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Cardiobacterium hominis endocarditis: two cases and a review of the literature

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Abstract

Cardiobacterium hominis, a member of the HACEK group (*Haemophilus parainfluenzae*, *Haemophilus aphrophilus*, and *Haemophilus paraphrophilus*, *Actinobacillus actinomycetemcomitans*, *C. hominis*, *Eikenella corrodens*, and *Kingella* species), is a rare cause of endocarditis. There are 61 reported cases of *C. hominis* infective endocarditis in the English-language literature, 15 of which involved prosthetic valve endocarditis. There is one reported case of *C. hominis* after upper endoscopy and none reported after colonoscopy. Presented here are two cases of *C. hominis* prosthetic valve endocarditis following colonoscopy and a review of the microbiological and clinical features of *C. hominis* endocarditis. Patients with *C. hominis* infection have a long duration of symptoms preceding diagnosis (138±128 days). The most common symptoms were fever (74%), fatigue/malaise (53%), weight loss/anorexia (40%), night sweats (24%), and arthralgia/myalgia (21%). The most common risk factors were pre-existing cardiac disease (61%), the presence of a prosthetic valve (28%), and history of rheumatic fever (20%). Of the 61 cases reviewed here, the aortic valve was infected in 24 (39%) and the mitral valve in 19 (31%) patients. The average duration of blood culture incubation before growth was detected was 6.3 days (range, 2–21 days). Complications were congestive heart failure (40%), central nervous system (CNS) emboli (21%), arrhythmia (16%), and mycotic aneurysm (9%). *C. hominis* is almost always susceptible to β-lactam antibiotics. Ceftriaxone is recommended by the recently published American Heart Association guidelines. The prognosis of *C. hominis* native valve and prosthetic valve endocarditis is favorable. The cure rate among 60 patients reviewed was 93% (56/60). For prosthetic valve endocarditis, the cure rate was 16/17 (94%). Valve replacement was required in 27 (45%) cases.

Introduction

In 1962, Tucker et al. [1] described four cases of infective endocarditis caused by a *Pasteurella*-like organism that had been designated as Group-II D by the Centers for Disease Control and Prevention. In 1964, Slotnick and Dougherty [2] further characterized the Group-II D organisms, renaming them *Cardiobacterium* and describing their enhanced ability to cause endocarditis.

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Cardiobacterium hominis, along with three *Haemophilus* species (*Haemophilus parainfluenzae*, *Haemophilus aphrophilus*, and *Haemophilus paraphrophilus*), *Actinobacillus actinomycetemcomitans*, *Eikenella corrodens*, and *Kingella* species, is a member of the HACEK group of endocarditis-causing gram-negative bacteria. There are 61 reported cases of *C. hominis* endocarditis in the English-language literature, 15 involving prosthetic valves. There is one reported case of *C. hominis* endocarditis following upper endoscopy [3] and none reported after colonoscopy. We now report two cases of *C. hominis* prosthetic valve endocarditis (PVE) that occurred following colonoscopy. One patient had also undergone an upper endoscopy. We reviewed the microbiological and clinical features of *C. hominis* endocarditis cases in the English-language literature.

Case reports and methods

Two cases of *C. hominis* endocarditis occurred at the University of Michigan Health System and the Veterans Affairs Ann Arbor Healthcare System during September and October of 2004, prompting a review of the patients' medical records. In addition, using MEDLINE (National Library of Medicine, Bethesda, MD), the English-language literature was searched from 1962 to 2005 for combinations of the following search terms: "*Cardiobacterium hominis endocarditis*," "*Cardiobacterium endocarditis*," and "*Cardiobacterium* bacteremia". Further references were identified within bibliographies provided by MEDLINE-cited studies.

Manuscripts were reviewed to identify potential risk factors, clinical characteristics, treatment, and outcomes. Putative risk factors assessed included quality of dentition, the occurrence of recent dental work, underlying valvular disease, recent endoscopy, or surgical procedures. Clinical and laboratory characteristics reviewed included age, gender, duration of symptoms, fever, night sweats, weight loss/anorexia, fatigue/malaise, confusion, the involved valve(s), presence of prosthetic valve(s), presence of murmur, evidence of embolic lesions, splenomegaly, congestive heart failure, mycotic aneurysm, laboratory values (leukocyte count, anemia, hematuria, Westergren erythrocyte sedimentation rate [WESR]), duration of incubation until blood cultures became positive, and whether valve replacement was necessary. Antibiotic treatment regimens were recorded, and mortality was noted for each case.

Case 1

A 76-year-old woman who had undergone a porcine aortic valve replacement in 2001 for aortic stenosis presented with right hip pain in August 2004. Cardiac history included pacemaker placement in 2002 and coronary artery bypass graft surgery in 2001. Five days prior to admission, the patient underwent a colonoscopy. No antibiotic prophylaxis was given. Over the next 5 days, she experienced fever ranging from 100.7 to 102.3°F. Physical examination showed an elderly, edentulous woman with a 3/6 systolic ejection murmur in the aortic position, with radiation to the carotid arteries. She had neither splenomegaly nor peripheral embolic lesions, but she had significant point tenderness near the right trochanteric bursa and sacroiliac joint, thought to be caused by bursitis. A computed tomography (CT) scan revealed no fluid collections within the right hip. Urinalysis showed an erythrocyte count of 10–25 cells per high-power field and a leukocyte count of 3–5 cells per high-power field; urine culture yielded 50,000–100,000 *Escherichia coli*. Peripheral leukocyte count was 12,000 cells/mm^3, hemoglobin 11.0 g/dl, platelets 151,000/mm^3, and serum creatinine 1.8 mg/dl. After 3 days, both sets of blood cultures taken the day after admission yielded a gram-negative bacillus. Fifteen days after the blood cultures were taken, the organism was identified as *C. hominis*. Twenty-six days after colonoscopy, trans-esophageal echocardiography (TEE) revealed vegetations on the prosthetic aortic valve. The patient began to experience back pain. A CT scan showed discitis at the L3–L4 level and lytic lesions within all lumbar vertebrae; further studies confirmed the diagnosis of multiple myeloma.

The patient was treated with ceftriaxone 2 gm/day intravenously for 6 weeks. In October 2004, she was admitted at the end of therapy for recurrent fever and continued back pain, and a bone scan demonstrated increased uptake at the L4 level on delayed imaging, with normal blood flow on early images. No vertebral biopsies were done. She completed another 4-week course of intravenous ceftriaxone for presumed bacterial discitis that had not resolved during the initial 6 weeks of antibiotic therapy. Oral amoxicillin/clavulanate 875 mg twice daily was given for an additional 6 months. After finishing parenteral antibiotics, she started chemotherapy for multiple myeloma. She continued to do well 5 months after completion of antibiotic therapy.

Case 2

A 67-year-old man with diabetes mellitus underwent porcine aortic valve replacement and coronary artery bypass graft surgery in 1997. In June 2004, he underwent an upper and lower endoscopy for anemia, without receiving antibiotic prophylaxis. In October 2004, he presented with chest pain and anemia and was hospitalized for 1 day with unstable angina. Within 24 h after discharge, however, he re-presented to the emergency department complaining of chest pain. His temperature was 100.6°F, and he was experiencing new-onset atrial fibrillation. Physical examination was remarkable for poor dentition, a harsh 3/6 systolic ejection murmur in the aortic position with radiation to the carotid arteries, and a soft diastolic murmur along the left sternal border. He had neither splenomegaly nor peripheral embolic lesions. Laboratory studies revealed the following: leukocytes 7,000 cells/mm^3, hemoglobin 9.1 g/dl, serum creatinine 1.4 mg/dl, and WESR 17 mm/h. The urinalysis showed no hematuria. Transthoracic echo-cardiography (TTE) demonstrated prosthetic aortic valve dehiscence and a paravalvular abscess. TEE confirmed these findings and further revealed echodense thickenings on all prosthetic valve leaflets along with a mobile echodensity on the left ventricular side of the valve. An emergent replacement of the porcine aortic valve was performed using a Carpentier–Edwards bioprosthetic valve. Three sets of blood cultures drawn before surgery yielded a gram-negative bacillus by day 6 of incubation. On day 7, the organism was identified as *C. hominis*. Cultures taken from the removed porcine valve yielded no growth. The patient was initially treated with intravenous vancomycin and gentamicin, but therapy was then changed to intravenous ceftriaxone 2 gm/day. After completing a 6-week course of ceftriaxone, he was placed on amoxicillin 500 mg t.i.d. for suppressive therapy for 6 months. Nine months after completion of parenteral therapy, the patient continued to do well, despite a chronic sternal wound infection caused by coagulase-negative *Staphylococcus* infection that developed postoperatively.

Literature review

A total of 61 English-language cases were identified from 48 manuscripts [1,3-49]. Thirteen non-English-language cases from 12 manuscripts were not included. Two cases lacked sufficient clinical data for analysis [6,43]. Including our two cases, a total of 61 cases were reviewed.

Demographics

The mean age (±SD) of the 61 patients was 50.2±15 years (range, 17–82 years) (Table 1). There were 42 (69%) men and 19 (31%) women.

Underlying diseases and risk factors

The mean duration of symptoms (±SD) preceding diagnosis in 53 patients was 138±128 days (range, 2–540 days). The duration of symptoms was >100 days in 25 (47%) patients and >200 days in 11 (21%) patients. Information on symptoms and putative risk factors was available for 58 patients and 61 patients, respectively (Table 1). The most common symptoms were fever in 43 (74%), fatigue/malaise in 31 (53%), and weight loss/anorexia in 23 (40%) patients. The

most common risk factors were pre-existing cardiac disease in 37 (61%), the presence of prosthetic valve(s) in 17 (28%), history of congenital valvular disease in 12 (20%), and rheumatic fever in 12 (20%) patients. There were no patients with a history of intravenous drug use.

The aortic valve was involved in 24 of the 61 (39%) patients, the mitral valve in 19 (31%) patients, and both valves in 8 (13%) patients (Table 2). There was one case each of tricuspid and pulmonic valve infection, and the valve involved was not noted in 8 (13%) cases.

Physical and laboratory findings

A physical examination was documented in 53 patients (Table 3). The most common findings were cardiac murmur in 50 (94%), peripheral embolic lesions in 27 (51%), and splenomegaly in 21 (40%). Fifty patients had murmurs. Findings were consistent with mitral regurgitation in 28 (56%), with aortic regurgitation in 21 (42%), with aortic stenosis in 19 (38%), and with mitral stenosis in 2 (4%); 17 patients had >1 murmur described. For two patients, there was no description of the murmur. The most common embolic findings were cutaneous (34%), retinal/conjunctival (26%), and large vessel (6%).

The mean leukocyte count for the 37 patients for whom this was listed was 8,930/mm^3 (range, 3,900–29,900/mm^3); only 10 (27%) patients had a leukocyte count of >10,000/mm^3. The average WESR for the 33 patients who had this test performed was 67 mm/h (range, 4–133 mm/h); 6 (18%) patients had a WESR of >100 mm/h and 3 (9%) a WESR of<20 mm/h. Laboratory findings are listed in Table 3.

Diagnosis

In 35 cases for whom the data were recorded, the average duration of incubation for blood cultures before growth was detected was 6.3 days (range, 2–21 days). In three patients, blood cultures yielded no organisms, but a definite diagnosis of endocarditis was established by culture of the valve at surgery [42] or by PCR genome amplification on either the resected valve [32] or an arterial embolus [49]. In two cases, *C. hominis* was also identified in cerebrospinal fluid [15] and synovial fluid [4].

An echocardiogram was performed in 37 patients (61%); 32 underwent a TTE and 10 a TEE. Five patients had both a TTE and a TEE. Eight of the 10 (80%) TEE examinations and 18 of the 32 (56%) TTE examinations revealed vegetations. In two patients, vegetations were visible on the TEE but not on the TTE [29,49]. The size of the vegetations, as determined by echocardiography, was described in only four cases: large (*n*=2), small (*n*=1), and <1 cm (*n*=1) [11,24,30,32]. Destruction of chordae tendinae was noted in two patients and paravalvular abscess and possible annular abscess in two other patients. In 16 of the 24 patients who did not have an echocardiogram, the illness occurred before echocardiograms were routinely performed.

Treatment and susceptibility

Treatment was detailed for 58 of the 61 patients, all of whom received a penicillin or cephalosporin sometime during the course of therapy. Therapy was almost always given by the intravenous route. The therapy most commonly given was a penicillin plus an aminoglycoside (19 cases, 33%) followed by a penicillin alone (10 cases, 17%) (Table 4). Ten (17%) patients received combinations of a cephalosporin, a penicillin, and other antimicrobial agents; three (5%) received ceftriaxone alone; and three (5%) received a cephalosporin plus an aminoglycoside. Fluoroquinolones were part of the antimicrobial therapy in 3 (5%) cases. One patient received a combination of cephalosporin, penicillin, and fluoroquinolone therapy. Other regimens included tetracycline or doxycycline (*n*=3), chloramphenicol (*n*=2), and

clindamycin (*n*=2). Two of four patients reported in 1962 received tetracycline and chloramphenicol as a part of their therapy. Sixteen (28%) patients completed their treatment as monotherapy with a penicillin. Six (10%) patients, including our two patients, completed their treatment as monotherapy with ceftriaxone. The mean length of treatment in 50 patients for whom the data were reported was 5.9±2.2 weeks (range, 12 days to 12 weeks). The mean length of treatment for native valve endocarditis was 5.7±2.3 weeks and for prothestic valve endocarditis 6.5±2.0 weeks.

The antimicrobial susceptibility of *C. hominis* has been reviewed [46], and additional case reports have noted susceptibility results. Almost all isolates have been susceptible to penicillins, cephalosporins, tetracyclines, chloram-phenicol, and aminoglycosides. Recently, two isolates with beta-lactamase production have been reported [24,26]. Susceptibility testing was performed on the isolates from both of our patients. Each isolate was susceptible to ampicillin, aztreonam, ceftriaxone, carbapenems, trimethoprim-sulfamethoxazole, and fluoroquinolones.

Outcome

Complications included congestive heart failure in 23 (40%) patients, central nervous system (CNS) emboli in 12 (21%), arrhythmia in 9 (16%), mycotic aneurysm in 5 (9%), glomerulonephritis in 3 (5%) and vertebral osteomyelitis in 2 (3%) (Table 5). Fifty-six of 60 (93%) cases were cured; the outcome was not specified for 1 case (Table 6). Forty of the 43 (93%) cases involving native valves and 16 of the 17 (94%) cases involving prosthetic valves were cured. Valve replacement was required in 27 (45%) cases: 20 native valves and 7 prosthetic valves. Of the 20 cases of native valve endocarditis, the aortic valve was replaced in 13, the mitral valve in 4, and both valves in 3. Of the seven cases of prosthetic valve endocarditis, the aortic was replaced in 5, the mitral valve in 1, and both valves in 1. Clinical and outcome data for all prosthetic valve cases is shown in Table 7.

Discussion

C. hominis is a pleomorphic gram-negative bacillus that often appears as pairs, short chains, teardrop forms, rosettes, or clusters [2,50]. The organism is often gram variable, with one or both ends retaining the crystal violet stain and appearing to be gram positive. The tendency to retain some crystal violet probably contributed to the early difficulties surrounding the exact taxonomic position of *C. hominis*.

Optimal growth of *C. hominis* occurs with supplemental CO_2 and increased humidity [38]. The organism grows well on standard enriched media (blood, chocolate, trypticase soy, and Mueller–Hinton agars), but not on selective enteric media (MacConkey agar, eosin methylene blue agar). *C. hominis* is oxidase positive, catalase negative, and produces indole. It typically ferments glucose, sucrose, mannose, sorbitol, mannitol, and maltose [19]. Table 8 displays biochemical properties that help differentiate *C. hominis* from others in the HACEK group [51].

C. hominis is a member of the normal flora of the nose and throat in most (~70%) individuals [50]. Respiratory tract carriage of *C. hominis* is seen among all ages without a predilection for gender. Fluorescent-antibody analysis has found that *C. hominis* is a probable colonizer of the gastrointestinal tract, although direct culture or stool isolation of this bacterium has been unsuccessful [50]. In one study, *C. hominis* was isolated from cervical and vaginal cultures of 2 of 159 patients; it appears to only be a transient colonizer of the genitourinary tract [52].

C. hominis is relatively avirulent. Inocula as great as 10^9 microorganisms injected into mice, guinea pigs, rabbits, hamsters, and pigeons produced no evidence of infection [1]. Almost all

patients with *C. hominis* bacteremia have infective endocarditis. Endocarditis was present in 60 of the 63 reported cases of *C. hominis* bacteremia. Of the three cases of apparent bacteremia without endocardial involvement, one occurred in a 65-year-old man with underlying adenocarcinoma of the right kidney with an abscess involving the cecum and the right kidney [53]. He underwent surgical drainage, and cultures of the abscess and three sets of blood cultures grew *C. hominis* and *Clostridium bifermentans*. A 67-year-old woman with metastatic adenocarcinoma of an unknown primary focus died of fatal *C. hominis* sepsis [54], and a 76-year-old woman with a pacemaker lead infection and vertebral osteomyelitis had multiple positive blood cultures for *C. hominis* but no valvular vegetations [55]. It is of interest that two of the three patients with *C. hominis* bacteremia without endocarditis had an underlying adenocarcinoma.

Previously, *C. hominis* was the only *Cardiobacterium* species associated with endocarditis. However, a second species was recently discovered by use of phylogenetic and phenotypic methods in a 37-year-old man with bicuspid aortic valve disease who developed *Cardiobacterium valvarum* endocarditis following dental work [56]. He suffered a ruptured cerebral aneurysm, underwent aortic valve replacement, and was treated successfully with parenteral antibiotics and surgery. To our knowledge, no other cases of *C. valvarum* infection have been described. Cellular fatty acid analysis can help differentiate *C. valvarum* from *C. hominis* [57].

C. hominis endocarditis is remarkably insidious in its presentation, with a tendency to infect damaged or prosthetic valves. The aortic valve is the most commonly infected valve. A longer duration of symptoms has been reported to occur with *C. hominis* endocarditis when compared with endocarditis caused by other HACEK organisms [14,58-61]. The delayed diagnosis noted with *C. hominis* is partially explained by the mild symptoms experienced by patients and the difficulty in isolating the organism from blood. Because of its fastidious and slow-growing nature, recommendations have been to hold blood cultures for 10–14 days. Newer techniques for diagnosis, such as PCR, may be increasingly used in the future.

Congestive heart failure is seen more often with *C. hominis* endocarditis than with endocarditis due to other HACEK organisms [14,58,59]. Whether this is related to the longer duration of infection remains unclear. Peripheral and CNS emboli are common complications of *C. hominis* endocarditis, noted in 51% and 21% of cases, respectively.

Of all the HACEK organisms, *C. hominis* (17 of 61 cases, 28%) and *A. actinomycetemcomitans* are most likely to involve a prosthetic valve [60]. Only 5 of 42 (12%) cases of *Haemophilus* endocarditis and 2 of 12 (17%) cases of *E. corrodens* endocarditis involved prosthetic valves [58,60,61]. Rheumatic and congenital heart disease, poor dentition, and recent dental work are commonly noted risk factors for endocarditis associated with any HACEK organisms [14,62].

The risk of bacterial endocarditis secondary to gastrointestinal endoscopy is quite low. Among at least 13 reported cases of endocarditis that have occurred with gastrointestinal endoscopy , three non-*Cardiobacterium* cases occurred with colonoscopy [63-66]. Colonoscopy may have been a risk factor in both of our patients. Neither patient received antibiotic prophylaxis prior to their procedures, and both had a prosthetic heart valve. Current guidelines from the American Society for Gastrointestinal Endoscopy state that prophylaxis is optional for patients at high risk for endocarditis undergoing esophagogastroduodenoscopy and colonoscopy (with or without biopsy/polypectomy) [65]. We believe antibiotic prophylaxis should be considered for patients who have prosthetic heart valves and who are at high risk for endocarditis when they undergo endoscopy.

The prognosis of both native valve and prosthetic valve *C. hominis* endocarditis is favorable. *C. hominis* is almost always susceptible to penicillin. Over a quarter of patients finished treatment with β-lactam monotherapy. However, because of reports of beta-lactamase-producing *C. hominis* strains causing endocarditis [24,26], it seems prudent to use a third-generation cephalosporin as first-line treatment, in accordance with recently published American Heart Association guidelines [67].

We recommend that the duration of intravenous antibiotic therapy be 4 weeks for native valve endocarditis and 6 weeks for prosthetic valve endocarditis. Our review shows that 16 of 17 (94%) cases of *C. hominis* prosthetic valve endocarditis were cured with a mean length of antimicrobial therapy of 6.5±2.0 weeks. Only 1 of the 16 patients who survived received therapy for less than 4 weeks. Valve replacement surgery is often needed as an adjunct to antimicrobial therapy. Our analysis shows that valve replacement was required in 27 (45%) cases: 20 native valves and 7 prosthetic valves.

A recent review of 45 cases of HACEK endocarditis reported a similar favorable prognosis: 2 of the 45 (4%) patients died. However, valve replacement surgery was required in 18 (40%) cases. The antimicrobial therapy used and the need for surgical intervention did not differ among cases caused by the different HACEK organisms [62].

In conclusion, *Cardiobacterium* endocarditis is a rare condition that is almost always caused by *C. hominis*. Unlike *Haemophilus*, *Actinobacillus*, and *Kingella* species, it rarely occurs in children (one case) [68]. The onset of *C. hominis* endocarditis is subacute with an extended duration of symptoms, usually accompanied by recurrent fever and frequently complicated by peripheral emboli and congestive heart failure. It has a favorable prognosis, often requiring a combination of medical and surgical therapy.

The major limitations of our review are the small number of cases reported in the English-language literature and the difficulty in deriving conclusions from case reports (publication bias). Future multicenter studies, like the International Collaboration of Endocarditis cohort, are needed to help further describe *C. hominis* endocarditis.

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Table 1

Characteristics of 61 patients with *C. hominis* endocarditis

Characteristic	No (%)
Age (mean±SD)	50.2±15 years
Men/women	42/19
Symptoms (*n*=58)[a, b]	
Fever	43 (74%)
Fatigue/malaise	31 (53%)
Weight loss/anorexia	23 (40%)
Night sweats	14 (24%)
Arthralgias/myalgias	12 (21%)
Visual disturbance	4 (7%)
Confusion	1 (2%)
Risk factors (*n*=61)[b]	
Cardiac disease	37 (61%)
Prosthetic valve	17 (28%)
Congenital valvular disease[c]	12 (20%)
Prior rheumatic fever	12 (20%)
Recent dental procedure	10 (16%)
Poor dentition	8 (13%)
Prior endocarditis	4 (7%)
Recent endoscopy	3 (5%)

[a] Symptoms were reported for 58 of 61 patients

[b] Patients could have >1 symptom reported or >1 risk factor for endocarditis

[c] Includes bicuspid aortic valve (*n*=4), ventricular septal defect (*n*=3), mitral valve prolapse (*n*=1), tricuspid pulmonic valve (*n*=1), and unspecified (*n*=4). One patient had both a ventricular septal defect and a tricuspid pulmonic valve

Table 2

Site of infection of *C. hominis* endocarditis in 61 patients

Valve	No. (%)
Aortic	24 (39)
Mitral	19 (31)
Mitral and aortic	8 (13)
Pulmonic	1 (2)
Tricuspid	1 (2)
Not specified	8 (13)

Table 3

Physical and laboratory findings in 53 cases of *C. hominis* endocarditis

Characteristic	No. (%)
Physical findings	
Murmur	50 (94%)
Mitral regurgitation	28
Aortic regurgitation	21
Aortic stenosis	19
Mitral stenosis	2
Splenomegaly	21 (40%)
Emboli	27 (51%)
Cutaneous lesions[a]	18
Retinal/conjunctival	14
Large-vessel emboli	3
Laboratory findings	
Leukocyte count 10,000/mm^3	10/37 (27%)
Anemia	30/35 (86%)
Elevated WESR	30/33 (91%)
WESR >100 mm/h	6/33 (18%)
Hematuria	15/29 (52%)

WESR Westergren erythrocyte sedimentation rate

[a] Petechiae, Janeway's lesions, splinter hemorrhages, Osler's nodes

Table 4

Treatment of *C. hominis* endocarditis in 58 cases

Antibiotics	No. (%)
PEN + AMG	19 (33%)
PEN	10 (17%)
PEN + CEPH + other[a]	10 (17%)
CEPH + AMG	3 (5%)
CEPH	3 (5%)
Fluoroquinolone[b]	3 (5%)
Other[c]	11 (19%)

PEN penicillin, *AMG* aminoglycoside, *CEPH* cephalosporin

[a] Penicillins, cephalosporins, and other antimicrobial agents were given during the course of therapy, not necessarily together. Other antimicrobial agents included fluoroquinolone (one case), gentamicin, rifampin, and vancomycin.

[b] One patient received a penicillin, a cephalosporin, and a fluoroquinolone during the course of therapy.

[c] Included amoxicillin, chloramphenicol, clindamycin, doxycycline, erythromycin, gentamicin, netilmicin, penicillin, streptomycin, and tetracycline.

Table 5

Complications in 58 cases of *C. hominis* endocarditis

Complication	No. (%)
Congestive heart failure	23 (40%)
CNS emboli	12 (21%)
Arrhythmia	9 (16%)
Mycotic aneurysm	5 (9%)
Glomerulonephritis	3 (5%)
Vertebral osteomyelitis	2 (3%)

CNS central nervous system

Table 6

Outcome of 60 cases of *C. hominis* endocarditis

Outcome	No. (%)
Cure	56/60 (93%)
Native valve	40/43 (93%)
Prosthetic valve	16/17 (94%)
Valve replacement surgery	27/60 (45%)
Native valve	20/43 (47%)
Prosthetic valve	7/17 (41%)

Table 7

Cases of prosthetic valve endocarditis due to *C. hominis*

Ref.	Valve	Surgery	Treatment	Cure
[47]	AV	Yes	PEN + GEN 10 days, then AMP + TOB 41 days	Yes
[16]	AV	Yes	AMP 4 weeks	Yes
[41]	MV	No	AMP, then PEN 6 weeks	Yes
[36]	MV	No	PEN 6 weeks	Yes
[8]	NR	NR	NR	No
[19]	MV	No	AMP + GEN 3 weeks, then AMP 3 weeks	Yes
[30]	MV	Yes	VAN/GEN, then AMP 6 weeks	Yes
[3]	AV	Yes	PEN/GEN, then CEF 6 weeks	Yes
[42]	MV/AV	Yes	AMP + GEN, then AMP 9 weeks	Yes
[29]	MV/AV	No	AMP + GEN 6 weeks	Yes
[25]	AV	No	CEF 3 weeks	Yes
[48]	AV	No	CEF + GEN, then CEF 6 weeks	Yes
[11]	AV	Yes	CEF + GEM 18 days, then AMX 10 weeks	Yes
[4]	MV	No	CEF 6 weeks	Yes
[5]	AV	No	CEF + CIP, duration NR	Yes
PR	AV	No	CEF 10 weeks	Yes
PR	AV	Yes	CEF 6 weeks	Yes

AV aortic valve, *MV* mitral valve, *NR* not recorded, *PR* present report, *AMP* ampicillin, *AMX* amoxicillin, *CEF* ceftriaxone, *CIP* ciprofloxacin, *PEN* penicillin, *GEN* gentamicin, *VAN* vancomycin, *TOB* tobramycin

Table 8

Comparison of biochemical characteristics of *C. hominis* and other HACEK organisms

Test	*Cardiobacterium hominis*	*Haemophilus aphrophilus*	*Actinobacillus actinomycetemcomitans*	*Eikenella corrodens*	*Kingella kingae*
Oxidase	+	v	−/w	+	+
Catalase	−	−	+	−	−
Nitrate reduction	−	+	+	+	−
Indole	+	−	−	−	+
Fermentation					
Glucose	+	+	+	−	+
Lactose	−	+	−	−	−
Maltose	+	+	+	−	+
Mannitol	+	−	v	−	−
Sucrose	+	+	−	−	−

+ positive, − negative, *v* variable, *w* weak

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