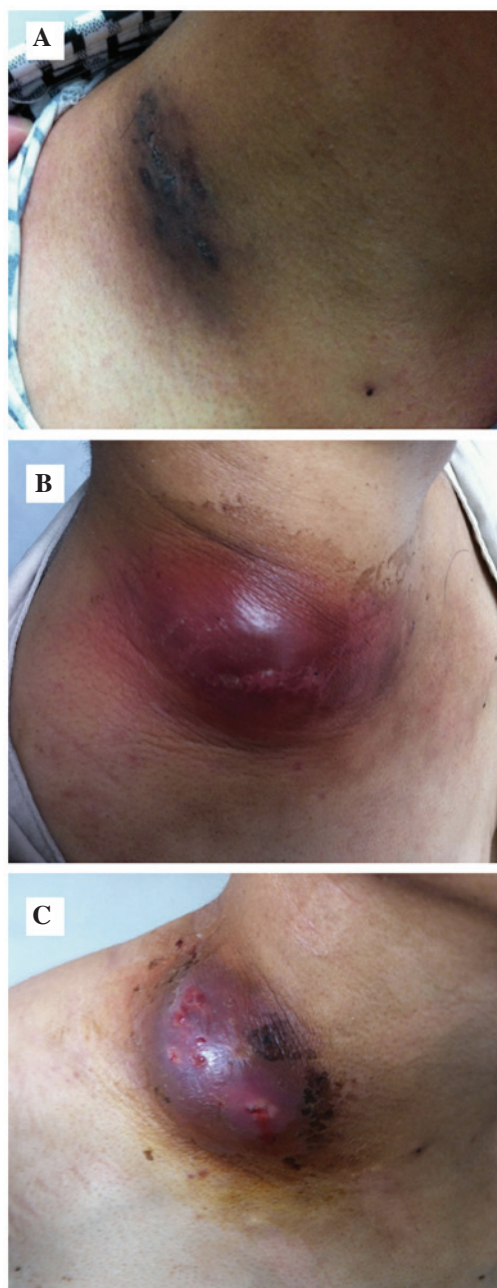


Figure 1. Visual observation of the patient's neck. (A) Mass on the right side of the patient's neck (size, 12x8 cm). After treatment for (B) 20 days and (C) 2 months.

Healthineers) demonstrated no abnormalities. Therefore the patient was diagnosed with disseminated nocardiosis of the subcutaneous soft tissue, lungs and liver.

The patient was initially treated with ceftriaxone (2 g/day) and sulfamethoxazole trimethoprim (2 tablets twice daily). Levothyroxine sodium (25 $\mu\text{g/day}$) was administered for subclinical hypothyroidism. Since the diagnosis of disseminated nocardiosis was confirmed, etiological investigations and drug sensitivity testing was conducted. Culturing of the mass biopsy tissue showed that the patient was positive for *N. otitidiscaviarum*. Using the disk diffusion method (Kirkby-Bauer method), susceptibility testing demonstrated the following diameters for areas of non-bacterial growth in response to various antibiotics: Amoxicillin-clavulanic

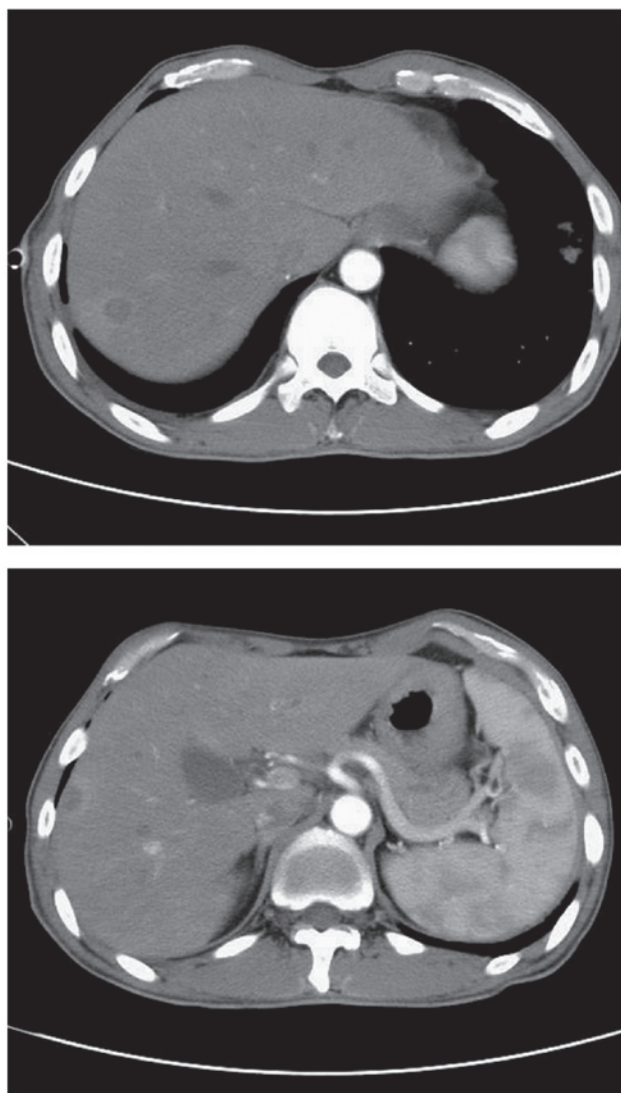


Figure 2. Chest computed tomography showed consolidation in the upper lobe of right lung, multiple nodules in both lung and right pleural effusion.

acid, 6 mm; cefepime 6 mm; imipenem, 6 mm; cefotaxime, 6 mm; ceftriaxone, 9 mm; erythromycin, 12 mm; ampicillin, 16 mm; gentamicin, 22 mm; ciprofloxacin, 24 mm; trimethoprim-sulfamethoxazole (TMP-SMZ), 30 mm; linezolid, 38 mm; minocycline, 40 mm; and amikacin, 42 mm. Therefore, on the basis of these results, combined minocycline and TMP-SMZ therapy was chosen. Following administration for 2 months, the mass on the right-hand side of the patient's neck markedly reduced in size (Fig. 1B and C) and the lung lesion gradually improved.

Discussion

The PubMed database was searched and 23 cases were retrieved with 'Nocardia otitidiscaviarum' as the search term from January 1990 to August 2014 as shown in Table I (3-25). These 23 cases included 11 cases of subcutaneous and soft tissue involvement, 5 patients with pulmonary involvement, 2 cases of brain involvement, 1 case of pyothorax involvement, 1 case of subcutaneous, soft tissue and lung involvement, 1 case of subcutaneous, soft tissue and brain involvement, 1 case of

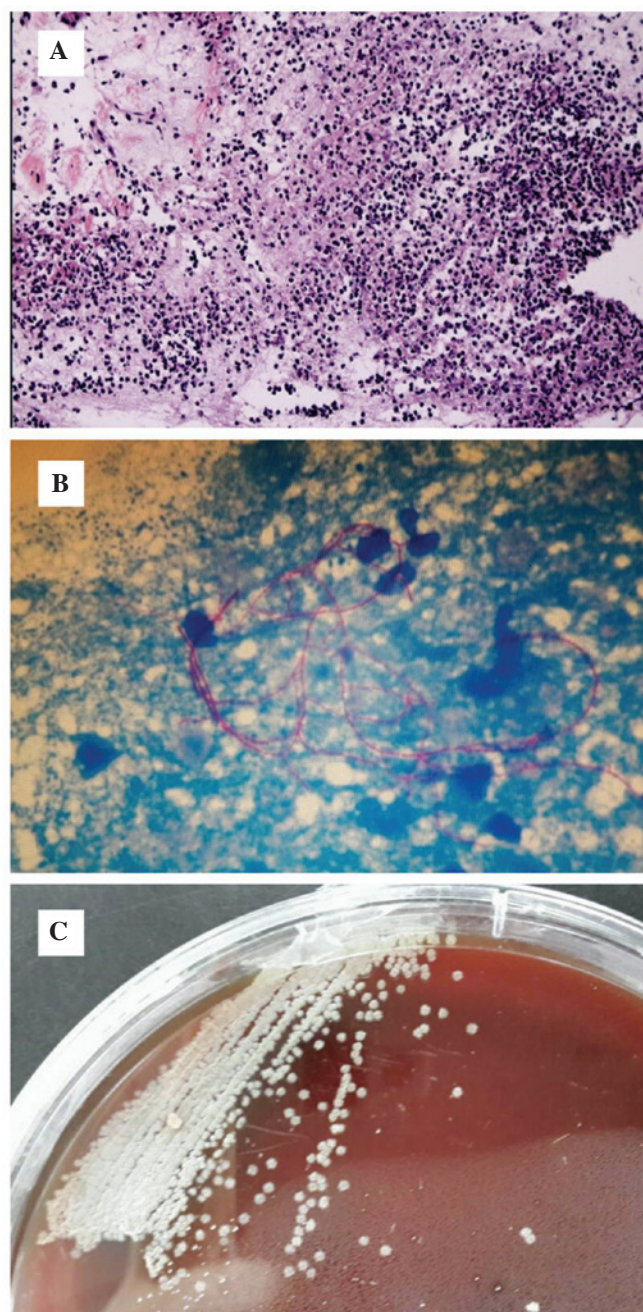


Figure 3. (A) Low power microscopy demonstrated a large amount of necrotic neutrophils, which indicated a purulent lesion. (B) *Nocardia* growth was confirmed by microscopy for a branching gram-positive rod, which was demonstrated to be positive for modified acid-fast stain. (C) *Nocardia* growth was observed by subculture, which demonstrated smooth and granular colonies.

pyothorax and brain involvement, and 1 case with chest wall abscesses, bilateral pulmonary infiltrates and intra-abdominal mass involvement. The mean age of the patients was 56.61 ± 18.58 years, and there were 6 female and 17 male patients. Nine cases were immunocompetent patients, of which 7 cases presented with cutaneous infection; all but one of the patients with cutaneous infection had a history of trauma. The remaining two cases presented with lung infections with no history of trauma. A total of 14 cases were immunosuppressed patients, including the following conditions: Rheumatoid joints (n=3); acquired immune deficiency syndrome (AIDS; n=2); intravenous drug use (n=1); renal transplantation (n=1);

Table I. Studies reviewed, including patient clinical characteristics.

Author, year	Age (years)	Gender	Underlying disease	Sites of infection	Treatment (drug susceptibility)	Ref
Praveen <i>et al</i> , 2014	60	Male	Chronic obstructive pulmonary disease, trauma	Lymphocutaneous	TMP-SMX: No clinical improvement. Amikacin + linezolid for 4 weeks: Clinical improvement. Oral linezolid for 8 weeks (susceptible to amikacin, minocycline and linezolid. Cotrimaxazole for 6 months.	(3)
Ramamoorthi <i>et al</i> , 2011	36	Female	Health no trauma	Lung		(4)
Chen <i>et al</i> , 2011	51	Male	Health trauma	Subcutaneous, soft tissue	TMP-SMX and repeated debridement.	(5)
Betran <i>et al</i> , 2010	57	Male	DM and thrombocytopenia treated with corticosteroid	Cavitary pneumonia	TMP-SMX (susceptible to amikacin, gentamycin and TMP-SMX.	(6)
Pelaez <i>et al</i> , 2009	85	Female	Hypertension coronary disease, chronic obstructive pulmonary disease	Lung, pyothorax, brain	TMP-SMX and imipenem for 10 days: Tonic-clonic convulsions. Oral linezolid for 1 week: Anemia and thrombocytopenia.	(7)
Thoms <i>et al</i> , 2007	55	Male	Health no trauma	Cutaneous nodules and abscesses	Amikacin and imipenem for 4 weeks. TMP-SMX for 1 year (according to susceptibility testing).	(8)
Sharma <i>et al</i> , 2007	36	Female	Sickle cell anemia and end-stage renal disease, no trauma	Lung	Intravenous TMP-SMX for 2 weeks. Amikacin and oral gatifloxacin for 2 weeks. Oral gatifloxacin for 7 months (sensitive to amikacin, ciprofloxacin, gatifloxacin, clarithromycin, gentamicin, kanamycin, tobramycin, sulfisoxazole and linezolid).	(9)
Fabre <i>et al</i> , 2005	70	Male	Rheumatoid arthritis treated with infliximab and prednisone, trauma	Subcutaneous, soft tissue ulcer	Ofloxacin and clindamycin for 3 months.	(10)
Yoshida <i>et al</i> , 2004	69	Male	Rheumatoid vasculitis with prednisone	Pyothorax	Imipen, minocyclin and TMP-SMX: Clinical improvement. Levofloxacin and gentamicin sulfate (susceptibility to levofloxacin and gentamicin sulfate, TMP-SMX and erythromycin intermediate).	(11)
Hemmersbach <i>et al</i> , 2004	44	Male	DM, previous tuberculosis renal transplant (3 years prior)	Brain, subcutaneous, soft tissue	TMP-SMX (susceptibility to TMP-SMX, gentamicin, ofloxacin, ciprofloxacin and doxycycline. Resistance to cefotaxime, ceftriaxone, imipenem and tobramycin, amikacin was not tested).	(12)
Dikensoy <i>et al</i> , 2004	65	Male	Immune competent	Lung	Amikacin and TMP-SMX for 20 days: Duodenal ulcer perforation. TMP-SMX for 4 months (sensitive to TMP-SMX, amikacin and tobramycin only).	(13)
Jennifer <i>et al</i> , 2002	77	Male	Rheumatoid arthritis with prednisoline trauma	Subcutaneous, soft tissue	Minocycline for 2 weeks, clarithromycin for 6 months (intermediate sensitivity to minocycline, sensitive to clarithromycin).	(14)

Table I. Continued.

Author, year	Age (years)	Gender	Underlying disease	Sites of infection	Treatment (drug susceptibility)	Ref
Wada <i>et al</i> , 2002	69	Female	Health trauma	Subcutaneous, soft tissue	TMP-SMX for 6 months.	(15)
Duran <i>et al</i> , 2001	21	Male	Intravenous drug abuser	Brain	Ceftriaxone for 20 days: Lesion increased. Cefotaxime and metronidazole, imipenem and TMP-SMX for 45 days: Improvement, oral TMP-SMX and 6 months (resistance to penicillin, second and third generation cephalosporins, erythromycin and vancomycin, sensitive to aminoglycoside, TMP-SMX, ciprofloxacin, intermediate susceptibility to imipenem and minocycline).	(16)
Hartmann <i>et al</i> , 2000	50	Female	Renal transplantation with prednisolone	Brain	Meopenem and rifampicin for 6 weeks. Oral ciprofloxacin and rifampicin for 2 months.	(17)
Taniguchi <i>et al</i> , 1998	76	Male	Tuberculosis chronic respiratory infection	Lung	Imipenem and oral minocycline: Responded poorly. TMP-SMX: Improvement (susceptible to minocycline, TMP-SMX, tobramycin, clindamycin, kanamycin and netilmycin).	(18)
Sandre <i>et al</i> , 1997	59	Male	AIDS	Chest wall abscesses, bilateral pulmonary infiltrates intra-abdominal mass	TMP-SMX and amikacin and surgical debridement.	(19)
Mereghetti <i>et al</i> , 1997	31	Male	Health trauma	Subcutaneous, soft tissue	TMP-SMX and imipenem for 3 week. TMP-SMX for 3 weeks (resistant to penicillins, cephalosporins, quinolones, erythromycin, clindamycin, tetracycline chloramphenicol, fosfomycin, vancomycin, tobramycin and gentamicin; sensitive to TMP-SMX, imipenem, amikacin and kanamycin).	(20)
Suzuki <i>et al</i> , 1995	78	Female	Therapy with prednisolone for bronchial asthma unknown	Subcutaneous	Minocycline, doxycycline and ofloxacin.	(21)
Clark <i>et al</i> , 1995	86	Male	Health trauma	Subcutaneous, soft tissue	TMP-SMX for 10 weeks (susceptibility to aminoglycoside, TMP-SMX, ceftazidime and imipenem).	(22)
Castelli <i>et al</i> , 1994	31	Male	Intravenous drug abuser AIDS trauma	Subcutaneous, soft tissue	TMP-SMX.	(23)
Yang <i>et al</i> , 1993	36	Male	Unknown	Subcutaneous, soft tissue	TMP-SMX for 5 months.	(24)

Table I. Continued.

Author, year	Age (years)	Gender	Underlying disease	Sites of infection	Treatment (drug susceptibility)	Ref
Simmons <i>et al</i> , 1992	60	Male	Heart transplant	Lung, subcutaneous, soft tissue	TMP-SMX for 10 days: No response. Ciprofloxacin for 24 days: No improvement. Imipenem/cilastatin and TMP-SMX and doxycycline for 14 days: Improvement. Imipenem/cilastatin and TMP-SMX and doxycycline for 14 days. Doxycycline for another 2 months (susceptibility to ciprofloxacin, amikacin, tetracycline and imipenem; resistant to TMP-SMX, methoxazole, ceftriaxone, ceftiofur and amoxicillin/clavulanate).	(25)
TMP-SMX, trimethoprim/sulfamethoxazole; DM, diabetes, mellitus; AIDS, acquired immunodeficiency syndrome.						

heart transplantation (n=1); asthma (n=1); chronic obstructive pulmonary disease (n=1); diabetes mellitus and thrombocytopenia (n=1); sickle cell anemia and chronic renal insufficiency (n=1); diabetes mellitus and renal transplantation (n=1); and tuberculosis and chronic respiratory infection (n=1). Among these immunosuppressed patients, 9 patients were treated with corticosteroids (9/14); the exceptions were 2 cases of AIDS, 1 case of intravenous drug abuse, 1 case of sickle cell anemia and chronic renal insufficiency and 1 case of tuberculosis and chronic respiratory infection. Among the 23 cases, 13 patients underwent drug susceptibility testing, which demonstrated that 77% of cases (10/13) were sensitive to TMP-SMX, with the remaining 3 cases being resistant to TMP-SMX. Furthermore, 12 cases (12/13) were sensitive to aminoglycoside and 12 cases (12/13) were resistant to cephalosporin.

According to the site of infection, human nocardiosis can be clinically classified into nocardial mycetoma or pulmonary, extrapulmonary, central nervous system, cutaneous or subcutaneous nocardiosis (3).

The present case is a patient who initially presented with a persistent cough (lasting 50 days) followed by a right cervical mass with no history of trauma. The diagnosis was primary lung infection caused by *N. otitidiscaviarum*. The patient had participated in carpentry work for 3 years and often had contact with soil and sawdust, and the infection may have been introduced into the respiratory tract via the inspiration of soil and/or sawdust.

Pulmonary nocardiosis is often associated with nocardia empyema, and it has been reported that *N. otitidiscaviarum* is capable of inducing empyema (11). Analysis of the right pleural effusion in the present case demonstrated that it was an exudate dominated by monocytes (pH 7.4) with 2.1 mmol/l glucose. These results indicated that the pleural fluid was parapneumonic without empyema.

It has previously been reported that *Nocardia* spp. are capable of causing disseminated disease that can readily enter the bloodstream and spread throughout the body, including the skin, lung, central nervous system and abdominal organs (3). Therefore, contrast-enhanced CT was performed, which detected a liver abscess, and cranial MRI demonstrated no structural disease. These results confirmed the diagnosis of disseminated nocardiosis of the subcutaneous soft tissue, lungs and liver.

N. otitidiscaviarum was first isolated in 1924 by Snijders (26). Gordon and Mihm were the first to define the biochemical criterion for its identification and distinguish it from other *Nocardia* species (27). Although the name *Nocardia caviae* was originally proposed, the organism is currently known as *N. otitidiscaviarum*, as defined in Bergey's Manual of Systematic Bacteriology (28). Although primary nocardiosis may be induced by infection with any *Nocardia* spp., *N. brasiliensis* is isolated from the majority of cases (~80%) (29). In a study conducted in the USA, only 2.9% (10/347) of infections due to *Nocardia* were identified as *N. otitidiscaviarum* (30). In Germany, *Nocardia* spp. were isolated in 131 patients at a national reference laboratory between 1979 and 1991, with only 8 patients having *N. otitidiscaviarum* infections (31). Therefore *N. otitidiscaviarum* causes fewer infections than other species of *Nocardia*. This low incidence has been attributed to reduced pathogenicity or its lower prevalence in soil (32).

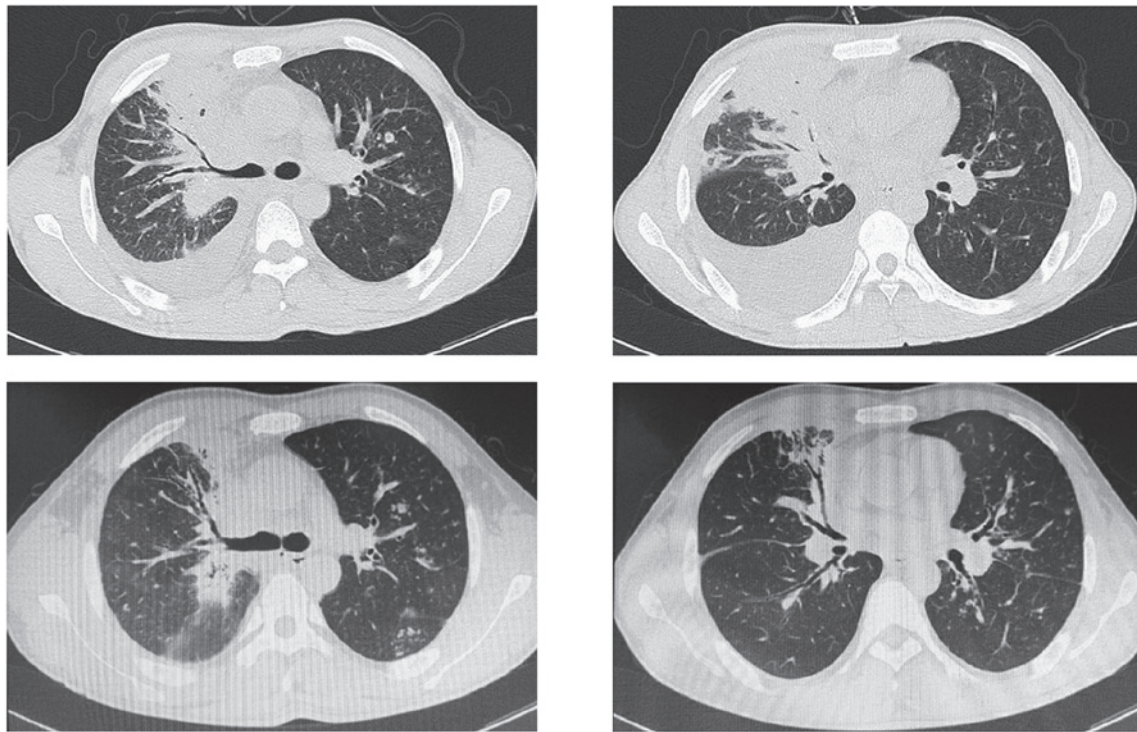


Figure 4. Enhanced computed tomography of the patient's abdomen demonstrated multiple low-density lesions in the right lobe of the liver, which suggested the presence of an abscess.

Tan *et al* (33) retrospectively reviewed the laboratory records of the Bacteriology Laboratory at National Taiwan University Hospital between January 1998 and June 2008 and discovered that the major types of *Nocardia* infection were cutaneous infection (56.6%), pulmonary infection (33.6%) and disseminated infection (7.1%). Therefore, disseminated nocardiosis is a rare disease. It has also been demonstrated that disseminated systemic infection arises in the respiratory tract and is usually associated with *N. asteroides*, in both healthy and immunocompromised hosts, although immunocompromised patients have a greater tendency to develop pulmonary or disseminated disease (34). The present patient was a healthy host with disseminated nocardiosis caused by *N. otitidiscaviarum*, which is rare. To the best of our knowledge, the present case report is the first to describe a case of disseminated nocardiosis of the subcutaneous soft tissue, lungs and liver, caused by *N. otitidiscaviarum* in an immunocompetent host.

The present report is also the first to summarize the literature concerning the clinical characteristics of *N. otitidiscaviarum* from 1990 to 2014, to the best of our knowledge. The present literature review demonstrated that subcutaneous and soft tissue were the most common sites of infection with *N. otitidiscaviarum* (14/23 cases). Amongst the 23 cases retrieved, 39% of the patients were immunocompetent (9/23). The majority of cases of primary cutaneous nocardiosis in healthy patients had a history of local trauma (5/9 cases). Three immunocompetent patients presented with primary lung infection with no history of trauma, and may have become infected by exposure to soil, although *N. otitidiscaviarum* has a lower prevalence in soil, as compared with other *Nocardia* spp. These 3 cases involved only the lungs, and were not disseminated infections; therefore, the present patient is the only case

of disseminated infection caused by *N. otitidiscaviarum* in a healthy patient without a history of local trauma, to date.

Glucocorticoids are well characterized and widely used for immune suppression, however, glucocorticoid use is also one of the risk factors for invasive nocardiosis (1,11). In the present review, corticosteroid administration was considered to be a major contributors to the impaired immunity of the patients (9/23 cases).

Nocardia spp. infection can be observed and confirmed by subculture and positive microscopic detection of a branching gram-positive rod and modified acid-fast stain. It is clinically imperative that the species be identified, as *N. farcinica* is resistant to third generation cephalosporins and tobramycin, and *N. brasiliensis* is resistant to minocycline (35). Although there is no uniform standard or recommended application method from the National Committee for Standardization of Clinical Trials, the majority of previous studies have used the diameter of a zone of inhibition to determine antimicrobial susceptibility (36). It has previously been reported that the sensitivity of *N. otitidiscaviarum* to β -lactam antibiotics is poor (37), which is consistent with the results of the present case. According to the economic conditions of the patient, minocycline combined with TMP-SMZ was recommended.

As with other types of nocardial infections, the optimal duration of antibiotic therapy for *N. otitidiscaviarum* infections remains unknown. Brown-Elliott *et al* (29) previously reported that relapse was rare in cases treated for 4-6 months, although prolonged antibiotic chemotherapy may be required for complete eradication. Furthermore, it has been reported that systemic symptoms disappear after ≥ 6 weeks, and that immunosuppressed patients should be treated for ≥ 6 months and patients with central nervous system involvement should

sustain treatment for 12 months (9). In nocardiosis cases with CNS involvement, treatment with a combination of antibiotics, such as amikacin and minocycline, is recommended for ≥ 2 months (13). Although treatment with sulfonamides has been effective in the majority of cases, susceptibility testing for individual patients should guide definitive therapy, particularly for *N. otitidiscaviarum* infections, which may be resistant to these agents (10,11,19). The present patient received minocycline and TMP-SMZ for 4 months and was considered to be cured.

In conclusion, the present study is the first report of disseminated *N. otitidiscaviarum* infection in an immunocompetent patient without a history of trauma. Clinical and microbiological manifestations of nocardiosis vary for different *Nocardia* spp.; therefore accurate identification of the species is crucial for effective diagnosis and treatment. Susceptibility testing should guide definitive therapy, particularly for *N. otitidiscaviarum* infections, which may be resistant to β -lactam antibiotics. Further experience in the treatment of *N. otitidiscaviarum* infections is required in order to assess drug susceptibility and clinical outcomes.

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