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Severe Progressive Subcutaneous Abscesses and Necrotizing Tenosynovitis Caused by *Rhodococcus aurantiacus*

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A case of severe progressive subcutaneous abscesses and necrotizing tenosynovitis of the right arm of a 30-year-old woman caused by *Rhodococcus aurantiacus* is reported.

Rhodococcus aurantiacus was reported by Tsukamura and Mizuno (6) as *Gordona aurantiaca*. The name was changed to *R. aurantiacus* (7). However, this taxon differs from other rhodococci by several characteristics (3, 7). A case of lung infection caused by this organism was reported by Tsukamura and Kawakami (5), and a case of lethal meningitis was reported by Prinz et al. (1). Here, we report the third case of infection caused by this organism.

CASE REPORT

The patient was a 30-year-old female (school teacher). In May 1981, she felt pain in her right forearm and was diagnosed as suffering from de Quervain disease (painful tenosynovitis due to relative narrowness of the common tendon sheath of the abductor pollicis longus and the extensor pollicis brevis). In September 1982, she visited our orthopedics clinic, since an incision of the right forearm performed elsewhere had not healed. We incised this surgical wound repeatedly to derive pus. The wound did not improve. Instead, multiple abscesses, necrotizing tenosynovitis, and muscle necrosis of the right forearm developed. In November 1986, the right forearm was amputated. A month after this procedure, the amputation site showed signs of severe infection that progressed to involve the upper arm, leading to its amputation on 20 December 1986. In January 1987, the surgical wound again showed signs of infection, and pus was obtained by incision. At present, there is a fistula in the right shoulder that produces a small amount of pus continuously. During the entire period, the patient had slight fever, and the leukocyte count ranged from 6,000 to 12,000/mm^3. No immunological abnormalities were found, including acquired immunodeficiency syndrome.

Originally, various bacteria were isolated from the pus on only one or two occasions. These were *Staphylococcus aureus*, *Staphylococcus epidermidis*, *Peptococcus* sp., *Serratia liquefaciens*, *Klebsiella pneumoniae*, *Klebsiella* sp., *Pseudomonas aeruginosa*, *Pseudomonas fluorescens*, and *Enterobacter cloacae*. Fungi were not isolated. Since only a few colonies of these bacteria were recovered on isolation media, it was unlikely that they represented the cause of the disease. Examinations for acid-fast bacteria with Ogawa egg medium (4) after pretreatment with a 4% NaOH solution for 20 min were carried out repeatedly without recovery of mycobacteria. During the entire period of illness, various antibiotics were administered to the patient without success. The drugs included penicillins (amoxicillin, benzylpenicillin, piperacillin, carbenicillin, ampicillin, and sulbenicillin), cephalosporins (cefoperazone, cefaclor, cefazolin, ceftizoxime, and cefotaxime), cephamycin (cefmetazole), oxacephem (moxalactam), cephalexin, amikacin, gentamicin, minocycline, erythromycin, and norfloxacin. After the causative organism was found to be *R. aurantiacus*, we used a combination of ofloxacin (0.4 g daily), minocycline (200 mg daily), sulfadimethoxine (1.0 g daily), and rifampin (0.45 g daily), which were administered orally. However, until now, no marked improvement was achieved. Instead, the organism became resistant to 5 μg of ofloxacin per ml 2 months after the beginning of the administration.

Histological examination of resected tissue specimens showed subcutaneous abscesses containing epitheloid cells and giant cells.

MATERIALS AND METHODS

Isolation of slightly acid-fast bacteria. From December 1986, pus specimens were examined by adding an equal volume of a 2% NaOH solution to the pus, followed by incubation at room temperature for 5 min. The mixture was inoculated on Ogawa egg medium slants with a pipette that delivers a 0.1-ml sample. The inoculated slants were incubated at 28°C for 7 days. Slightly acid-fast bacteria were isolated from the pus each time, and five isolates were obtained showing two or three colonies on the isolation medium. From March 1987, the pus mixture was inoculated with a spiral loop that delivers 0.02 ml of sample. The spiral loop was used to facilitate neutralization of the inoculated material on medium and to obtain better adhesion to the medium. From March to June 1987, six isolates were obtained by this method. The specimens showed from several to 60 colonies. Thus, a total of 11 isolates were studied.

Identification. The isolates were identified with 114 tests. Of these, 104 have been described previously (2). To these 104, the following 10 tests were added: Gram reactivity, growth at 42°C, utilization of L-serine as the sole nitrogen source, utilization of succinamide as the sole nitrogen source, resistance to 5% NaCl, resistance to isoniazid (10 μg/ml), resistance to ofloxacin (1 μg/ml), resistance to ofloxacin (5 μg/ml), resistance to 5-fluorouracil (20 μg/ml), and resistance to mitomycin C (5 μg/ml) (the resistance tests were performed in Ogawa egg medium). The results of the tests were read after incubation at 37°C for 7 days. The matching coefficient (*M* value) was calculated as the percent

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TABLE 1. Comparison of the characters of *R. aurantiacus* and other rhodococci[a]

Character	% of strains with character[b]										
	Present isolates (n = 11)	*R. aurantiacus* (n = 11)	*R. bronchialis* (n = 7)	*R. rubropertinctus* (n = 11)	*R. terrae* (n = 9)	*R. sputi* (n = 9)	*R. aichiensis* (n = 5)	*R. rhodochrous* (n = 5)	*R. lentifragmentus* (n = 9)	*R. erythropolis* (n = 4)	*R. equi* (n = 8)
Gram reactivity	100	100	100	100	100	100	100	100	100	100	100
Strong acid-fastness	18	18	0	0	0	0	0	0	0	0	0
Weak or partial acid-fastness	100	100	100	100	100	100	100	60	100	0	0
Permanent mycelium	0	0	0	0	0	0	0	0	0	0	0
Fragmenting mycelium	0	0	0	9	0	0	0	20	78	25	0
Long rods (>7 μm long)	0	0	14	9	0	0	20	60	78	100	0
Intermediate rods (3–6 μm long)	36	73	100	100	100	100	100	100	78	100	13
Short rods (<2 μm long)	100	100	100	100	100	100	100	100	78	100	100
Cross bars of the cell	0	9	29	0	0	33	20	20	0	0	0
Cord formation	0	0	0	0	0	0	0	0	0	0	0
Rough colonies	100	100	100	91	89	89	100	80	100	75	0
Colony pigmentation in the dark	100	100	100	100	100	100	100	100	100	100	100
Photochromogenicity	0	0	0	0	0	0	0	0	0	0	0
Growth											
After 3 days	100	100	100	100	100	100	100	100	100	100	100
28°C	100	100	100	100	100	100	100	100	100	100	100
37°C	100	100	100	100	100	100	100	100	100	100	100
42°C	91	9	100	45	0	0	80	40	44	0	25
45°C	27	0	0	0	0	0	0	0	0	0	0
52°C	0	0	0	0	0	0	0	0	0	0	0
Resistance to 0.2% sodium *p*-aminosalicylate	100	100	100	100	100	100	100	100	100	100	100
Degradation of *p*-aminosalicylate to catechol	0	0	0	0	0	0	0	0	0	0	0
Resistance to $NH_2OH \cdot HCl$											
125 μg/ml	100	100	86	91	100	78	100	100	100	100	100
250 μg/ml	91	100	0	9	33	0	40	0	100	75	100
500 μg/ml	45	0	0	0	0	0	0	0	78	0	100
Growth on modified Sauton agar medium	100	100	100	100	100	100	100	100	100	100	100
Tolerance to 0.1% sodium salicylate	100	100	71	100	100	100	100	100	89	50	25
Degradation of salicylate to catechol	0	0	0	0	0	0	0	0	0	0	0
Tolerance to picric acid											
0.1%	100	100	100	100	100	100	100	100	100	50	38
0.2%	100	100	100	100	100	100	100	100	100	25	38
Arylsulfatase											
3 days	0	0	0	0	0	0	0	0	0	0	0
14 days	0	18	0	0	0	22	0	0	0	0	0
Resistance to thiophene-2-caroxylic acid hydrazide (10 μg/ml)	100	100	100	100	100	100	100	100	100	100	100
Resistance to salicylate (0.5 mg/ml)	100	100	100	100	100	100	100	100	100	100	100
Resistance to ethambutol (5 μg/ml)	100	100	100	100	100	100	100	80	11	0	75
Tolerance to sodium nitrite											
0.1%	100	100	100	100	100	11	100	80	100	25	13
0.2%	100	82	100	100	100	0	0	80	56	0	0
Tolerance to 1% Tween 80	100	100	100	100	100	67	100	0	78	0	63
Resistance to *p*-nitrobenzoic acid (0.5 mg/ml)	91	100	100	100	100	44	60	100	100	0	38
Resistance to rifampin (25 μg/ml)	82	82	0	64	89	44	0	0	0	0	13
Niacin production	0	0	0	0	0	0	0	0	0	0	0

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TABLE 1—*Continued*

Character	% of strains with character[b]										
	Present isolates (*n* = 11)	*R. aurantiacus* (*n* = 11)	*R. bronchialis* (*n* = 7)	*R. rubropertinctus* (*n* = 11)	*R. terrae* (*n* = 9)	*R. sputi* (*n* = 9)	*R. aichiensis* (*n* = 5)	*R. rhodochrous* (*n* = 5)	*R. lentifragmentus* (*n* = 9)	*R. erythropolis* (*n* = 4)	*R. equi* (*n* = 8)
Tween 80 hydrolysis											
7 days	0	0	0	0	0	0	0	0	0	0	0
14 days	27	100	0	55	67	11	40	0	0	0	13
Catalase (foam height more than 45 mm)	100	100	100	100	100	100	100	100	100	100	100
α-Esterase activity	0	0	0	45	100	33	0	0	0	0	50
β-Esterase activity	64	0	43	55	100	0	0	0	0	0	50
β-Galactosidase activity	18	100	0	0	0	0	0	0	0	0	0
Acid phosphatase activity	55	73	100	0	0	100	100	60	0	100	100
Nitrate reduced to nitrite											
6 h	36	0	100	82	100	44	100	100	100	0	100
24 h	36	0	100	82	100	44	100	100	100	0	100
Acetamidase activity	100	100	100	0	0	78	80	0	100	75	100
Benzamidase activity	0	0	0	0	0	0	0	0	0	0	13
Urease activity	100	100	100	100	100	100	100	20	0	100	0
Isonicotinamidase activity	0	0	0	0	0	0	0	0	0	0	0
Nicotinamidase activity	100	100	71	9	100	89	100	0	100	0	0
Pyrazinamidase activity	100	100	71	9	100	78	100	0	100	0	13
Salicylamidase activity	0	0	0	0	0	0	0	0	0	0	0
Allantoinase activity	91	100	0	100	100	56	100	0	0	0	0
Succinamidase activity	0	0	0	0	0	0	0	0	0	0	0
L-Glutamate as simultaneous N and C source	100	100	100	100	100	100	100	100	100	25	63
L-Serine as simultaneous N and C source	91	100	0	9	44	89	100	0	44	0	0
Glucosamine as simultaneous N and C source	91	100	43	91	100	56	60	60	78	0	0
Acetamide as simultaneous N and C source	100	100	100	0	0	100	100	0	67	0	75
Benzamide as simultaneous N and C source	0	0	0	0	0	0	0	0	56	0	0
Monoethaolamine as simultaneous N and C source	100	100	0	100	100	78	100	0	100	0	13
Trimethylene diamine as simultaneous N and C source	0	0	0	0	0	0	0	0	0	0	0
Glucose as C source (glutamate for N)	100	100	100	100	100	100	100	100	100	100	100
Acetate as C source (glutamate for N)	100	100	100	100	100	100	100	100	100	100	100
Succinate as C source (glutamate for N)	100	100	100	100	100	100	100	100	100	100	100
Pyruvate as C source (glutamate for N)	100	100	100	100	100	100	100	100	100	100	100
Acetate as C source	100	100	100	100	100	100	100	100	100	100	100
Citrate as C source	100	100	100	100	100	67	100	40	78	100	0
Succinate as C source	100	100	100	100	100	100	100	100	100	100	100
Malate as C source	100	100	100	100	100	100	100	100	100	100	100
Pyruvate as C source	100	100	100	100	100	100	100	100	100	100	100
Benzoate as C source	18	55	57	100	100	11	0	80	100	0	0
Malonate as C source	0	0	0	0	0	0	0	0	0	0	0
Fumarate as C source	100	100	100	100	100	89	20	80	100	100	88
Glucose as C source	100	100	100	100	100	100	100	100	100	100	100
Fructose as C source	100	100	100	100	100	100	100	100	100	100	100
Sucrose as C source	100	100	100	100	100	100	100	60	100	100	88
Ethanol as C source	100	91	100	100	100	100	100	80	100	100	100
n-Propanol as C source	100	100	100	100	100	100	100	100	100	100	100
Propylene glycol as C source	100	91	100	0	67	22	20	60	89	75	88
1,3-Butylene glycol as C source	0	0	0	82	22	0	20	0	0	0	0

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TABLE 1—*Continued*

Character	% of strains with character[b]										
	Present isolates (*n* = 11)	*R. aurantiacus* (*n* = 11)	*R. bronchialis* (*n* = 7)	*R. rubropertinctus* (*n* = 11)	*R. terrae* (*n* = 9)	*R. sputi* (*n* = 9)	*R. aichiensis* (*n* = 5)	*R. rhodochrous* (*n* = 5)	*R. lentifragmentus* (*n* = 9)	*R. erythropolis* (*n* = 4)	*R. equi* (*n* = 8)
1,4-Butylene glycol as C source	100	0	14	82	0	0	0	0	0	0	0
2,3-Butylene glycol as C source	100	91	29	82	44	100	100	100	44	50	0
n-Butanol as C source	100	100	100	0	100	100	80	100	100	25	100
iso-Butanol as C source	100	100	100	0	100	100	80	100	100	25	100
Acid from glucose	100	100	100	100	100	100	100	100	100	0	0
Acid from mannose	100	100	100	100	100	100	100	100	100	0	0
Mannose as C source	100	100	100	100	100	100	100	100	100	100	38
D-Galactose as C source	100	100	0	0	0	0	0	0	0	0	0
L-Arabinose as C source	0	0	0	0	0	0	0	0	0	0	0
D-Xylose as C source	0	0	0	0	0	0	0	0	0	0	0
L-Rhamnose as C source	0	0	0	0	100	0	0	0	0	0	0
Trehalose as C source	100	100	100	100	100	89	100	0	78	0	0
Inositol as C source	91	100	100	0	0	0	0	0	0	0	0
Mannitol as C source	55	100	0	100	100	100	60	0	100	0	0
Sorbitol as C source	55	100	0	100	100	100	60	0	100	0	0
L-Serine as N source	100	100	43	91	100	100	100	20	100	0	0
Acetamide as N source	100	100	100	100	100	100	100	60	100	0	0
Benzamide as N source	0	0	0	18	67	0	0	0	0	0	0
Urea as N source	91	100	86	100	100	100	100	20	100	0	0
Pyrazinamide as N source	91	100	71	73	100	100	100	0	100	0	0
Nicotinamide as N source	82	100	100	91	100	100	100	0	100	0	0
Succinamide as N source	91	100	57	100	100	11	40	0	67	0	0
Nitrate as N source	91	100	100	100	100	100	100	20	100	0	0
Nitrite as N source	0	18	0	0	0	0	0	0	0	0	0
Resistance to 5% NaCl	100	100	71	100	100	100	100	80	22	0	88
Resistance to isoniazid (10 μg/ml)	82	100	100	100	100	100	100	100	100	100	100
Resistance to ofloxacin (1 μg/ml)	82	82	57	36	89	100	20	100	78	0	88
Resistance to ofloxacin (5 μg/ml)	27	0	0	0	0	11	0	40	0	0	0
Resistance to 5-fluorouracil (20 μg/ml)	100	100	0	0	22	11	0	0	11	0	50
Resistance to mitomycin C (5 μg/ml)	100	100	100	0	100	33	0	20	0	0	0

[a] Unless specially noted, the utilization of carbohydrates as sole carbon sources was tested in the presence of ammoniacal nitrogen, and the utilization of nitrogen compounds as sole nitrogen sources was tested in the presence of glycerol as a carbon source. Resistances were tested in Ogawa egg medium, and tolerances were tested in a modified Sauton agar medium. The composition of the modified Sauton agar medium is as follows: glycerol, 30 ml; KH_2PO_4, 0.5 g; $MgSO_4 \cdot 7H_2O$, 0.5 g; citric acid, 2.0 g; ferric ammonium citrate, 0.05 g; agar, 20.0 g; distilled water, 970 ml. The pH was adjusted to 7.0 by adding a 10% NaOH Solution.

[b] The number of strains tested is shown in parentheses.

agreement of the tests with those for the prototype of the species.

RESULTS

The isolates appeared to be slightly acid-fast short rods and did not form mycelium, suggesting that the isolates belonged to the genus *Rhodococcus* (3, 7). On subculture, they grew on Ogawa egg medium after 3 days of incubation and formed rough, slightly brownish or orange-pigmented colonies, forming no spore and growing only under aerobic conditions. The isolates were identified as *R. aurantiacus*, showing 90 to 96% agreement with the reactions of the type strain. Reaction concordance with other rhodococci was at most 82%. Comparison of the characters of the isolates with the control *R. aurantiacus* strains and with other rhodococci is shown in Table 1.

The susceptibilities to various antituberculosis drugs were determined in Ogawa egg medium, inoculating 0.1 mg (wet weight) of an isolate and incubating the inoculated slants at 37°C for 3 days. The isolates were resistant to streptomycin (200 μg/ml), isoniazid (200 μg/ml), ethionamide (200 μg/ml), and ethambutol (50 μg/ml). They showed the following MICs: rifampin, 100 μg/ml; kanamycin, 400 μg/ml; enviomycin (tuberactinomycin N; Toyo Jozo Co., Shizuoka, Japan), 400 μg/ml; kitasamycin (leucomycin; Toyo Jozo Co., Shizuoka, Japan), 25 μg/ml; sulfadimethoxine, 12.5 μg/ml; and minocycline, 3.13 μg/ml.

DISCUSSION

The pus of the patient yielded only *R. aurantiacus* consistently. All other bacteria were isolated sporadically and were considered contaminants. *R. aurantiacus* strains are resis-

tant to most antibiotics and antibacterial substances, as demonstrated by the clinical failure of most drug regimens in this patient. The persistence of *R. aurantiacus* and its drug resistance suggest that it is the etiological agent in this patient. Two cases of infections caused by this organism have been reported (1, 5). The first involved a lung infection that was not cured but had a remission (5). The second was a fatal meningitis (1). The present case is a very severe, gangrenous tenosynovitis with multiple subcutaneous abscesses. In our case, various drug regimens have been used, but until now the chemotherapeutic treatment seems to have been unsuccessful.

We reported that β-galactosidase activity is important in identifying this organism (5). However, the present isolates did not show this activity. Even without β-galactosidase activity, identification is based on the following characteristics: (i) growth of subculture after 3 days, forming rough, brownish (or orange-pigmented) colonies; (ii) the bacteria are slightly acid-fast rods (at most 5 μm in length) and do not form mycelium (some strains occur as strongly acid-fast short rods); (iii) they tolerate 0.2% picric acid and 0.2% sodium nitrite in a modified Sauton agar medium, in which sodium glutamate has been substituted for asparagine; (iv) they do not show arylsulfatase activity after 14 days; (v) they do not reduce nitrate to nitrite; (vi) they utilize sucrose as a sole carbon source in the presence of ammoniacal nitrogen; (vii) they utilize galactose as a sole carbon source in the presence of ammoniacal nitrogen; and (viii) they are resistant to 5-fluorouracil (20 μg/ml) and to mitomycin C (5 μg/ml) in Ogawa egg medium (or Lowenstein-Jensen medium).

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