

The clinical management of cesarean section-acquired *Mycobacterium abscessus* surgical site infections

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Abstract

Introduction: Rapidly growing mycobacteria (RGM) can cause a broad spectrum of both community and healthcare-associated infections in humans. The aim of this study was to report the clinical management and outcomes of successive patients following cesarean delivery with healthcare-associated surgical site infections (SSIs) caused by RGM.

Methodology: Patients who were admitted to Chung Shan Medical University Hospital, Taichung, Taiwan, between September 2006 and July 2008, and who developed SSIs following cesarean delivery at an obstetrics hospital and were then referred to our hospital, were enrolled. Demographic characteristics of the patients and clinical isolates were obtained retrospectively and an environmental investigation was performed. PCR-restriction fragment length polymorphism (PCR-RFLP) analysis of the *hsp65* gene and pulsed-field gel electrophoresis (PFGE) of large genomic DNA restriction fragments were applied to differentiate *Mycobacterium* species.

Results: Seventeen patients were diagnosed with RGM infections by microbiology and/or histopathology. Mycobacterial isolates by PCR-RFLP analysis from 15 patients revealed *Mycobacterium abscessus* (*M. abscessus*) and *M. lentiflavum*. Most of the patients received surgical debridement and combination antimicrobial therapy and were eventually cured.

Conclusions: Our study demonstrates the potential that RGM infections have in causing healthcare-associated SSIs. Surgery plus prolonged combination antimicrobial therapy seemed to be an effective option for the management of *M. abscessus* infections.

Key words: surgical site infections; healthcare-associated infection; antimicrobial management; nontuberculous mycobacterial infection; *Mycobacterium abscessus*; cesarean section

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Introduction

Nontuberculous mycobacteria (NTM) exist widely in the environment, occurring in natural and tap water systems, plant materials, and soil. These organisms can cause pulmonary disease, skin and soft tissue infections (SSTI), lymphadenitis, and disseminated disease in humans [1-5]. Among these diseases, SSTI is one of the main entities, and rapidly growing mycobacteria (RGM) are emerging as the most important causes of both sporadic healthcare-associated infections (HAIs) and outbreaks [6].

Mycobacterium abscessus (*M. abscessus*), an RGM species, has been shown to be resistant *in vitro* to several antiseptic agents such as chlorine and glutaraldehyde [7]. These organisms are frequently detected in hospital water systems, endoscopy equipment, and chronic ventilator settings, and most commonly cause HAIs, outbreaks, pseudo-outbreaks, and surgical site infections (SSIs) [8,9]. Healthcare-associated surgical infections caused by *M. abscessus* have been documented following liposuction [10], rhytidectomy [11], acupuncture [12], mesotherapy

[13,14], prosthetic joint infection [15], and breast implants [16].

The recommended therapy for these infections is the combination of surgical and antimicrobial interventions. NTM are naturally resistant to first-line anti-tuberculosis drugs such as isoniazid, rifampin, pyrazinamide, and ethambutol [9]. The choice of antimicrobial treatment is variable depending on the isolate, and should be guided by *in vitro* susceptibility testing. Only a limited amount of data are available about whether monotherapy or combination antimicrobial therapy is most effective, and about the most effective duration of treatment [9].

Prior studies have reported that the incidence of NTM has increased in Taiwan and worldwide in recent years [4,5,17]. To the best of our knowledge, the association of NTM infection with SSIs following cesarean delivery has not been previously reported. We describe the clinical management and outcomes of SSIs caused by *M. abscessus* related to cesarean delivery at a tertiary care university hospital.

Methodology

Hospital setting

This study was conducted at the Chung Shan Medical University Hospital (CSMUH), a tertiary care university hospital in Taichung, Taiwan. The patients who were referred from an obstetrics hospital in Taichung City and who visited the surgical department of CSMUH between September 2006 and July 2008 were enrolled. This study was approved by the Institutional Review Board of CSMUH (No. CS12114).

Description of the scenario

In November 2006, a general surgery specialist at CSMUH noticed that several previously healthy female patients who had cutaneous and subcutaneous infections and abscesses with multiple grouped nontender erythematous papules and nodules along the suture lines around the postoperative sites following cesarean delivery had all had cesarean deliveries at the same obstetrics hospital. The cutaneous and subcutaneous abscesses were initially debrided and treated with conventional antimicrobials, but without success. Between January 2007 and May 2008, more patients with cutaneous and subcutaneous infections were transferred from this obstetrics hospital to CSMUH. During this period, the 30-bed obstetrics hospital had four obstetricians and a mean delivery of 157 babies per month, including a mean of 45 cesarean deliveries per month.

Definitions

The diagnosis of SSIs due to NTM was defined as certain if the patients had subcutaneous inflammatory lesions, purulence, or other findings consistent with an infection at the site of the cesarean section in association with cultures positive for NTM and/or the results of histopathological examinations consistent with NTM infection from a postoperative tissue specimen. The diagnosis of SSIs was defined as probable if the patients had subcutaneous lesions consistent with an infection, but their smears, cultures, or histopathological examinations were negative for NTM. Definitions for HAIs and SSIs followed the guidelines of the Centers for Disease Control and Prevention (CDC) Hospital Infection Control Practices Advisory Committee [18-21]. In this study, the first-line conventional antimicrobials included beta-lactam antibacterial penicillin administered intravenously or orally (penicillin G, oxacillin, dicloxacillin), first-generation cephalosporins administered intravenously or orally (cephalexin, cephazolin, and cephadrine), and a combination of penicillins and beta-lactamase inhibitors administered intravenously or orally (amoxicillin/clavulanic acid; ampicillin/sulbactam), and a combination antimicrobial therapy consisting of imipenem/cilastatin sodium plus amikacin and clarithromycin.

Data collection and patient characteristics

The medical records of patients who presented at the Department of General Surgery of CSMUH with a diagnosis of an SSI – fulfilling the definition given above – between September 2006 and July 2008 were reviewed. Data on demographic characteristics, clinical symptomatology, comorbidities, mycobacteriology, histopathology, treatment, and outcomes were collected.

Infection control measures and environmental mycobacterial investigation

The Infection Control Committee of CSMUH reviewed the data of the patients when it seemed an outbreak was possible, and environmental investigation teams were deployed to investigate the source of the mycobacterial infection at the obstetrics hospital. Forty-five environmental samples were collected from this obstetrics hospital, including samples from the hands of healthcare workers, from tap water, sterile bottled water, alcohol-retained bottles, and objects from the operation rooms. The settle plate test was performed in the operation rooms. Culture samples were also obtained from any items

that may have been involved during the cesarean deliveries, such as absorbable sutures and surgical staplers. These samples were tested for bacterial and mycobacterial cultures. In addition, a biological control method was used to test the effectiveness of the autoclaving process. Sterile gauze was impregnated with colony growths of *M. abscessus* and then subjected to autoclaving. After the completion of autoclaving, samples were obtained for cultures. The Infection Control Committee of CSMUH helped the obstetrics hospital to enforce the new infection control measures, which included hand hygiene practice, concepts in outbreak investigation, cleaning and disinfecting the environment, monitoring the disinfection and sterilization of devices, and antimicrobial stewardship to optimize the use of antimicrobials.

Mycobacterial isolates

The clinical specimens for microbiological examinations included superficial swabs of drainage fluid, swabs collected during surgery, and needle aspirations. The detailed procedures of mycobacterial isolates were described in a previous study [22].

Mycobacterium species identification

The identification and differentiation of *Mycobacterium* species were performed by colony morphology, biochemical tests, and the molecular method of polymerase chain reaction (PCR)-restriction fragment length polymorphism (PCR-RFLP) [23-25]. The detailed procedures of *Mycobacterium* species identification included DNA extraction, amplification, restriction digestion, and analysis are described in previous studies [22,23,26].

Isolates were identified by checking the mycobacteria PRA pattern database (<http://app.chuv.ch/prasite/index.html>).

Antimicrobial susceptibility testing

Antimicrobial susceptibility testing was performed using the disk diffusion method recommended by Wallace *et al.* [27]. The tested drugs included imipenem (8µg/mL), cefoxitin (30µg/mL), ciprofloxacin (2µg/mL), clarithromycin (3µg/mL), and amikacin (6µg/mL). The *M. abscessus* strain ATCC199777 was used as the control strain for routine disk susceptibility testing in this study. Susceptibility testing was interpreted according to the Clinical and Laboratory Standards Institute guidelines and as described previously [28,29].

Pulsed-field gel electrophoresis typing

Eight *M. abscessus* isolates and two environmental isolates were genotyped by pulsed-field gel electrophoresis (PFGE) to confirm the epidemiologic linkage. PFGE was performed on large genomic mycobacterial DNA restriction fragments using a previously described method [30]. *Salmonella enterica* serovar Braenderup H9812 was used as the DNA size standard [31]. The results of PFGE were interpreted based on the criteria set forth by Tenover *et al.* [32]. The detailed procedures were described in a previous study [25].

Histopathology

All clinical samples from patients after surgery were routinely processed at the Department of Pathology of CSMUH. The results of the histopathological characteristics of the NTM infections of the patients were collected to define the diagnosis as described previously [33]. Ziehl-Neelsen acid-fast bacilli (AFB) smears were performed to detect mycobacteria in the biopsy and discharge specimens. NTM identification of histopathological specimens by cultures and PCR-RFLP was not performed because the biopsy specimens were formalin fixed and paraffin embedded.

Statistical analysis

All statistical analyses were performed using SPSS version 15.0 (SPSS Inc., Chicago, USA). Continuous variables were expressed as means values ± standard deviation (SD), and categorical variables as a percentage of the total number of patients analyzed.

Results

Epidemiology and clinical characteristics of patients

Between September 2006 and July 2008, 17 female patients meeting the diagnostic criteria of the present study were enrolled. All of the patients had visited the potentially implicated obstetrics hospital related to this cluster of infections and had undergone cesarean delivery with a low transverse incision prior to the onset of the infections. The median age was 29 years (range, 20-33 years). None of the patients had any significant systemic diseases, except for one patient who had a hepatitis B infection. Initial symptoms developed from the 14th to the 98th day following cesarean delivery (mean, 44 days). A broad spectrum of clinical manifestations of SSIs was found, including dull abdominal pain, fever, swelling, indurated lesions, discharge, and erythematous lesions in the poorly healed or non-healed wounds (Figure 1).

Table 1. Demographic and clinical characteristics of 17 female patients with rapidly growing mycobacterial infections

Patient age (years) No.	Clinical features		Microbiological findings	Histopathological findings	Treatment	Duration of follow-up ^a (months); outcome
29 (case 1)	Cellulitis, induration		No growth	Chronic inflammation, foamy cells, granuloma, necrosis, fibrosis	IV: 12 wks (F) Oral: clarithromycin (12 mo)	12 cure
29 (case 2)	Cellulitis, discharge		<i>M. abscessus</i> type II	Chronic inflammation, foamy, multinucleated cells, granuloma	IV: 4 wks (C) Oral: clarithromycin (7 mo)	24 cure
29 (case 3)	Cellulitis, discharge	induration,	<i>M. abscessus</i> types I and II	Chronic inflammation, granuloma, foreign body, giant cell	IV: 3 wks (F) Oral: clarithromycin (6 mo)	10 cure
26 (case 4)	Cellulitis, discharge	induration,	<i>M. abscessus</i> type I	Chronic inflammation, granuloma, foreign body, giant cell	IV: 3 wks (F) and 4 wks (C) Oral: clarithromycin (5 mo)	16 cure
27 (case 5)	Cellulitis, discharge	induration,	<i>M. abscessus</i> type II	Granuloma, foreign body, giant cell, fibrosis	IV: 4 wks (C) Oral: clarithromycin (4 mo)	6 cure
23 (case 6)	Cellulitis, discharge	induration,	<i>M. abscessus</i> type II	Chronic inflammation, granuloma, foreign body, giant cell	IV : 4 wks (C) Oral: clarithromycin (9 mo)	18 cure
28 (case 7)	Cellulitis, discharge	induration,	<i>M. abscessus</i> type II	Chronic inflammation, granuloma, foreign body, giant cell	IV: 4 wks (C) Oral: clarithromycin (11 mo)	24 cure
26 (case 8)	Cellulitis, discharge	induration,	<i>M. abscessus</i> types I and II	NA	NA	NA
32 (case 9)	Cellulitis, discharge	induration,	<i>M. abscessus</i> type II	NA	Oral: clarithromycin (2wks)	NA
31 (case 10)	Cellulitis, discharge	induration,	<i>M. abscessus</i> type II	Chronic inflammation	IV: 4 wks (C) Oral: clarithromycin (10 mo)	12 cure
30 (case 11)	Cellulitis, discharge	induration,	<i>M. abscessus</i> type II	Granuloma, foreign body, giant cell	IV: 4 wks (C) Oral: clarithromycin (4 mo)	6 cure
32 (case 12)	Cellulitis, discharge	induration,	<i>M. abscessus</i> type II	Foreign body, giant cell, acute necrotizing inflammation	IV: 4 wks (C) Oral: clarithromycin (6 mo)	24 cure
27 (case 13)	Cellulitis, discharge	induration	<i>M. abscessus</i> type II	NA	Oral: clarithromycin (2 wks)	NA
32 (case 15)	Cellulitis, discharge	induration,	No growth	Granuloma, foreign body, giant cell, acute necrotizing inflammation, microabscess	IV: 4 wks (C) Oral: clarithromycin (6 mo)	6 cure
20 (case 16)	Cellulitis, discharge	induration	<i>M. abscessus</i> type II	Granuloma, giant cell	IV: 4 wks (C) Oral: clarithromycin (3 wks)	24 cure
33 (case 17)	Cellulitis, discharge	induration,	<i>M. lentiflavum</i> type II	Granuloma, giant cell	IV: 4 wks (C) Oral: clarithromycin (3 wks)	6 cure

^aDenotes the combination of effective antimicrobials targeted against rapidly growing mycobacterial and does not include agents that may have been used empirically before diagnosis and performance of antimicrobial susceptibility tests

IV: antibiotics intravenous injection in hospital

Oral: received oral clarithromycin after discharge or at the outpatient department

(F): First-line antimicrobials including, beta-lactam antibacterial penicillin intravenously and orally (penicillin G, oxacillin, dicloxacillin), first-generation cephalosporins intravenously and orally (cephalexin, cephazolin, and cephadrine), and a combination of penicillin and beta-lactamase inhibitors orally and via injections (amoxicillin/clavulanic acid; ampicillin/sulbactam).

©: Combination antimicrobials including imipenem/cilastatin sodium (500 mg q6 hours), amikacin (500 mg/day), and clarithromycin (500 mg q12 hours)

M. abscessus: *Mycobacterium abscessus*, including *M. abscessus* type I and II; *M. lentiflavum*: *Mycobacterium lentiflavum*

NA: not available; Mo: months; Wks: weeks

Table 2. Summary of the demographic characteristics, diagnoses, histopathology, treatment, and outcome of the 17 female patients with surgical site infections caused by *Mycobacterium abscessus* following cesarean delivery in Taiwan

Clinical manifestations	Results
Age, years (medium, (range))	29 (20-33)
Underlying disease (n, %)	
Hepatitis B infection	1 (6%)
Interval between symptoms onset and surgery given, days (mean ± SD)	44 ± 23
Interval between symptoms onset and diagnosis, days (mean ± SD)	83 ± 109
Symptoms and signs (n, %)	
Fever	3 (18%)
Fatigue	11 (65%)
Abdominal pain	6 (35%)
Skin lesions	17 (100%)
WBC per mm ³ (mean ± SD) ^a	6723 ± 1673
Number of <i>M. abscessus</i> isolates ^b	14 (82%)
Number patients of diagnosis by histopathology	10 (59%)
Treatment with combined antimicrobial therapy only	3 (18%)
Treatment with surgical interventions and combined antimicrobial therapy	14 (82%)
Day of combined antimicrobial therapy (mean ± SD)	28 ± 8
Number of surgical interventions procedures (medium)	3 (2-7)
In hospital (n, %)	14 (82%)
Hospital stay, days (mean ± SD)	35 ± 14 (75-18)

^a White cell count: WBC

^b *Mycobacterium abscessus*: *M. abscessus*, including *M. abscessus* type I and II

Figure 1: A picture of the patient (from case No. 2) showing abdominal wall subcutaneous abscesses due to *Mycobacterium abscessus* after cesarean section.



Figure 2: A computed tomography scan with contrast enhancement of the lower abdomen (from case No. 2) showing swollen superficial soft tissue on the anterior abdominal wall and a large, well-defined, oval mass overlapping the uterus of the pelvic cavity. An intra-abdominal abscess is suspected.



Diagnosis was usually delayed, with the average time from symptom onset to microbiological and/or clinical diagnosis being 83 days (range, 7-475 days) (Tables 1 and 2). Table 2 summarizes the demographic characteristics, diagnoses, histopathology, treatment, and outcomes of the 17 female patients with SSIs caused by NTM following cesarean delivery.

All patients but two underwent abdominal computed tomography. The most common finding was fluid collection beneath and in the abdominal wall, and intra-abdominal involvement was also noted in three patients (Figure 2).

Microbiology, antimicrobial susceptibility, and molecular studies

No organisms were detected in Gram and AFB stain smears in any of the clinical specimens. RGM strains of NTM were recovered both on L-J media agar and 7H11 selective agar from 15 (88.2%) of the 17 patients three to seven days after the specimens were placed on the L-J media agar (median interval, four days).

The antimicrobial susceptibility patterns of these 15 isolates were identical; all were susceptible to imipenem, amikacin, clarithromycin, and ceftazidime. All of these 15 isolates were complexes which were identified as *M. abscessus* (including *M. abscessus* type I and II) and *M. lentiflavum* using standard biochemical methods and PCR-RFLP (Table 1).

Environmental samples were obtained from the obstetrics hospital at the end of February 2008. All environmental cultures were negative for *M. abscessus*; however, *M. peregrinum* was isolated from faucets and sinks in the operation rooms. Two environmental samples and eight of these isolates were compared using PFGE. Of the eight isolates, seven were found to be *M. abscessus* type II, and one was found to be *M. abscessus* type I (Figure 3).

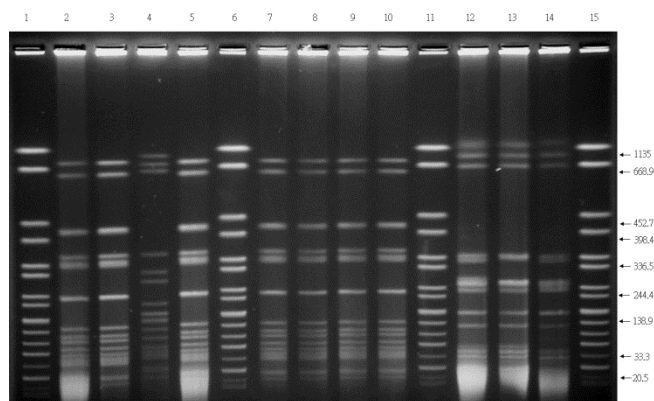
Histopathology

All of the surgical specimens were negative in the AFB smear microscopy in the histopathological examinations. The typical findings of these surgical samples were granulomatous inflammation with foreign body giant cells (86%), granulomatous inflammation (14%), and caseous necrosis in one specimen (Table 1).

Treatment and outcomes

Of all patients in this study, 14 were hospitalized for surgical management and antimicrobial therapy. During their hospital stay, these patients received

Figure 3: Representative PFGE patterns for *Mycobacterium abscessus* isolates. Lanes 1, 6, 11 and 15: molecular-weight marker with H9812 (*Salmonella enterica* serovar Braenderup). Lanes 2-5 and 7-10 show *M. abscessus* isolates from 8 patients. Lane 4 shows *M. abscessus* type I, and the other 7 are *M. abscessus* type II. Lanes 12-14 show *M. peregrinum* isolates from environmental samples



prolonged combination antimicrobial therapy (mean±SD, 28±8 days) of intravenous imipenem (500 mg every 6 hours) and amikacin (7.5 mg/kg every 12 hours) plus oral clarithromycin (500 mg every 12 hours). Four patients were initially treated with first-line conventional antimicrobials. All 14 patients also underwent surgical interventions (2-7 procedures, median 3 procedures). After discharge, all 14 patients received prolonged clarithromycin therapy (mean±SD, 23±13 weeks). The other three patients did not receive any surgical management, completed the whole course of treatment, and were followed-up at CSMUH. All 14 patients were then followed-up by an infectious diseases specialist once a month for a minimum of six months and were eventually cured. Five patients relapsed during the treatment course despite undergoing surgical management and antimicrobial therapy. Of these five patients, three were initially treated with antibiotics that were not effective for the *M. abscessus* infections, and two received oral clarithromycin alone. When the antibiotic regimen was switched to a combination of imipenem, amikacin, and clarithromycin, there were no further relapses.

Discussion

RGM infections have emerged as a significant cause of HAIs in recent years [8,14,15,34-40]. SSIs are the second most common infectious complication following urinary tract infections after cesarean delivery, with an infection rate of 6.3% to 11.2% [41-43]. The most common pathogens causing delayed SSIs following cesarean delivery are *Staphylococcus epidermidis*, *Enterococcus faecalis*, *Staphylococcus aureus*, *Escherichia coli*, and *Proteus mirabilis* [44].

However, healthcare-associated SSIs caused by *M. abscessus* involving inguinal herniotomy, cosmetic surgery, cataract surgery, and outbreaks of injection-related *M. abscessus* infections following contaminated materials have been reported previously [10,35,36]. The *M. abscessus* SSI related to cesarean delivery has not been reported in the English literature.

The diagnosis of postoperative *M. abscessus* infection is potentially challenging. Most clinicians only perform routine bacterial cultures, and although *M. abscessus* can grow on a standard culture medium after three to seven days in ideal conditions, cultures for routine bacteria often fail to yield *M. abscessus* due to insufficient growth time in general practice [45]. Histopathological examinations provided more information for the diagnosis in our study compared to the microbiological cultures and AFB smear microscopy. Granulomatous inflammation with foreign body giant cells was the typical finding, which provided a strong diagnostic clue [33]. Thus, prompt histopathological examinations and mycobacterial cultures are suggested and encouraged. Furthermore, to determine the genetic relatedness among epidemiologically related strains, all strains isolated from infected wounds should be compared using PFGE, which is the most common molecular biology-based technique currently used [30].

The present study highlights two important points. First, clinicians should be particularly aware of the possibility of infections caused by *M. abscessus* in patients who develop delayed or *non-healing* infected wounds following any kind of surgery, particularly if they do not respond to conventional first-line antimicrobial therapy, because the presenting symptoms and signs of *M. abscessus* infections are non-specific and indolent. Computed tomography is a useful tool to detect deep fascia or muscles involved in infections that require urgent hospitalization for both parental antimicrobial therapy and surgical intervention. Second, earlier initiation of adequate prolonged combination antimicrobial therapy with timely surgical management appeared to cure and reduce the relapse rate in such extensively delayed wound infections. No reliable research or randomized clinical trials have demonstrated the most appropriate regimen for *M. abscessus* infections; however, the use of a combination of macrolides with intravenous imipenem, amikacin, or cefoxitin has been reported to be the optimal therapy [9,46]. In the current study, we found that multiple surgical debridement along with prolonged combination antimicrobial therapy

decreased the chance of a relapse and enhanced infection control [46].

Several potential explanations for the source of *M. abscessus* have been discussed in previous reports; some of the noted sources included contaminated solutions such as gentian violet [34], instrumentation [8], injectable medications [37], implantable devices [40], tap water, and deficiencies in sterilization techniques [35]. The exact source of *M. abscessus* in this investigation could not be determined. Absorbable sutures have been suggested as the most likely source because most lesions originate from deep suture sites [47]. Unfortunately, we were unable to culture the absorbable sutures from the obstetrics hospital because the packed commercial sutures had all been used. Water and related equipment has been reported to be a reservoir of *M. abscessus*; however, the results of environmental samples yielded pathogens different from those found in the patients in this study. The environmental survey was performed several months after the initial exposure in this study because the clusters of infection developed initially during primary care and were not promptly recognized as NTM infections. This may explain the discordant findings. The result of the PFGE analysis could not establish a *M. abscessus* cluster (Figure 3). In our study, the patients were infected by *M. abscessus* type I and II, as determined by the *hsp65* PCR-RFLP result [23, 25]. However, the clinical manifestation of the two types of *M. abscessus* found from our research is unclear. A previous study reported that *M. abscessus* type I infected patients might have poor clinical outcomes [25].

There are some limitations to this study. The primary limitation is that we were unable to identify the source of the infection in order to prevent additional cases. Second, some of the patients were diagnosed based on the histopathology alone. The third limitation was the retrospective nature of this research. Fourth, in the PFGE analysis, we used the *Salmonella enterica* serotype *Braenderup* as reference strains and did not include the other *M. abscessus* strains unrelated to the potential cluster to establish a *M. abscessus* cluster. Finally, the disadvantages of PFGE are that it is expensive, time consuming, and labor intensive. Furthermore, *M. abscessus* isolates can suffer DNA degradation during electrophoresis. In contrast, PCR-based methods are cheaper, faster, and easier to perform. Discriminatory power, however, varies depending on the primer used [48]. PFGE pattern is not sufficiently sensitive to discriminate among non-epidemiologically related *M. abscessus*

strains belonging to the same type. We could not provide a dendrogram of PFGE patterns for discriminatory power among unrelated *M. abscessus* strains.

In conclusion, our investigation, based on the epidemiological and microbiological data, demonstrated a relationship between *M. abscessus* and SSIs following cesarean delivery. Although we did not find strong evidence of the source of infection, the SSIs at the obstetrics hospital were controlled after infection control measures were put in place. This study highlights the necessity of being aware of NTM infections in patients who develop delayed or non-healing SSIs which do not respond well to treatment with conventional first-line antimicrobials. Surgery plus prolonged combination antimicrobial therapy seemed to be effective and may be an option for the management of *M. abscessus* infections.

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