OPEN

PRS GLOBAL OPEN

SPECIAL TOPIC
Cosmetic

Managing Complicated Nontuberculous Mycobacteria Infections in Plastic Surgery

Miriam García-Ruza, MD*
Juan Blanco, MD*
Katherine Campusano, MD*
Douglas Silva, BSc†
Franklin Claro, BSc†
Jacobus H. de Waard, PhD*‡

Summary: Nontuberculous mycobacteria (NTM) infections after cosmetic surgery have become an increasing concern. These infections are often initially misdiagnosed and treated with standard antibiotic regimens, which fail to resolve the underlying infection, leading to prolonged patient suffering. In this case study, we describe a chronic wound infection caused by *Mycobacterium abscessus* subsp. *bolletii* after a muscle-repair abdominoplasty. This case illustrates the diagnostic and therapeutic challenges plastic surgeons face in successfully treating such infections. Initial obstacles included the isolation of co-contaminating bacteria that masked the NTM infection, the use of antibiotics ineffective against the specific NTM species, and the failure to identify the infection source. In this instance, contaminated skin marker ink used to mark the rectus muscle, combined with a nonabsorbable (permanent) suture for muscle repair, led to the development of a biofilm that acted as a persistent reservoir for the infection, resistant to antibiotic treatments. Complete resolution was achieved only after evaluation by a plastic surgeon experienced in treating NTM infections and the subsequent removal of the permanent suture. The delayed suture removal contributed to a 15-month recovery period. This case underscores the importance of early recognition of NTM infections after cosmetic procedures. By sharing this case, we aim to raise awareness of NTM infections and help prevent future cases of misdiagnosis and prolonged antibiotic treatments. Key points regarding the diagnosis, sources of infection, and treatment options for NTM infections are highlighted in this article using "text boxes" to emphasize the most important information and provide concise summaries of critical insights. *(Plast Reconstr Surg Glob Open 2024; 12:e6254; doi: 10.1097/GOX.0000000000006254; Published online 24 October 2024.)*

INTRODUCTION

Nontuberculous mycobacteria (NTM) are mycobacteria distinct from *Mycobacterium tuberculosis* (causing tuberculosis) and *Mycobacterium leprae* (causing leprosy). NTM are also known as atypical mycobacteria, or environmental mycobacteria, and can cause skin and soft-tissue infections upon skin penetration. They are commonly present in soil, dust, and water sources, including municipal water supplies. NTM are categorized into 2 groups: slow-growing and rapid-growing mycobacteria, determined by the time taken for colony formation on solid media.

Reports of NTM infections after cosmetic procedures are rising, with cases documented across different procedures and countries.[1–5] The United States is not exempt from this problem. Recently, an outbreak after a cosmetic surgical procedure was reported with a total of 15 cases among patients who received cosmetic surgical procedures at the same facility in Florida.[6] Fast-growing NTM, in particular the species *Mycobacterium abscessus, Mycobacterium chelonae,* and *Mycobacterium fortuitum,* have been increasingly identified as the culprits behind these cosmetic procedure–related infections, but slow-growing NTM, although less frequently reported, have also been isolated.[7,8] NTM infections affect procedures as diverse as breast augmentation, implants, abdominoplasty, fillers, mesotherapy, facelifts, and liposuction.[9–14] Postsurgical wound infections due to NTM are not limited to plastic surgery. Eyebrow tattooing, biopsies, tattoos, pedicures, piercings, acupuncture, laser resurfacing, and intramuscular injections can cause NTM infections.[1,15–17] Notably,

*From the *Department of Plastic, Reconstructive, Aesthetic, and Maxillofacial Surgery. Hospital Vargas de Caracas, San José, Caracas, Venezuela; †Departamento de Tuberculosis y Micobacteriosis, Servicio Autónomo Instituto de Biomedicina "Dr. Jacinto Convit, Hospital Vargas de Caracas, San José, Caracas, Venezuela; and ‡One Health Research Group, Facultad de Ciencias de la Salud, Universidad de Las Américas, Quito, Ecuador.*

Received for publication May 5, 2024; accepted August 27, 2024.

DOI: 10.1097/GOX.0000000000006254

Disclosure statements are at the end of this article, following the correspondence information.

our own research in Venezuela confirms this trend, with reports and case studies involving NTM infections after mesotherapy, hydrolipoclasy therapy, acupuncture, breast implants, liposuction, and dental procedures.[18–21] The sources of infection have been the subject of investigations in multiple publications, with various potential sources identified. These include contaminated water supplies, a contaminated air-conditioning system, the use of ineffective antiseptic solutions, inadequately sterilized medical devices, contaminated medical solutions, and contaminated skin markers.[14,21–27]

In the case of an NTM infection, it is crucial to isolate the mycobacterium in culture and identify the isolated acid-fast microorganism to species level because different species have varying treatment options, and antibiotic susceptibility patterns vary according to the geographical origin of the NTM.[28–33] In addition to a prolonged antibiotic treatment, lasting from 6 months to a year, foreign bodies, such as breast or facial implants, surgical meshes, or fillers, must be removed. The rationale behind this is that when a foreign body remains in place for an extended period, mycobacteria can colonize it, forming a protective layer known as a biofilm. This biofilm acts as a shield, making it challenging for the body's immune system to combat the bacteria and for antibiotics to penetrate effectively.[34]

Abdominoplasty is among the most frequently performed aesthetic procedures, aimed at enhancing the abdomen's shape and appearance. During this intervention, excess skin and fat are removed from the abdomen. Additionally, during an abdominoplasty, the abdominal muscles, using sutures, are often tightened for a firmer abdomen, and the remaining skin is repositioned to create a more toned appearance. Infections are an important complication after abdominoplasty, with an estimated incidence of 1%–3.8%, including operative site infections and infected seromas.[35] Here, we discuss a case involving an NTM infection. This case report describes common mistakes made during the diagnosis of an NTM infection, including the treatment of a coinfection, the use of incorrect antibiotics, and the lack of awareness regarding the presence of a foreign body with a biofilm.

CASE REPORT

A 43-year-old woman, who underwent an abdominoplasty 1 month prior, attended the plastic surgery clinic with symptoms including fever, wound dehiscence displaying signs of inflammation, and serous discharge from the periumbilical surgical wound (Fig. 1A). A culture of the discharge revealed coagulase-positive *Staphylococcus*, sensitive to quinolones. Outpatient treatment was described, consisting of ciprofloxacin (500 mg every 12 h). Despite a 21-day course of ciprofloxacin, the patient showed no improvement, and due to a strong clinical suspicion of an NTM infection, cultures were performed to isolate mycobacteria from the wound discharge. The wound discharge tested positive for *M. abscessus* subsp. *bolletii*.[36,37] To ascertain the source of the infection, samples were collected from various solutions in the surgical area, including iodopovidone, skin markers (methylene blue and gentian violet), and running water from the operating room and the patient's shower. Interestingly, a culture of a commercially available methylene blue antiseptic used for surgical skin marking revealed a strain of *M. abscessus* subsp. *bolletii* with the same genetic profile as the patient's isolate (publication in preparation). This "antiseptic" transmitted the NTM infection during swab marking. Cultures of other solutions, such as tap water and saline solutions, revealed no NTM growth, or NTM species unrelated to this case (*M. fortuitum* was isolated from tap water).

Upon recommendation from an infectious disease specialist, and without antibiotic susceptibility testing, the patient received treatment with oral doxycycline 100 mg every 12 hours for 6 weeks (a poor choice, as in Venezuela, only about 2% of this NTM is susceptible to this antibiotic[33]) and intravenous amikacin 500 mg for 2 weeks, resulting in partial recovery. However, after 6 weeks of treatment, serous discharge from the wound recurred. The patient was then sent back to the laboratory, and susceptibility testing of a new isolate showed susceptibility to amikacin, imipenem, and linezolid but resistance to doxycycline.

A new treatment regimen was initiated, consisting of 4 weeks of amikacin (1 g daily) in combination with intravenous imipenem (500 mg every 12 h for 7 d), followed by daily 50-mg doses of clofazimine and 600 mg of linezolid every 12 hours. After 4 months of treatment and persistent positive results for *M. abscessus* subsp. *bolletii* in the yellow transparent discharge, the case was re-evaluated. Due to suspicion of a fistulous tract, a surgical intervention was planned (Fig. 1B, C).

During the operation, a fistulous tract was discovered from the umbilical region to the right hypochondrium, involving the Prolene sutures used in the abdominoplasty procedure (Fig. 1B). Prolene sutures are nonabsorbable, synthetic (polypropylene) sutures, considered permanent, as they do not dissolve or get absorbed by the body, providing long-term support for wound closure or tissue approximation. The patient had the permanent suture removed, the abdominal area was irrigated and drained with an isotonic solution of 700 ppm hypochlorous acid (Oxikill), and the operation wound was closed using

Takeaways

Question: Why did a nontuberculous mycobacteria (NTM) infection persist despite the prior identification of the species and effective antibiotic treatment through drug resistance testing?

Findings: During surgical exploration, a foreign object—a permanent suture—was discovered, serving as a site for NTM colonization.

Meaning: The removal of foreign materials, along with appropriate antibiotic therapy, is essential for the successful treatment of NTM infections.

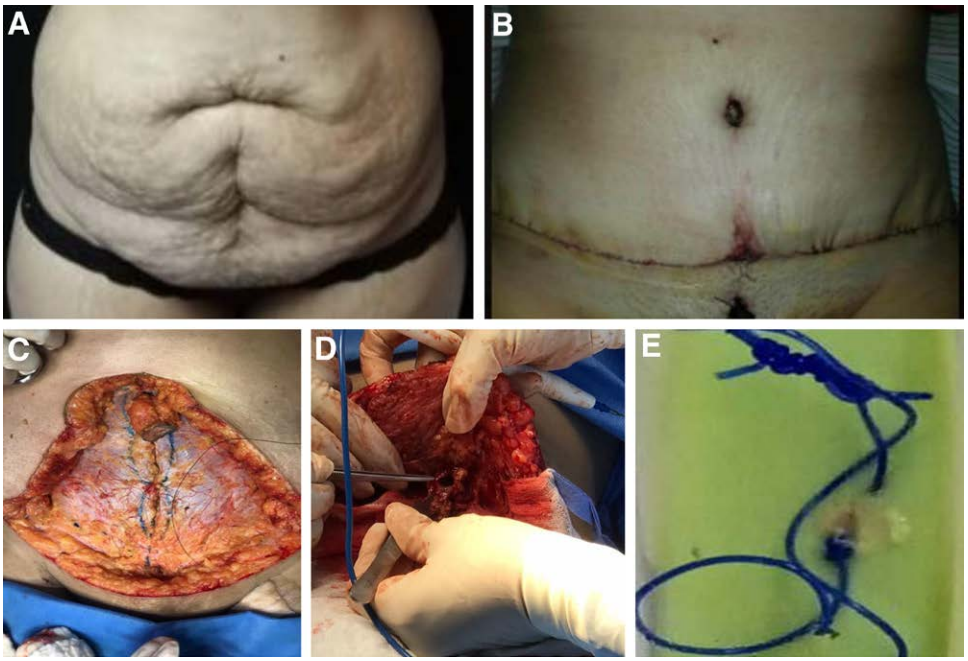

Fig. 1. NTM infection post-abdominoplasty: clinical features and diagnostic insights. A, Patient just before the first plastic surgery procedure, and (B) 4 months after the muscle-repair abdominoplasty procedure, showing wound dehiscence and a fistula. C, The application of the contaminated marker ink delineating the surgical site and the application of permanent sutures for tightening lax abdominal muscles during an abdominoplasty procedure. D, The sinus tract due to the *M. abscessus* infection, indicated with the point of the tweezers, and draining from the abdomen, near the permanent suture, to the skin. E, The suture culture, performed on L-J medium. The area where the suture encountered the L-J medium (depicted by the green color in the photograph due to the presence of Malachite green in this solid egg-based medium) showed the growth of an *M. abscessus* colony, which became visible after 5 days of incubation at 37°C.

Vicryl absorbable sutures for subcutaneous tissue and Prolene sutures for the skin.

The removed suture was sent for microbiological analysis and cultured on Lowenstein-Jensen (L-J) medium, revealing the growth of *M. abscessus* subsp. *bolletii* where the suture touched the culture medium (Fig. 1D). After the surgical intervention, the infectious disease department prescribed treatment with amikacin (1 g for 30 d), in combination with linezolid (600 mg every 12 h), and clofazimine (100 mg daily), followed by 50 mg of clofazimine once daily and 600 mg of linezolid every 12 hours. The patient progressed satisfactorily, experiencing complete wound healing and no discharge after 8 months of treatment. Currently, 2 years have passed without treatment, and the patient remains asymptomatic

DISCUSSION

The increasing number of NTM infections after cosmetic procedures is worrying. These infections, caused by different NTM species, are hard to diagnose, and the infection comes from various sources. Determining which NTM is causing the infection is crucial for finding the right treatment, as different species respond differently to treatment.[38] Hence, mycobacterial cultures are imperative, enabling both identification and antibiotic drug resistance testing.

NTM infections after abdominoplasty have been reported before and were successfully treated.[39–41] However, in this case, the persistent NTM infection required extensive investigation. Despite initial treatments with broad-spectrum antibiotics, the infection persisted, but the presence of a fistulous tract involving nonabsorbable Prolene sutures sheds light on a potential source of persistent infection, highlighting the critical role of foreign bodies in such cases.[42,43]

Microbiological Diagnosis

The presented case highlights the common errors encountered by physicians and microbiology laboratories when diagnosing and treating NTM infections. These errors include isolating and treating co-contaminant microorganisms, a coagulase-positive *Staphylococcus,* a common member of the body's microbiota. The initial sample was obtained using a swab from the open surgical wound, which is susceptible to contamination with skin flora. For NTM isolation, the clinical sample needs to be sterile; that is, without contamination from skin flora. If contamination of the sample with other bacteria is suspected and an NTM infection is suspected, the sample should be decontaminated using NaOH or HPC before inoculating on culture medium. This is a common technique in mycobacterial laboratories to eliminate contaminating flora, ensuring that only NTM are inoculated onto the culture medium.[22] In our case, the skin was decontaminated with 70% alcohol prior to taking a sample of the

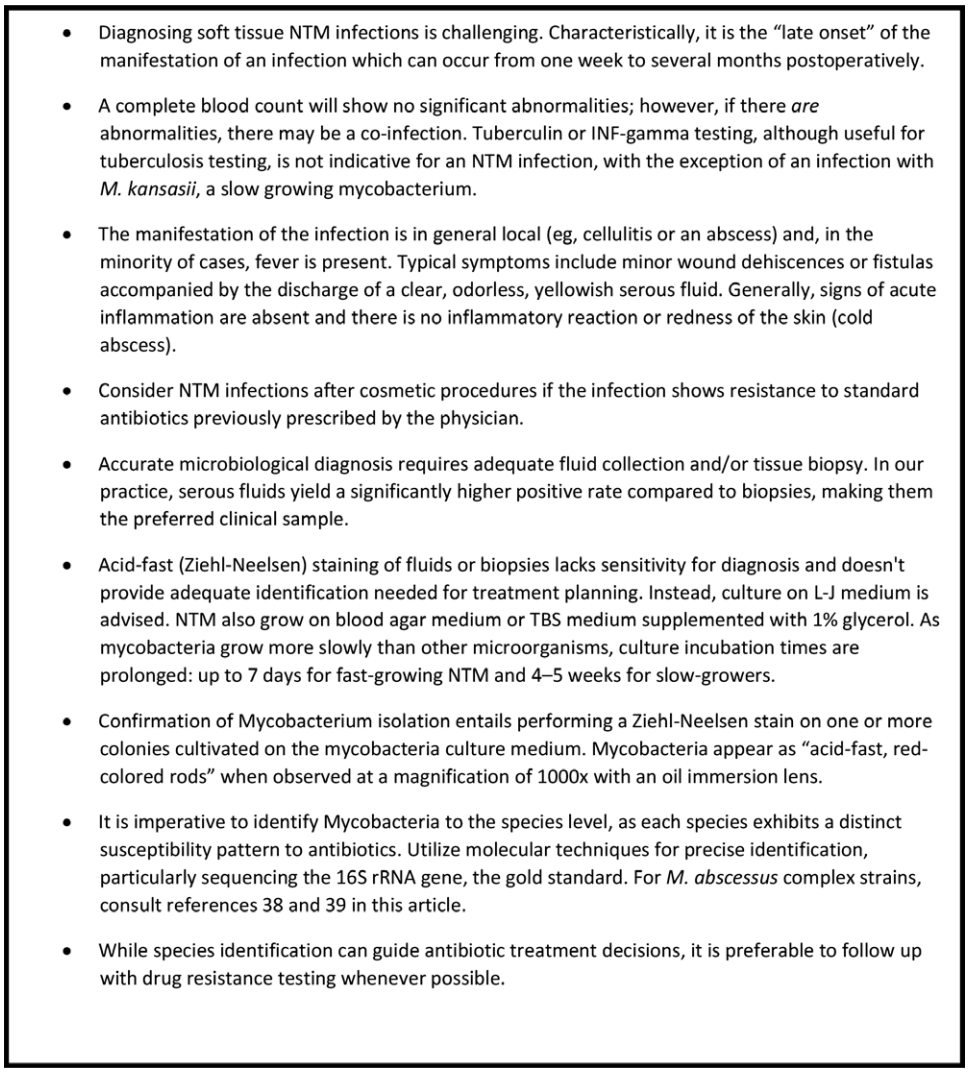

Fig. 2. Diagnoses of NTM infections.

yellowish serous discharge, which is characteristic of NTM infections. This sample did not grow any contaminated bacteria on blood agar after 24 hours of incubation but yielded the mycobacterium on the selective L-J medium, which moreover has a growth inhibitor for most Gram-positive and Gram-negative microorganisms (Malachite green). More information about the microbiological diagnosis of NTM infections can be found in Figure 2.

Treatment of NTM Infections

The second error, once the NTM was isolated, concerned the treatment with doxycycline, a tetracycline antibiotic. Doxycycline is effective against other NTM: clinical usefulness has been mentioned for *M. fortuitum* and *M. chelonae* infections.[44] Nonetheless, in our setting, less than 2% of the *M. abscessus* strains are susceptible to this antibiotic.[33] In contrast, tigecycline, another tetracycline antibiotic, has demonstrated susceptibility across most, if not all, *M. abscessus* strains.[33] This treatment failure underscores the critical need for initial drug resistance testing before commencing NTM treatment. It is noteworthy that the majority of NTM are resistant to drugs commonly used in tuberculosis treatment.[45–47] Further details on NTM infection treatment can be found in Figure 3.

Foreign Body Removal

Once the appropriate treatment was initiated, based on drug resistance testing, nobody recalled the presence of sutures. This was the third error that affected the patient's care. Contaminated marker ink had been used to delineate the abdominal muscles (Fig. 1A), raising the possibility that the infection had triggered a biofilm formation on the suture. The act of forgetting to remove foreign bodies, ie, the permanent suture, sustained the infection. The surgical intervention—involving the removal of the permanent suture, extensive debridement, and lavage with hypochlorous acid (700 ppm HOCl, or Oxikill, FUNDAIM, Caracas)—alongside targeted antibiotic therapy, proved pivotal in achieving a successful resolution of the infection.

The Infection Sources

Identifying the source of infection is crucial, as it can prevent future occurrences. In this particular case, the

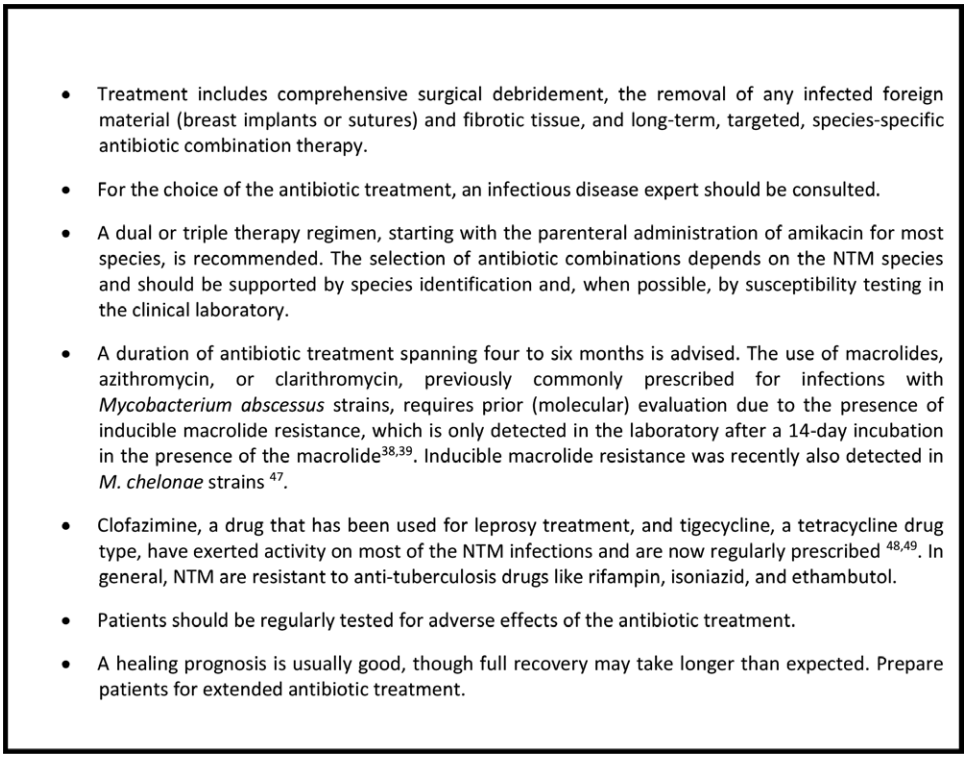

Fig. 3. Treatment of NTM infections

marker ink was found to be contaminated with NTM. Previous reports have also documented NTM contamination of marker ink, not only in surgical settings but also in tattooing procedures.[21,25,48–50]

Municipal water supplies are recognized as significant reservoirs for mycobacteria and are the primary source of most nosocomial outbreaks.[51,52] Supported by biofilms in pipes, NTM can flourish at high temperatures, survive in distilled water, and resist common disinfectants (such as quaternary ammonium compounds[26,53]) as well as the low chlorine concentrations found in tap water.[54] Easy-to-use physical methods must be used to reduce NTM from municipal water, the potential source of infection in a hospital setting.[55,56]

Outbreaks have been linked to various sources of NTM contamination, including ice machines in operating rooms,[57] dental water lines that are not properly disinfected,[20,22] whirlpool foot baths at nail salons,[58] and the use of humidifiers and heater-cooler devices in the operation room.[59,60] Additionally, potential origins of NTM infection include contaminated multidose vials, solutions used for skin marking, and improper handling of injectable medications, particularly when aseptic techniques are not strictly followed. Moreover, inadequate sterilization techniques of potentially NTM-contaminated instruments, such as liposuction cannulas, tattoo and acupuncture needles,[19,48] and piercing tools, can lead to skin or surgical wound infections.[14,61,62] See also the textbox of Figure 4 for a comprehensive overview of potential infection sources. These examples emphasize the importance of strict sterilization protocols and regular monitoring of equipment and water systems in healthcare settings to prevent NTM infections.[55,56]

Infection Source Investigation

For infection source investigations, samples for NTM isolation should include tap water, water from the air-conditioning systems,[63] saline solutions, injectable drugs, surgical dressings, skin markers, and cleaning solutions. Swab samples of surgical instruments, implants, and air-conditioning filters should be collected.[64–66] Air can be sampled with an air sampler. Samples should be processed in a laboratory experienced in isolating mycobacteria using special decontamination techniques and/or selective culture media.[67,68] It is important to remember that mycobacterial infections can be established with very low inocula. For instance, *M. tuberculosis* infections can occur with as few as 10–100 bacteria.[69,70] Although the exact infectious dose for *M. abscessus* skin or soft-tissue infection remains unknown, analyses of mesotherapy solutions implicated in infections have revealed the presence of approximately 10 culturable *M. abscessus* per injection dose[18] (personal communication, J.H.d.W.).

CONCLUSIONS

This case underscores the importance of a multidisciplinary approach involving plastic surgeons, infectious disease specialists, and microbiologists for accurate diagnosis, effective treatment, and optimal management of NTM infections after cosmetic procedures. Stringent infection control measures, including sterile medical devices,

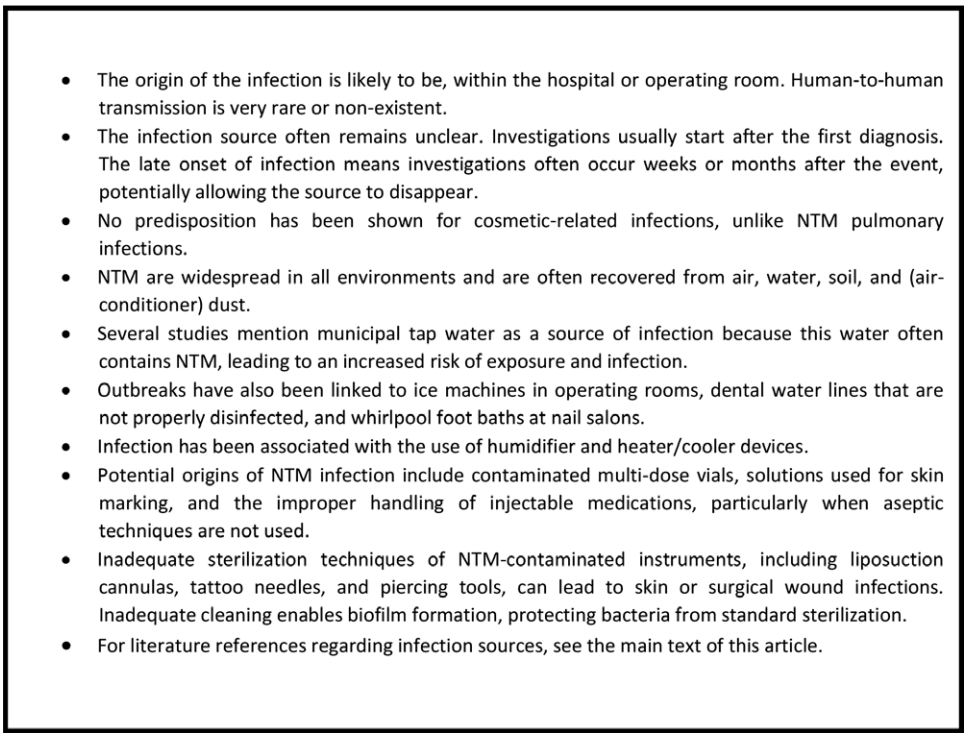

Fig. 4. The source of NTM infections.

effective antiseptics, and vigilant surveillance for contamination sources, are crucial for prevention. Furthermore, NTM infections pose significant diagnostic and treatment challenges. Prompt pathogen identification and recognition of foreign bodies, like nonabsorbable sutures, are critical in persistent infections. Tailored antibiotic regimens and surgical interventions, guided by thorough microbiological analyses, are essential for achieving favorable outcomes in mycobacterial infections.

Jacobus H. de Waard, PhD
Universidad de Las Americas
Campus UDLAPARK
Redondel del Ciclista
Antigua Vía a Nayón
Quito, EC 170124, Ecuador
E-mail: jacobus.dewaard@udla.edu.ec

DISCLOSURES

The authors have no financial interest to declare in relation to the content of this article. The Universidad de Las Américas, Quito, Ecuador, sponsored the article processing fee.

PATIENT CONSENT

The authors have obtained written permission from the patient to publish this case, and this permission is available upon request. Personal details of the patient have been minimized, and irrelevant information for this case study has been omitted.

DECLARATION OF HELSINKI

The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Hospital Vargas and "Servicio Autónomo Instituto de Biomedicina Dr. Jacinto Convit," San José, Caracas, Venezuela.

REFERENCES

1. Hypolite T, Grant-Kels JM, Chirch LM. Nontuberculous mycobacterial infections: a potential complication of cosmetic procedures. *Int J Womens Dermatol.* 2015;1:51–54.
2. Jabbour SF, Malek AE, Kechichian EG, et al. Nontuberculous mycobacterial infections after cosmetic procedures: a systematic review and management algorithm. *Dermatol Surg.* 2020;46:116–121.
3. Safe IP, Macedo V, Marcelo W, et al. Nontuberculous mycobacterial infections after aesthetic procedures: comparison of clinical features and treatment. *J Clin Aesthet Dermatol.* 2021;14:46–49.
4. Cusumano LR, Tran V, Tlamsa A, et al. Rapidly growing *Mycobacterium* infections after cosmetic surgery in medical tourists: the Bronx experience and a review of the literature. *Int J Infect Dis.* 2017;63:1–6.
5. Daniau C, Lecorche E, Mougari F, et al. Association of Healthcare and Aesthetic procedures with infections caused by nontuberculous mycobacteria, France, 2012–2020. *Emerg Infect Dis.* 2022;28:518–526.
6. Saunders KE, Reyes JM, Cyril L, et al. Notes from the field: nontuberculous mycobacteria infections after cosmetic surgery procedures in Florida—nine states, 2022–2023. *MMWR Morb Mortal Wkly Rep.* 2024;73:66–67.
7. Torres-Coy J, Carrera C, Rodríguez-Castillo B, et al. *Mycobacterium szulgai*: an unusual cause of skin and soft tissue infection after breast augmentation. *Int J Dermatol.* 2017;56:e122–e124.
8. Piquero J, Casals V, Higuera E, et al. Iatrogenic *Mycobacterium simiae* skin infection in an immunocompetent patient. *Emerg Infect Dis.* 2004;10:969–970.
9. Centers for Disease Control and Prevention (CDC). *Mycobacterium chelonae* infections associated with face lifts–New Jersey, 2002-2003. *MMWR Morb Mortal Wkly Rep.* 2004;53:192–194.

10. Rodriguez JM, Xie YL, Winthrop KL, et al. *Mycobacterium chelonae* facial infections following injection of dermal filler. *Aesthet Surg J.* 2013;33:265–269.
11. Carbonne A, Brossier F, Arnaud I, et al. Outbreak of nontuberculous mycobacterial subcutaneous infections related to multiple mesotherapy injections. *J Clin Microbiol.* 2009;47:1961–1964.
12. Furuya EY, Paez A, Srinivasan A, et al. Outbreak of Mycobacterium abscessus wound infections among "lipotourists" from the United States who underwent abdominoplasty in the Dominican Republic. *Clin Infect Dis.* 2008;46:1181–1188.
13. Romero FA, Powell EA, Babady NE, et al. Nontuberculous mycobacterial infections after silicone breast implant reconstruction emphasize a diversity of infecting mycobacteria. *Open Forum Infect Dis.* 2017;4:ofx189.
14. Meyers H, Brown-Elliott BA, Moore D, et al. An outbreak of *Mycobacterium chelonae* infection following liposuction. *Clin Infect Dis.* 2002;34:1500–1507.
15. Young Bae J, Sik Yun I, Suk Roh T, et al. Treatment strategy for skin and soft tissue infections caused by nontuberculous mycobacteria following various procedures. *Arch Aesthet Plast Surg.* 2021;27:3–11.
16. Cooksey R, de Waard JH, Yakrus M, et al. *Mycobacterium cosmeticum* sp. nov., a novel rapidly growing species isolated from a cosmetic infection and from a nail salon. *Int J Syst Evol Microbiol.* 2004;54:2385–2391.
17. Kim HY, Yun YJ, Park CG, et al. Outbreak of *Mycobacterium massiliense* infection associated with intramuscular injections. *J Clin Microbiol.* 2007;45:3127–3130.
18. Rivera-Olivero IA, Guevara A, Escalona A, et al. Soft-tissue infections due to non-tuberculous mycobacteria following mesotherapy. What is the price of beauty? *Enferm Infecc Microbiol Clin.* 2006;24:302–306.
19. Guevara-Patiño A, Sandoval de Mora M, Farreras A, et al. Soft tissue infection due to *Mycobacterium fortuitum* following acupuncture: a case report and review of the literature. *J Infect Dev Ctries.* 2010;4:521–525.
20. Pérez-Alfonzo R, Poleo Brito LE, Vergara MS, et al. Odontogenic cutaneous sinus tracts due to infection with nontuberculous mycobacteria: a report of three cases. *BMC Infect Dis.* 2020;20:295.
21. Torres-Coy JA, Rodríguez-Castillo BA, Pérez-Alfonzo R, et al. Source investigation of two outbreaks of skin and soft tissue infection by *Mycobacterium abscessus* subsp. abscessus in Venezuela. *Epidemiol Infect.* 2016;144:1117–1120.
22. Castellano Realpe OJ, Gutiérrez JC, Sierra DA, et al. Dental unit waterlines in Quito and Caracas contaminated with nontuberculous mycobacteria: a potential health risk in dental practice. *Int J Environ Res Public Health.* 2020;17:2348.
23. Scheflan M, Wixtrom RN. Over troubled water: an outbreak of infection due to a new species of *Mycobacterium* following implant-based breast surgery. *Plast Reconstr Surg.* 2016;137:97–105.
24. Da Mata Jardín O, Hernández-Pérez R, Corrales H, et al. Follow-up on an outbreak in Venezuela of soft-tissue infection due to *Mycobacterium abscessus* associated with mesotherapy. *Enferm Infecc Microbiol Clin.* 2010;28:596–601.
25. Safranek TJ, Jarvis WR, Carson LA, et al. *Mycobacterium chelonae* wound infections after plastic surgery employing contaminated gentian violet skin-marking solution. *N Engl J Med.* 1987;317:197–201.
26. Cortesia C, Lopez GJ, de Waard JH, et al. The use of quaternary ammonium disinfectants selects for persisters at high frequency from some species of non-tuberculous mycobacteria and may be associated with outbreaks of soft tissue infections. *J Antimicrob Chemother.* 2010;65:2574–2581.
27. Tiwari TS, Ray B, Jost KC Jr, et al. Forty years of disinfectant failure: outbreak of postinjection *Mycobacterium abscessus* infection caused by contamination of benzalkonium chloride. *Clin Infect Dis.* 2003;36:954–962.
28. Griffith DE, Aksamit T, Brown-Elliott BA, et al; ATS Mycobacterial Diseases Subcommittee. An official ATS/IDSA statement: diagnosis, treatment, and prevention of nontuberculous mycobacterial diseases. *Am J Respir Crit Care Med.* 2007;175:367–416.
29. Hatakeyama S, Ohama Y, Okazaki M, et al. Antimicrobial susceptibility testing of rapidly growing mycobacteria isolated in Japan. *BMC Infect Dis.* 2017;17:197.
30. Pang H, Li G, Zhao X, et al. Drug susceptibility testing of 31 antimicrobial agents on rapidly growing mycobacteria isolates from China. *Biomed Res Int.* 2015;2015:419392.
31. Park S, Kim S, Park E, et al. In vitro antimicrobial susceptibility of *Mycobacterium abscessus* in Korea. *J Korean Med Sci.* 2008;23:49–52.
32. Yang S, Hsueh P, Lai H, et al. High prevalence of antimicrobial resistance in rapidly growing mycobacteria in Taiwan. *Antimicrob Agents Chemother.* 2003;47:1958–1962.
33. Da Mata-Jardín O, Angulo A, Rodríguez M, et al. Drug susceptibility patterns of rapidly growing mycobacteria isolated from skin and soft tissue infections in Venezuela. *Eur J Clin Microbiol Infect Dis.* 2020;39:433–441.
34. Jansen B, Peters G. Foreign body associated infection. *J Antimicrob Chemother.* 1993;32:69–75.
35. Vidal P, Berner JE, Will PA. Managing complications in abdominoplasty: a literature review. *Arch Plast Surg.* 2017;44:457–468.
36. Lee MR, Sheng WH, Hung CC, et al. *Mycobacterium abscessus* complex infections in humans. *Emerg Infect Dis.* 2015;21:1638–1646.
37. Koh WJ, Jeon K, Lee NY, et al. Clinical significance of differentiation of *Mycobacterium massiliense* from *Mycobacterium abscessus*. *Am J Respir Crit Care Med.* 2011;183:405–410.
38. Sharma SK, Upadhyay V. Epidemiology, diagnosis & treatment of non-tuberculous mycobacterial diseases. *Indian J Med Res.* 2020;152:185–226.
39. Sharma P, Vazquez Guillamet LJ, Miljkovic G. Atypical mycobacterial infection after abdominoplasty overseas: a case report and literature review. *Case Rep Infect Dis.* 2016;2016:3642567.
40. Engdahl R, Cohen L, Pouch S, et al. Management of *Mycobacterium abscessus* post abdominoplasty. *Aesthetic Plast Surg.* 2014;38:1138–1142.
41. Adjei PC. *Mycobacterium abscessus* surgical wound infection following abdominoplasty in the Dominican Republic. *Consultant.* 2021;60:26–29.
42. Kathju S, Nistico L, Hall-Stoodley L, et al. Chronic surgical site infection due to suture-associated polymicrobial biofilm. *Surg Infect (Larchmt).* 2009;10:457–461.
43. Hrynyshyn A, Simões M, Borges A. Biofilms in surgical site infections: recent advances and novel prevention and eradication strategies. *Antibiotics (Basel).* 2022;11:69.
44. Dalovisio JR, Pankey GA, Wallace RJ, et al. Clinical usefulness of amikacin and doxycycline in the treatment of infection due to *Mycobacterium fortuitum* and *Mycobacterium chelonei*. *Rev Infect Dis.* 1981;3:1068–1074.
45. Brown-Elliott BA, Wallace RJ Jr, Wengenack NL, et al. Emergence of inducible macrolide resistance in *Mycobacterium chelonae* due to broad-host-range plasmid and chromosomal variants of the novel 23S rRNA methylase gene, erm(55). *J Clin Microbiol.* 2023;61:e0042823.
46. Gu Y, Nie W, Huang H, et al. Non-tuberculous mycobacterial disease: progress and advances in the development of novel candidate and repurposed drugs. *Front Cell Infect Microbiol.* 2023;13:1243457.
47. Pfaeffle HOI, Alameer RM, Marshall MH, et al. Clofazimine for treatment of multidrug-resistant non-tuberculous mycobacteria. *Pulm Pharmacol Ther.* 2021;70:102058.
48. Velez L, Harb J, Anuszewski S, et al. Cutaneous *Mycobacterium massiliense* infection from tattooing: a common yet under-reported

and persistent epidemic hazard for dermatologists. *BMJ Case Rep.* 2018;2018:bcr2017222762.
49. Kennedy BS, Bedard B, Younge M, et al. Outbreak of *Mycobacterium chelonae* infection associated with tattoo ink. *N Engl J Med.* 2012;367:1020–1024.
50. Chen TM, Castaneda M, Wanitphakdeedecha R, et al. Precautions with gentian violet: skin marking made sterile, effective, and economical. *Am J Infect Control.* 2009;37:244–246.
51. Vaerewijck MJ, Huys G, Palomino JC, et al. Mycobacteria in drinking water distribution systems: ecology and significance for human health. *FEMS Microbiol Rev.* 200;29:911–934.
52. Honda JR, Virdi R, Chan ED. Global environmental nontuberculous mycobacteria and their contemporaneous man-made and natural niches. *Front Microbiol.* 2018;9:2029.
53. Bello T, Rivera-Olivero IA, de Waard JH. Inactivation of mycobacteria by disinfectants with a tuberculocidal label. *Enferm Infecc Microbiol Clin.* 2006;24:319–321.
54. Russell AD. Bacterial resistance to disinfectants: present knowledge and future problems. *J Hosp Infect.* 1999;43:S57–S68.
55. Dowdell K, Haig SJ, Caverly LJ, et al. Nontuberculous mycobacteria in drinking water systems—the challenges of characterization and risk mitigation. *Curr Opin Biotechnol.* 2019;57:127–136.
56. Norton GJ, Williams M, Falkinham JO, III, et al. Physical measures to reduce exposure to tap water-associated nontuberculous mycobacteria. *Front Public Health.* 2020;8:190.
57. Wallace RJ, Jr, Musser JM, Hull SI, et al. Diversity and sources of rapidly growing mycobacteria associated with infections following cardiac surgery. *J Infect Dis.* 1989;159:708–716.
58. Winthrop KL, Abrams M, Yakrus M, et al. An outbreak of mycobacterial furunculosis associated with footbaths at a nail salon . *N Engl J Med.* 2002;346:1366–1371.
59. Stammers AH, Riley JB. The heater cooler as a source of infection from nontuberculous mycobacteria. *J Extra Corpor Technol.* 2016;48:55–59.
60. Lyman MM, Grigg C, Kinsey CB, et al. Invasive nontuberculous mycobacterial infections among cardiothoracic surgical patients exposed to heater-cooler devices. *Emerg Infect Dis.* 2017;23:796–805.
61. Kim MJ, Mascola L. *Mycobacterium chelonae* wound infection after liposuction. *Emerg Infect Dis.* 2010;16:1173–1175.
62. Bronzatti JAG, de Souza RQ, Niero CV, et al. Evaluation of cleaning and sterilization of liposuction cannulas after intentional contamination with human fat, *Mycobacterium abscessus* subspecies bolletii, and *Geobacillus stearothermophilus*. *J Hosp Infect.* 2023;136:8–13.
63. Moghaddam S, Nojoomi F, Dabbagh Moghaddam A, et al. Isolation of nontuberculous mycobacteria species from different water sources: a study of six hospitals in Tehran, Iran. *BMC Microbiol.* 2022;22:1–8.
64. Freitas D, Alvarenga L, Sampaio J, et al. An outbreak of *Mycobacterium chelonae* infection after LASIK. *Ophthalmology.* 2003;110:276–285.
65. Choi SG, Sik Choi MS. Isolation of nontuberculous mycobacteria (NTM) from air conditioner dust. *Korean J Clin Lab Sci.* 2017;49:435–438.
66. Das S, Murthy SI, Padhi TR, et al. Ocular infections associated with atypical mycobacteria: a review. *Indian J Ophthalmol.* 2024;72:19–28.
67. Neumann M, Schulze-Robbecke R, Hagenau C, et al. Comparison of methods for isolation of mycobacteria from water. *Appl Environ Microbiol.* 1997;63:547–552.
68. Wallace E, Hendrickson D, Tolli N, et al. Culturing mycobacteria. *Methods Mol Biol.* 2021;2314:1–58.
69. Gilchrist, MJR. Biosafety precautions for airborne pathogens. In: Flemming DO, Richrdson JH, Tulis JJ, et al, eds. *Laboratory Safety: Principles and Practices.* 2nd ed. Washington D.C.: ASM Press; 1995:67–76.
70. Pfyffer, G. E. Mycobacterium: general characteristics, laboratory detection, and staining procedures. In: Murray PR, ed. *Manual of Clinical Microbiology.* 9th ed. Washington D.C.: ASM Press; 2007:543–572.