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REVIEW

Actinobaculum schaalii: Review of an emerging uropathogen

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Summary *Actinobaculum schaalii* is a facultative anaerobic, Gram-positive rod-shaped species phylogenetically related to *Actinomyces* that is likely part of the commensal flora of the human genitourinary tract. Because of its fastidious growth under aerobic conditions and its resemblance to bacteria of the resident flora, *A. schaalii* is frequently overlooked or considered as a contaminant. It is also difficult to identify phenotypically, still requiring molecular identification. Note that the recent technology of matrix-assisted laser desorption/ionisation time-of-flight-mass spectrometry could be a promising tool for its identification. Recent studies using sensitive PCR assays showed that its clinical significance was largely underestimated. Since its first description in 1997, *A. schaalii* has been responsible for numerous urinary tract infections (UTIs), mainly in elderly (usually >60 years) and patients with underlying urological conditions. Infected urines usually show many Gram-positive rods with significant leukocyturia and a negative test for nitrites. Numerous cases of severe infections have also been described, such as urosepsis, bacteremia, cellulitis, spondylodiscitis, and endocarditis. In vitro, *A. schaalii* is highly susceptible to β-lactams but it is resistant to ciprofloxacin and cotrimoxazole, first-choice antimicrobials for the oral treatment of UTIs. A penicillin (e.g. amoxicillin) or a cephalosporin (e.g. cefuroxime, ceftriaxone) should be the preferred treatment.

Introduction

Actinobaculum spp. are Gram-positive, nonmotile, asporogenous, facultative anaerobic, rod-shaped organisms related to *Actinomyces*. To date, four different species have been described (http://www.bacterio.cict.fr/): *Actinobaculum suis* (1997), *Actinobaculum schaalii* (1997), *Actinobaculum massiliense* (2002), and *Actinobaculum urinale* (2003).

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A. suis is a well-established veterinary pathogen causing cystitis, pyelonephritis, and metritis with abortions in sows.[1,2] Only a few human infections due to *A. massiliense* and *A. urinale* have been described so far. *A. massiliense* has only been described in one case of recurrent cystitis in an elderly woman and in one case of superficial skin infection.[3,4] *A. urinale* has only been isolated from urine in a woman with cystitis and from blood (together with *A. schaalii*) in an old patient with chronic renal failure.[5,6] By contrast, *A. schaalii* appears to be an emerging pathogen, with more than 115 human infections reported during the last decade. This review summarizes current knowledge of the microbiology, epidemiology, clinical presentation, diagnosis, and treatment of human infections caused by *A. schaalii*.

Taxonomy

The genus *Actinobaculum* is part of the family Actinomycetaceae, which also comprises the genera *Actinomyces*, *Arcanobacterium*, and *Mobiluncus* (Fig. 1).[7,8] This family belongs to the high-G+C-content of the Gram-positive Actinobacteria.[8] The type species of the genus is *A. suis*, which was formerly assigned to genera *Corynebacterium*, *Eubacterium*, and *Actinomyces*.[9] By phylogenetic analysis, *A. schaalii* exhibits ca. 94% 16S rRNA sequence similarity with *A. suis*, *A. urinale*, and *A. massiliense*, ca. 92—93% with *Arcanobacterium* spp., ca. 88—89% with *Mobiluncus* spp., and ca. 85—90% with *Actinomyces* spp.[3,5,8,10] The DNA G+C content of *A. schaalii* is 57 mol%.[8] Note that the phylogeny of the species of *Actinobaculum* genus is not clearly established and may need further taxonomic revisions, as recently described for *Arcanobacterium* species.[10] The genome of *A. schaalii* FB123-CAN-2 is currently in progress as part of the Human Microbiome Project (BioProject accession no. PRJNA52093).

Microbiology

A. schaalii was named after Klaus P. Schaal, a German microbiologist specialized in actinomycetes. These bacteria are nonmotile, non-spore-forming, non-acid-fast, Gram-positive, straight to slightly curved coccoid rods (Fig. 2a), some of which exhibiting branching.[8] They are catalase, oxidase, and urease negative (Table 1).[6,8,13,14,16,17] Noteworthy, the negative urease test can distinguish *A. schaalii* from *A. urinale* (Table 1).[5,6] Hippurate is hydrolyzed whereas esculin (except a few exceptions) and gelatin are

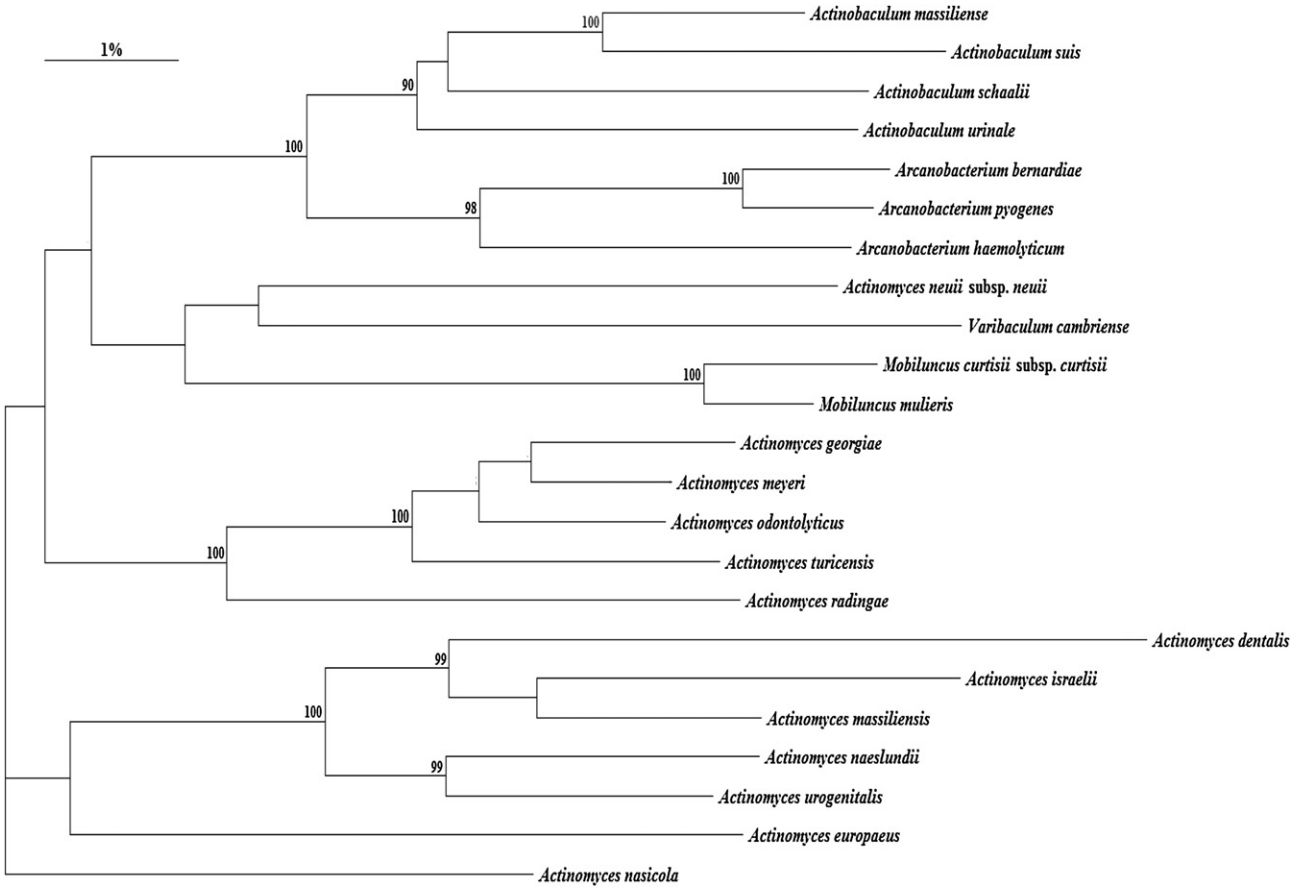

Figure 1 Phylogenetic tree showing relationships between 16S rRNA gene sequences from *A. schaalii* and related species belonging to the Actinomycetaceae family. Tree was obtained by the neighbor-joining method and estimated confidence limits (expressed as a percentage) were determined by bootstrap analysis (Clustal X and TreeView X progams). Only bootstrap values superior or equal to 90% were indicated. The scale bar represents 1% differences in nucleotide sequences.