Cutaneous nontuberculous mycobacteria infections: A retrospective case series of 78 patients from the Texas Gulf Coast region

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Background: The incidence of cutaneous nontuberculous mycobacteria (NTM) infections is increasing. These infections are a diagnostic and therapeutic challenge.

Objective: We investigated the clinical features, diagnosis, and management of cutaneous NTM infections.

Methods: A retrospective case series studied 78 patients from a Gulf Coast tertiary referral center diagnosed with cutaneous NTM infection by culture or stain of a skin biopsy specimen.

Results: A history of trauma, procedure, or environmental exposure was common. The mean time between the initial evaluation and diagnosis was 12 weeks. Only 15% of acid-fast bacillus-positive cultures had a positive acid-fast bacillus smear, and only 43% of those accompanied by skin biopsy specimen had a positive Fite stain. Immunosuppressed patients were more likely to have a positive Fite stain. Treatment included surgery and multiple antibiotics. Immunosuppressed patients and *Mycobacterium abscessus* group infections were more likely to have persistent disease.

Limitations: *M chelonae* and *M abscessus* isolates were indistinguishable and therefore were reported together. Five cases were not confirmed by culture.

Conclusions: Even with clinical suspicion, the diagnosis of NTM infection can be difficult. Results of acid-fast bacillus smears and special stains are frequently negative. Antibiotic resistance is common. Multidrug treatment is often required, and surgical therapy may be needed. (J Am Acad Dermatol 2019;81:730-9.)

Key words: acid-fast bacilli; antibiotic susceptibility; atypical mycobacteria; case series; cutaneous; diagnosis; nontuberculous mycobacteria; risk factors; skin; treatment.

The group of *Mycobacterium* species that excludes *M tuberculosis* complex and *M leprae* is known as atypical or nontuberculous mycobacteria (NTM).[1-3] Nearly all NTM species can cause cutaneous infection. *M marinum* and rapidly growing mycobacteria (RGM), *M abscessus, M chelonae,* and *M fortuitum,* are the most frequently implicated in the United States.[1-4] Infection occurs through environmental exposure.[1,3,5] Immunosuppression increases susceptibility.[2,6]

The diagnosis and treatment of cutaneous NTM infection is challenging. Disease may take months to

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become clinically apparent and morphology is nonspecific.[1,2,5] Routine culture may fail to identify NTM.[5,6] Histopathology is nonspecific.[6-9] Treatment decisions rely on recommendations from case reports and expert guidelines owing to the lack of comparative clinical trials.[1,3,5] Antibiotic resistance and susceptibility variation further complicate management.[5]

Although the true incidence of NTM infection is unknown, an increasing incidence has been suggested. One series demonstrated a nearly 3-fold increased incidence over 30 years and a higher proportion of RGM cases in the past decade.[10] A United States Veterans Health Administration study demonstrated an increased incidence of extrapulmonary NTM infection in all but the Mountain region between 2008 and 2012. The Gulf Coast had the highest rates of NTM infection, especially the *M abscessus* group.[11]

As a Gulf Coast tertiary referral center, we predicted that the rates of NTM infection at our institution would provide a unique opportunity to study cutaneous presentation. We investigated risk factors, clinical features, diagnosis, and management.

CAPSULE SUMMARY

- Cutaneous nontuberculous mycobacteria infections are difficult to diagnose and treat.
- The diagnosis should be considered in treatment-resistant lesions, particularly with immunosuppression, trauma, invasive procedure, or environmental exposure. Simultaneous skin biopsy specimen and tissue culture can increase diagnostic yield. Multiple antibiotics combined with surgery may improve treatment success.

METHODS

We performed a retrospective case series of cutaneous NTM infections at The University of Texas Medical Branch in Galveston. Our study was reviewed under an expedited review process by the University of Texas Medical Branch Institutional Review Board and approved (approval IRB #14-0364).

Medical records of patients diagnosed with cutaneous NTM infection between 2009 and 2016 were each reviewed by 2 investigators to collect clinical, microbiologic, histopathologic, management, and outcome data. Inclusion criteria were (1) NTM isolation in culture from a cutaneous source or (2) identification of acid-fast bacilli (AFB) in a Fite-stained biopsy specimen from a skin lesion that was clinically consistent with cutaneous NTM infection.

NTM isolation from cutaneous specimens was achieved using standard methods. All nonsterile and normally sterile but purulent specimens were subjected to digestion and decontamination using *N*-acetyl-L-cysteine—NaOH. After decontamination, specimens were concentrated by centrifugation at 3,200*g* for 15 minutes and resuspended in 2 mL of sterile 0.067 mol/L phosphate buffer. Processed specimen sediment was used to inoculate a BBL Mycobacteria Growth Indicator Tube (MGIT) (Becton Dickinson, Sparks, MD) and a Middlebrook 7H11/Middlebrook 7H11 selective agar biplate (BBL; BD Diagnostic Systems), which were incubated at 37°C. According to the laboratory protocol for mycobacterial isolation from tissue recovered from external sites, an additional Middlebrook 7H11 biplate and a chocolate agar plate (BBL; BD Diagnostic Systems) were inoculated and incubated at 30°C. Media were incubated for 6 weeks. Smears of processed sediment were stained with Auramine O, and if positive, a Kinyoun stain was performed.

Some isolates were sent to Associated Regional and University Pathologists Reference Laboratories for identification to species or complex level by 16S ribosomal (r)RNA gene sequencing or matrix-assisted laser desorption/ionization-time of flight mass spectrometry. *M chelonae* and *M abscessus* are indistinguishable by 16S rRNA gene sequencing and were reported together as *M abscessus* group. Antimicrobial susceptibility testing was performed using the Clinical and Laboratory Standards Institute recommended broth microdilution method for RGM.[12]

Skin biopsy specimens were routinely processed for hematoxylin-eosin stain. Fite stain was performed on formalin-fixed paraffin-embedded tissue from the skin biopsy specimen.

Data were summarized with univariate descriptive statistics. Categorical variables are summarized by counts and percentages, and continuous variables are summarized by means, standard deviations, or minimums and maximums. Modeling of binary outcomes was performed by logistic regression. Each resulting odds ratio was interpreted as the odds of a "yes" or "positive" outcome. Persistence of infection, or "infection survival," was based on observation of clinical appearance and was modeled by weighted log-rank methods over interval-censored time with relation to immunosuppression status, and separately with relation

Abbreviations used:

AFB: acid-fast bacilli
NTM: nontuberculous mycobacteria
RGM: rapidly-growing mycobacteria
rRNA: ribosomal RNA

to NTM species. In all statistical tests, $\alpha = .05$, for a 95% level of confidence.

RESULTS

We identified 78 patients with cutaneous NTM infection, including 32 *M abscessus* group, 18 *M fortuitum* complex, 14 *M marinum*, 2 *M avium* complex, 2 *M neoaurum*, and 1 each of *M haemophilum, M kansasii, M moriokaense, M monacense,* and *M rutilum*. Diagnostic method was AFB culture only in 59 (75.6%), skin biopsy specimen only in 5 (6.4%), and by both in 14 (17.9%). NTM species-specific data are presented in Table I.

There were 38 female and 40 male patients. *M marinum* demonstrated a male predominance (71.4%). The mean age was 47 years (range, 1 month-85 years). Twenty-four patients (30.8%) had a history of immunosuppression. Odds of immunosuppression trended higher with the *M abscessus* group (0.68 odds; 41% of patients) compared with *M fortuitum* complex (0.2; 17%) and *M marinum* (0.17; 14%); however, differences were not significant ($P > .2$). Seventeen patients (21.8%) had a history of diabetes.

Additional risk factors included prior trauma, environmental exposure, invasive procedure, and indwelling foreign body. Of the 3 most common NTMs, the odds of prior trauma were highest for *M fortuitum* complex (0.8 odds; 44% of patients), followed by *M marinum* (0.4; 29%) and *M abscessus* group (0.14; 13%); however, only the difference between *M fortuitum* complex and *M abscessus* group was significant ($P = .042$). The odds of environmental exposure were highest for *M marinum* (2.5; 71% of patients), followed by *M abscessus* group (0.14; 13%) and *M fortuitum* complex (0.13; 11%). Differences between *M marinum* and *M abscessus* group as well as *M fortuitum* complex were significant ($P = .001$ and $P = .0049$, respectively). Among RGM, examples of trauma and environmental exposure included recreational vehicle accidents with exposure to stagnant water, laceration from a soil tiller blade, dog bite, nail penetrating injury, and catfish barb puncture irrigated with tap water. For *M marinum*, most environmental exposures were aquatic, including ocean swimming and fish and turtle handling. Nonaquatic exposures, such as soil exposure, were also documented. Trauma for *M marinum* included cat bite, lawn mower blade laceration, and fish fin injury.

The odds of prior invasive procedure were highest for *M fortuitum* complex (0.8; 44% of patients), followed by *M abscessus* group (0.52; 34%), although there was no significant difference ($P = .48$). Examples included heart and lung transplantation, mastectomy, colostomy, cesarean section, skin excision, tubal ligation, sclerotherapy, liposuction, body piercing, and tattoo. The odds of indwelling foreign body were highest for the *M abscessus* group (0.33; 25%), followed by *M fortuitum* complex (0.2; 17%), although the difference was not significant ($P = .50$). Examples included left ventricular assist device, tissue expander, breast implant, intraperitoneal dialysis catheter, and retained surgical gauze. Patients with *M marinum* had no documented prior invasive procedure or foreign body.

No site predilection was identified for the *M abscessus* group and *M fortuitum* complex; however, *M marinum* exclusively presented on the arm. The *M abscessus* group had the highest odds of multifocal disease (0.46 odds; 31% of patients) compared with *M fortuitum* complex (0.13; 11%) and *M marinum* (0.08; 7%), although the difference was not significant ($P > .24$). Immunosuppressed patients had 11-times higher odds of multifocal disease (46%) compared with immunocompetent patients (7%) ($P = .0004$). Size, symptoms, and morphology varied. A sporotrichoid pattern was described in 2 *M marinum* and 2 *M fortuitum* complex patients.

Extracutaneous disease was documented in 7 patients (50%) with *M marinum*, all with extension to underlying structures. Extracutaneous disease associated with *M fortuitum* was less common (3 patients [17%]), but also involved extension to underlying structures. Extracutaneous disease was documented in 9 patients (28%) in the *M abscessus* group, including extension to underlying structures, pulmonary disease, and bacteremia. Extracutaneous disease was more common in immunosuppressed (61%) compared with immunocompetent patients (23%).

Patients presented to primary care (33%), surgery (36%), dermatology (23%), emergency medicine (4%), infectious disease (3%), and obstetrics/gynecology (1%). The diagnosis was considered in 16.7% of initial encounters. The odds of inclusion of NTM in the initial differential diagnosis was 45-times higher if seen by dermatology compared with other

fields ($P < .001$), but even so, the diagnosis was considered in only 61% of initial dermatology encounters. The mean time between the initial visit and diagnosis was 12 weeks (range, 2 days-150 weeks).

AFB culture was positive in 73 of 78 patients (93.6%). AFB smear was positive in 11 patients (15.1%) with positive AFB culture. Immunosuppressed patients were more likely to have positive AFB smear (29%) than immunocompetent patients (7%). Skin biopsy was performed in 44 patients (56.4%). Histopathology was varied. Granulomatous inflammation was described in 32 patients (73%). Other findings included acute inflammation, dermal necrosis, and pseudoepitheliomatous hyperplasia. All biopsy specimens were accompanied by Fite stain, which was positive in 19 patients (43.2%). Of the patients with positive AFB culture, in which biopsy was performed, only 34.2% were Fite positive. Conversely, of the patients who were Fite positive, only 68.4% had a positive AFB culture. The odds of a positive Fite stain was 4.4-times higher for immunosuppressed patients ($P = .028$).

Three patients (3.8%) were treated with surgery alone, 28 (35.9%) with antibiotics alone, and 37 (47.4%) with both. Treatment was undocumented in 10 patients (12.8%). Of those who received antibiotics, 75% used combination therapy and 25% used monotherapy. Combination therapy was used in 78.6%, 73.1%, and 71.4% of *M fortuitum* complex, *M abscessus* group, and *M marinum*, respectively, and was more commonly used among immunosuppressed (86%) than among immunocompetent patients (69%).

All regimens included at least 1 oral antibiotic. In addition, at least 1 parenteral antibiotic was used in 34.6% of the *M abscessus* group, whereas neither *M fortuitum complex* nor *M marinum* required parenteral therapy.

Oral antibiotics used to treat *M abscessus* group included macrolides (eg, clarithromycin, azithromycin) in 18 patients (69.2%), tetracyclines (eg, minocycline, doxycycline) in 8 (30.8%), fluoroquinolones (eg, moxifloxacin, ciprofloxacin, levofloxacin) in 7 (26.9%), linezolid in 4 (15.4%) and trimethoprim-sulfamethoxazole in 2 (7.7%). Parenteral antibiotics for the *M abscessus* group included amikacin in 8 (30.8%), imipenem in 7 (26.9%), tigecycline in 4 (15.4%), and cefoxitin in 3 (11.5%).

Antibiotics for *M fortuitum* complex included fluoroquinolones (eg, ciprofloxacin, moxifloxacin) in 8 (57.1%), trimethoprim-sulfamethoxazole in 6 (42.9%), tetracyclines (eg, doxycycline, minocycline) in 4 (28.6%), and clarithromycin in 4 (28.6%).

Antibiotics for *M marinum* included clarithromycin in 12 (85.7%), minocycline in 6 (42.9%), ciprofloxacin in 4 (28.6%), trimethoprim-sulfamethoxazole in 3 (21.4%), rifampin in 3 (21.4%), and ethambutol in 1 (7.1%).

Examples of successful antibiotic regimens are summarized in Table II. Treatment duration was longest for the *M abscessus* group (mean, 28 weeks), followed by *M fortuitum* complex (mean, 22 weeks) and *M marinum* (mean, 20 weeks). Antibiotic resistance was common but most pronounced for *M abscessus* group (Table III).

Persistence of infection (infection survival) was significantly higher for the *M abscessus* group compared with *M fortuitum* complex ($P = .017$) and trended higher compared with *M marinum* (Fig 1). Immunosuppressed patients were significantly more likely to have persistent infection compared with immunocompetent patients ($P = .0013$) (Fig 2).

DISCUSSION

Prior case series have contributed to our understanding of cutaneous NTM disease[7-10,13-20]; however, these infections continue to present a diagnostic and therapeutic challenge. We retrospectively reviewed 78 patients with cutaneous NTM infection.

The diagnosis of cutaneous NTM infection was considered in few initial encounters, often with a significant delay between presentation and identification. Many patients had identifiable risk factors, which can alert the clinician to the possibility of NTM infection and prompt AFB-specific testing. However, even with specific diagnostic methods, low sensitivity and processing time hinder timely diagnosis.

In recent years, molecular techniques have helped to address the diagnostic delay imposed by traditional phenotypic identification. Recent developments include use of real-time polymerase chain reaction, followed by postamplification techniques, such as amplicon melt analysis,[21] sequencing (eg, of 16S rRNA, *hsp65*, and *rpoB*, etc),[22] or hybridization probes,[23] and matrix-assisted laser desorption/ionization-time of flight mass spectrometry.[24] These methods can rapidly and accurately identify NTM; however, their use is often limited to reference laboratories owing to required equipment, databases, experience, and in-house validation.[1,5,6,25,26]

Table I. Summary of clinical data by nontuberculous mycobacteria species

	Mycobacterium species									
Variable*	*M abscessus* group (n = 32)	*M avium complex* (n = 2)	*M fortuitum complex* (n = 18)	*M haemophilum* (n = 1)	*M kansasii* (n = 1)	*M marinum* (n = 14)	*M monacense* (n = 1)	*M moriokaense* (n = 1)	*M neoaurum* (n = 2)	*M rutilum* (n = 1)
Age, y	49 ± 18 (15-80)	59 ± 15 (48-69)	44 ± 21 (7-85)	22	79	48 ± 22 (6-74)	75	16	18 ± 25 (0.1-35)	54
Sex										
Female	17	1	9	0	0	4	1	1	1	1
Male	15	1	9	1	1	10	0	0	1	0
Immunosuppressed	13 (41)	2 (100)	3 (17)	1 (100)	0	2 (14)	0	0	1 (50)	0
Risk factors†										
Trauma	4 (13)	0	8 (44)	1 (100)	0	4 (29)	0	1 (100)	0	0
Surgery/procedure	11 (34)	1 (50)	8 (44)	1 (100)	0	0	0	0	0	0
Foreign body	8 (25)	1 (50)	3 (17)	0	0	0	0	0	0	0
Environmental	4 (13)	0	2 (11)	0	0	10 (71)	0	0	0	0
Site‡										
Head and neck	1 (3)	0	0	0	1 (100)	0	0	0	0	0
Trunk	13 (41)	1 (50)	3 (17)	1 (100)	0	0	0	0	1 (50)	0
Arm	8 (25)	1 (50)	6 (33)	1 (100)	0	14 (100)	0	0	1 (50)	0
Leg	13 (41)	0	7 (39)	1 (100)	0	0	1 (100)	1 (100)	0	1 (100)
Buttock/groin	3 (9)	0	3 (17)	0	0	0	0	0	1 (50)	0
Cutaneous disease extent										
Limited (1 site)	22 (69)	2 (100)	16 (89)	0	1 (100)	13 (93)	1 (100)	1 (100)	1 (50)	1 (100)
Multifocal	10 (31)	0	2 (11)	1 (100)	0	1 (7)	0	0	1 (50)	0
Cutaneous morphology	Erosion; nodule; papule; patch; plaque; pustule; ulcer	Nodule; patch	Nodule; papule; patch; plaque; ulcer	Papule; plaque	Nodule	Nodule; papule; plaque; pustule; ulcer	Bulla	ND	Nodule; papule	Nodule; ulcer
Cutaneous symptoms	None; pain; pruritus	Pain	None; pain	ND	Pain	None; pain	Pain; pruritus	Pain	Pain; pruritus	Pain
Extracutaneous disease	9 (28)	1 (50)	3 (17)	1 (100)	0	7 (50)	0	0	0	0
Type	Bacteremia; bursitis; myositis; osteomyelitis; pulmonary; tenosynovitis	Seroma	Osteomyelitis; seroma; tenosynovitis	Tenosynovitis	N/A	Epicondylitis; olecranon bursitis; osteomyelitis; tenosynovitis	N/A	N/A	N/A	N/A

Treatment										
Surgery only	1 (3)	0	1 (6)	0	0	0	0	0	0	0
ABX Only	11 (34)	1 (50)	5 (28)	0	1 (100)	6 (43)	0	0	1 (50)	0
Surgery + ABX	15 (47)	1 (50)	10 (56)	1 (100)	0	8 (57)	0	1 (100)	0	1 (100)
None	5 (16)	0	2 (11)	0	0	0	1 (100)	0	1 (50)	0
Outcome										
Resolution	15 (47)	1 (50)	13 (72)	1 (100)	1 (100)	10 (71)	1 (100)	1 (100)	1 (50)	0
Persistent	8 (25)	1 (50)	0	0	0	0	0	0	0	0
Unknown	9 (28)	0	5 (28)	0	0	4 (29)	0	0	1 (50)	1 (100)

ABX, Antibiotics; *ND*, no data; *N/A*, not applicable.
*Continuous data are presented as the mean ± standard deviation (range) and categorical data as number (%).
†Some patients represented with >1 risk factor.
‡Some patients represented at >1 site.

Diagnostic delay threatens successful treatment by increasing the risk of multifocal and extracutaneous disease. With clinical suspicion, empiric treatment can be considered. Clarithromycin has been recommended as the empiric antibiotic of choice.[5] We agree with this recommendation, because all species displayed at least partial susceptibility to clarithromycin (Table III). Clarithromycin must be used with caution, however, because of an erythromycin resistance methylase (*erm)* gene, which confers inducible macrolide resistance for some RGM species, including *M abscessus* subsp. *abscessus* and *M fortuitum*.[25,27] If the risk of complications is low, some advocate awaiting species identification and susceptibility before treatment owing to the risk of antibiotic resistance and interspecies as well as intraspecies variation.[26] Treatment should be tailored to the NTM species and susceptibility profile, when available.[28]

For uncomplicated RGM infections, at least 2 antibiotics with in vitro susceptibility should be used for a minimum of 4 months. With severe or unresponsive disease, strategies include use of parenteral antibiotics, increasing the number of antibiotics, and increasing the duration of therapy to 6 months or longer.[1-3,28,29] Although some of our patients responded to monotherapy, avoiding this strategy is recommended due to resistance risk. Macrolides were the most active oral agent against the *M abscessus* group in our study, despite only 50% in vitro susceptibility. Parenteral antibiotics, such as amikacin, imipenem, and cefoxitin, were sometimes required. *M fortuitum* complex was treated successfully with combinations of fluoroquinolones, sulfonamides, tetracyclines, and macrolides (Table II).

For *M marinum*, 2 antibiotics should be used for 1 to 2 months beyond resolution, usually at least 3 to 4 months; however, some recommend monotherapy for limited disease.[3] Unlike other NTM species, routine susceptibility testing of *M marinum* is not required due to consistent susceptibility to macrolides, tetracyclines, sulfonamides, rifampin, ethambutol, and amikacin.[1,3,5,25,27] The susceptibility profile of our isolates was consistent with the expected pattern. Occasional resistance to doxycycline and ciprofloxacin was noted, which has been reported.[28] Combinations of macrolides, tetracyclines, sulfonamides, and fluoroquinolones were used with success. Rifampin and ethambutol were used in nonresponsive patients and in those with severe extracutaneous involvement (Table II). Surgery was an important adjunct for all NTM species, particularly with an indwelling foreign body or localized extracutaneous involvement.

Table II. Treatment of cutaneous NTM infection: Examples of successful regimens from our case series

NTM species	Uncomplicated infection	Complicated infection*
M abscessus group	Clarithromycin monotherapy (8-64 wks), 2/3 successful	(Clarithromycin or azithromycin) ± linezolid (52 wks), 1/1 successful
	Clarithromycin or azithromycin (20-51 wks) and surgery, 2/3 successful	± Azithromycin ± amikacin ± imipenem ± cefoxitin ± tigecycline (91 weeks) and surgery, 1/1 successful
	Clarithromycin + moxifloxacin (12 wks), 1/1 successful	Clarithromycin ± moxifloxacin (20 wks), 1/1 successful
	Clarithromycin + TMP/SMX (8 wks) and surgery, 1/1 successful	
	Azithromycin + amikacin + cefoxitin + tigecycline (29 wks) and surgery, 1/1 successful	
	Doxycycline + levofloxacin (3 wks) and surgery, 1/1 successful	
M fortuitum complex	Doxycycline monotherapy (8 wks), 1/1 successful	Ciprofloxacin (52 wks) and surgery, 1/1 successful
	Clarithromycin + minocycline (10 wks), 1/1 successful	Clarithromycin + moxifloxacin (35 wks) and surgery, 1/1 successful
	Clarithromycin + TMP/SMX (40 weeks) and surgery, 1/1 successful	Ciprofloxacin + TMP/SMX (56 weeks), 1/2 successful
	Clarithromycin + ciprofloxacin (16 wks) and surgery, 1/1 successful	
	Ciprofloxacin + TMP/SMX (30 wks) and surgery, 1/1 successful	
M marinum	Clarithromycin monotherapy (10-20 wks), 2/2 successful	Clarithromycin + ethambutol ± TMP/SMX ± rifampin (36 wks) and surgery, 1/1 successful
	Clarithromycin + ciprofloxacin (4-12 weeks) and surgery, 2/2 successful	Clarithromycin + rifampin (52 wks) and surgery, 1/1 successful
	Clarithromycin + minocycline (4 wks), 1/1 successful	Clarithromycin + ciprofloxacin (unknown duration), 1/1 successful
		Clarithromycin ± minocycline (16 wks) and surgery, 1/1 successful
		Minocycline + TMP/SMX (48 wks) and surgery, 1/1 successful

M, *Mycobacterium; NTM*, nontuberculous mycobacteria; *SMX*, sulfamethoxazole; *TMP*, trimethoprim; ±, antibiotic was not used for entire duration.
*Presence of ≥1 of the following: immunosuppression, multifocal disease, or extracutaneous disease.

Table III. Antimicrobial susceptibility profile of nontuberculous mycobacteria isolates in our case series

	Mycobacterium species					
Antibiotic	*M abscessus* group, % (n = 32)	*M fortuitum* complex, % (n = 18)	*M marinum*, % (n = 14)	*M moriokaense*, % (n = 1)	*M neoaurum*, % (n = 2)	*M avium* complex, % (n = 2)
Amikacin	75.0 S (21) 25.0 I (7)	100 S (14)	100 S (3)	100 S (1)	100 S (2)	No data
Cefoxitin	82.8 I (24) 17.2 R (5)	6.7 S (1) 73.3 I (11) 20.0 R (3)	No data	100 S (1)	100 S (2)	No data
Ciprofloxacin	3.4 I (1) 96.6 R (28)	93.3 S (14) 6.7 R (1)	100 R (1)	100 S (1)	100 S (2)	No data
Clarithromycin	50.0 S (14)* 10.7 I (3) 39.3 R (11)	20.0 S (3) 13.3 I (2) 66.7 R (10)	100 S (4)	100 S (1)	100 S (2)	100 S (1)
Doxycycline	100.0 R (11)	33.3 S (1) 66.7 R (2)	66.7 S (2) 33.3 R (1)	No data	100 S (1)	No data
Ethambutol	No data	No data	100 S (3)	No data	No data	No data
Imipenem	69.2 I (18) 30.8 R (8)	33.3 S (5) 60.0 I (9) 6.7 R (1)	No data	100 S (1)	100 S (2)	No data
Linezolid	3.6 S (1) 53.6 I (15) 42.9 R (12)	61.5 S (8) 15.4 I (2) 23.1 R (3)	No data	100 S (1)	100 S (1)	100 S (1)
Minocycline	100 R (27)	7.7 S (1) 23.1 I (3) 69.2 R (9)	100 S (1)	100 S (1)	100 S (1)	No data
Moxifloxacin	100 R (11)	100 S (5)	No data	No data	No data	100 S (1)
Rifampin	No data	No data	100 S (4)	No data	No data	No data
TMP/SMX	100 R (29)	92.9 S (13) 7.1 R (1)	100 S (4)	100 S (1)	100 S (1)	No data
Tobramycin	50 S (1) 50 R (1)	100 S (1)	No data	No data	No data	No data

I, Intermediate; *R*, resistant; S, sensitive; *SMX*, sulfamethoxazole; *TMP*, trimethoprim.
*The protocol to test *M abscessus* group susceptibility to clarithromycin was changed during the study period to include a longer incubation to allow for possible inducible resistance. The reported susceptibility is a summary from the entire study period. Therefore, *M abscessus* group susceptibility to clarithromycin may be artificially high. Susceptibility data were not available for *M haemophilum* (1), *M kansasii* (1), *M rutilum* (1), and *M monacense* (1).

Immunosuppression affected both diagnosis and management. The sensitivity of AFB-specific diagnostic methods was higher in this population. Immunosuppressed patients were more likely to be treated with multiple antibiotics and parenteral therapy; however, they were significantly more likely to have persistent infection, perhaps owing to increased multifocal disease and extracutaneous involvement.

Two limitations were noted. *M chelonae* and *M abscessus* isolates were indistinguishable by 16S rRNA gene sequencing and were reported together as the *M abscessus* group. Five patients were identified by Fite-positive biopsy specimen but were culture negative. Although cutaneous NTM could not be confirmed, each patient was clinically consistent with the diagnosis, and 2 had a documented extracutaneous NTM-positive culture.

CONCLUSIONS

One must maintain a high index of suspicion for NTM whenever considering an infection owing to its nonspecific nature. The diagnosis should be considered in any lesion not responding to traditional treatment, particularly in the setting of immunosuppression, trauma, invasive procedure, indwelling foreign body, or environmental exposure. To increase diagnostic yield, AFB tissue culture and skin biopsy with special stains for AFB should both be performed. A negative result of either test does not preclude the diagnosis, and a negative initial AFB

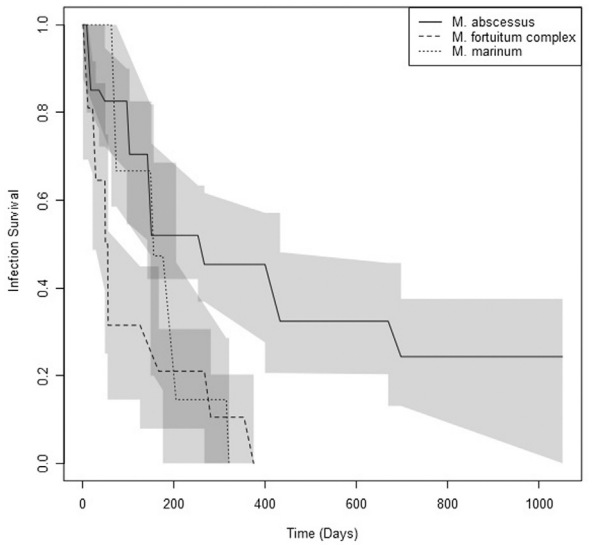

Fig 1. Cutaneous nontuberculous mycobacteria infection survival by species. Persistence of infection (infection survival) was significantly higher for *Mycobacterium abscessus* group compared with *M fortuitum* complex, and trended higher compared with *M marinum*. The *shaded areas* show the 95% confidence interval.

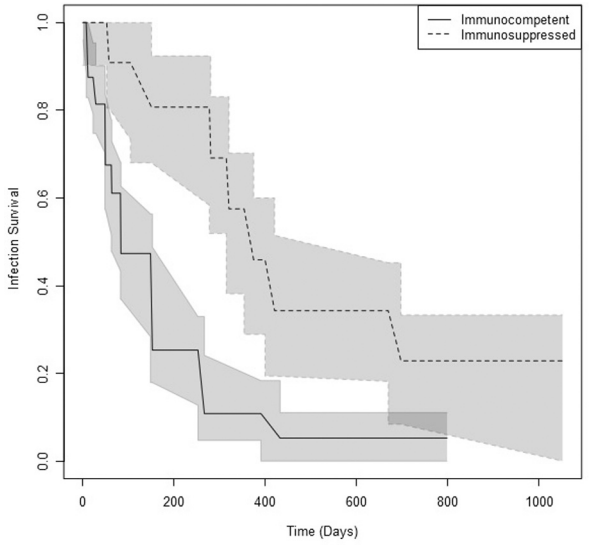

Fig 2. Cutaneous nontuberculous mycobacteria infection survival by immunosuppression status. Immunosuppressed patients were significantly more likely to have persistent infection compared with immunocompetent patients. The *shaded areas* show the 95% confidence interval.

smear does not imply a negative AFB culture. If clinically suspicious, repeat testing should be considered. Antibiotic susceptibility of individual isolates should guide therapy.

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