Capnocytophaga canimorsus is a fastidious, Gram-negative rod that forms part of the normal oral flora of dogs and cats. Known for its ability to cause fulminant sepsis following dog bites, particularly in asplenic patients or alcoholics, this bacterium is also an uncommon cause of endocarditis. This article reviews 12 cases of endocarditis caused by C. canimorsus. Mean age of patients was 53 years, with 78% of cases occurring in males. Overall, a history of dog-bite was documented in four cases (33%) and a further four (33%) reported contact with dogs. Four (33%) of the endocarditis cases had underlying cardiological risk factors and two abused alcohol, but none had had a previous splenectomy. Subacute presentation, often involving more than one hospital admission, was common, as were initially negative blood cultures. A variety of antibiotics was used, but penicillins were the most common therapy. Three (25%) of the 12 endocarditis patients died.

**Introduction**

Capnocytophaga canimorsus, formerly known as dysgonic fermenter 2 (DF2), is a fastidious, Gram-negative rod that forms part of the normal oral flora of dogs and cats (Westwell et al., 1987). This organism has a fusiform appearance on Gram-staining and exhibits characteristic gliding motility. C. canimorsus is known for its ability to cause fulminant sepsis following dog bites, particularly in asplenic patients or alcoholics (Lion et al., 1996), but its ability to cause endocarditis is less well appreciated. This article describes the clinical features, treatment and outcome of previously published cases of endocarditis caused by C. canimorsus.

**Methods and Patients**

Possible cases of C. canimorsus endocarditis were identified by using Medline. Search terms used were ‘endocarditis’, ‘DF2’, ‘Capnocytophaga canimorsus’ and ‘Capnocytophaga’. Further cases were identified from references of published reports. Cases that were due to other Capnocytophaga species or where the species was not stated were not included. Where reported information allowed, cases of endocarditis were categorized as definite, possible or rejected by using the modified ‘Duke criteria’ (Durack et al., 1994; Li et al., 2000). Diagnosis of endocarditis by using these criteria relies on pathological findings, such as demonstration of micro-organisms in resected heart valve tissue, or clinical criteria. Definite diagnosis based on clinical criteria depends on the presence of two major criteria, one major criterion and three minor criteria or of five minor criteria, where major criteria are based on blood-culture results and echocardiographic findings and minor criteria include fever, predisposing heart conditions and immunological and vascular phenomena. Possible cases were those with one major and one minor criterion or three minor criteria (Li et al., 2000). Cases were classified as ‘acute’ if symptoms had been present for up to 2 weeks prior to diagnosis and as ‘subacute’ for any period longer than 2 weeks.

**Results and Discussion**

Table 1 summarizes the findings for 12 cases of C. canimorsus endocarditis that were published between 1977 and 2002. Sufficient information was available to categorize nine of the reported endocarditis episodes by using previously published criteria (Durack et al., 1994; Li et al., 2000). Two cases were excluded, as the species was not known or was thought not to be C. canimorsus (Montejo Baranda et al., 1984; Roig et al., 1996). Patients had a mean age of 53 years (range, 24–69 years). Male:female ratio was 4:5:1. Four (33%) of the endocarditis cases had underlying cardiological risk factors: one patient was known to have aortic stenosis and a permanent pacemaker in situ, a murmur had been detected previously in another, one patient had an atrial myxoma and the other had had a previous aortic valve replacement. Five patients had been in good health prior to presentation; the others had underlying risk factors such as chronic lymphocytic leukaemia (n = 1) and alcohol abuse (n = 2). Previous splenectomy was not reported in any of the patients. A history of dog-bite was documented in four cases (33%) and a further four (33%) reported contact with dogs; in one case, the dog had licked a lesion on the patient’s leg. Three (25%) of the 12 endocarditis patients died. Initial clinical signs and laboratory findings are summarized in Table 2. A mixture of different antibiotic regimens had been used in treatment, as summarized in Table 1. It is not possible to draw any conclusions regarding optimal therapy from such a small number of cases.

C. canimorsus has been associated with a variety of conditions, including meningitis, fulminant septicaemia, cellulitis and endocarditis (Pers et al., 1996). There are well-described risk factors for infections caused by this bacterium, including dog-bite, previous splenectomy and alcohol abuse. A history of dog-bite has been reported in 43–47% of cases (Brenner et al., 1994; Li et al., 2000).
Table 1. Summary of the main clinical features of 12 episodes of endocarditis caused by *C. canimorsus*

Abbreviations: A, aortic valve; AVR, aortic valve replacement; CLL, chronic lymphocytic leukaemia; COPD, chronic obstructive pulmonary disease; E, endocarditis; M, mitral valve; MI, myocardial infarction; P, prosthetic; PPM, permanent pacemaker; T, tricuspid valve; NK, not known; NS, not stated.

<table>
<thead>
<tr>
<th>Case</th>
<th>Age/sex</th>
<th>Previous cardiac pathology</th>
<th>Associated conditions</th>
<th>Previous splenectomy</th>
<th>Valve affected</th>
<th>Animal exposure</th>
<th>Surgery</th>
<th>Antibiotics (duration, days)</th>
<th>Diagnosis</th>
<th>Outcome</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>NK</td>
<td>NK</td>
<td>NK</td>
<td>NK</td>
<td>A</td>
<td>Dog bite</td>
<td>Yes</td>
<td>Penicillin (5), erythromycin (5)</td>
<td>E</td>
<td>Died</td>
<td>Butler et al. (1977)</td>
</tr>
<tr>
<td>2</td>
<td>NK</td>
<td>NK</td>
<td>NK</td>
<td>NK</td>
<td>A</td>
<td>NK</td>
<td>No</td>
<td>NK</td>
<td>E</td>
<td>Recovered</td>
<td>Butler et al. (1977)</td>
</tr>
<tr>
<td>3</td>
<td>NK</td>
<td>NK</td>
<td>NK</td>
<td>NK</td>
<td>M</td>
<td>NK</td>
<td>No</td>
<td>NK</td>
<td>E</td>
<td>Recovered</td>
<td>Butler et al. (1977)</td>
</tr>
<tr>
<td>4</td>
<td>64M</td>
<td>NK</td>
<td>No</td>
<td>T+A</td>
<td>Dog bite</td>
<td>No</td>
<td>Penicillin (5), erythromycin (5)</td>
<td>E</td>
<td>Died</td>
<td>Shankar et al. (1980)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>59F</td>
<td>Atrial myxoma, CLL, steroids</td>
<td>No</td>
<td>T</td>
<td>NS</td>
<td>Yes</td>
<td>Cephalothin + gentamicin (14)</td>
<td>E</td>
<td>Died</td>
<td>Worthington et al. (1984)</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>39M</td>
<td>Alcohol abuse</td>
<td>No</td>
<td>M</td>
<td>Dog contact</td>
<td>No</td>
<td>Ampicillin (42) + tobramycin (NS)</td>
<td>E</td>
<td>Recovered</td>
<td>Archer (1985)</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>24M</td>
<td>Heart murmur</td>
<td>NK</td>
<td>A</td>
<td>Dog bite</td>
<td>No</td>
<td>Penicillin (28)</td>
<td>MI + E</td>
<td>Recovered</td>
<td>Newton &amp; Sharma (1986)</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>47M</td>
<td>Alcohol abuse</td>
<td>No</td>
<td>T</td>
<td>Dog contact</td>
<td>Yes</td>
<td>Vancomycin (14) + gentamicin (14), penicillin (42)</td>
<td>E</td>
<td>Recovered</td>
<td>Niefield &amp; Young (1988)</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>56M</td>
<td>NK</td>
<td>No</td>
<td>T</td>
<td>Dog contact</td>
<td>No</td>
<td>Penicillin (42) + gentamicin (NS)</td>
<td>E</td>
<td>Recovered</td>
<td>Andersen &amp; Pedersen (1992)</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>52M</td>
<td>Aortic stenosis, PPM</td>
<td>No</td>
<td>A</td>
<td>Dog bite</td>
<td>No</td>
<td>Penicillin (NS), aztreonam (35)</td>
<td>E</td>
<td>Recovered</td>
<td>Decoster et al. (1992)</td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>69F</td>
<td>COPD</td>
<td>No</td>
<td>T</td>
<td>None</td>
<td>No</td>
<td>Cefuroxime (7) + gentamicin (7), + flucloxacin (7), then penicillin G (42)</td>
<td>E</td>
<td>Recovered</td>
<td>Kooter et al. (1999)</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>63M</td>
<td>AVR</td>
<td>No</td>
<td>PA</td>
<td>Dog contact</td>
<td>Yes</td>
<td>Ceftriaxone (28) + gentamicin (28), then penicillin G (28)</td>
<td>E</td>
<td>Recovered</td>
<td>Ngaage et al. (1999)</td>
<td></td>
</tr>
</tbody>
</table>
Table 2. Summary of clinical features of C. canimorsus endocarditis

<table>
<thead>
<tr>
<th>Case</th>
<th>Pyrexia (&gt;38 C)</th>
<th>Leukocytosis</th>
<th>Anaemia</th>
<th>Membranous or petechial haemorrhages on skin</th>
<th>Raised CRP/ESR</th>
<th>Duke classification (modified)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1-3</td>
<td>8</td>
<td>(D7)</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>Acute/subacute Duke classification</td>
</tr>
<tr>
<td>4</td>
<td>10/7</td>
<td>12/7</td>
<td>5/12</td>
<td>5/7</td>
<td>4/12</td>
<td>Acute/subacute Duke classification</td>
</tr>
<tr>
<td>5</td>
<td>1++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>++</td>
<td>Acute/subacute Duke classification</td>
</tr>
<tr>
<td>6</td>
<td>10/7</td>
<td>12/7</td>
<td>5/12</td>
<td>5/7</td>
<td>4/12</td>
<td>Acute/subacute Duke classification</td>
</tr>
<tr>
<td>7</td>
<td>4/6</td>
<td>6/6</td>
<td>1+</td>
<td>(D5)</td>
<td>(+)</td>
<td>Acute/subacute Duke classification</td>
</tr>
<tr>
<td>8</td>
<td>6/6</td>
<td>12/7</td>
<td>5/7</td>
<td>7/7</td>
<td>4/12</td>
<td>Acute/subacute Duke classification</td>
</tr>
<tr>
<td>9</td>
<td>4/6</td>
<td>6/6</td>
<td>1+</td>
<td>(D5)</td>
<td>(+)</td>
<td>Acute/subacute Duke classification</td>
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<tr>
<td>10</td>
<td>1+</td>
<td>NS</td>
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<td>NS</td>
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<td>Acute/subacute Duke classification</td>
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<tr>
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<td>2/3</td>
<td>3/3</td>
<td>2/3</td>
<td>2/3</td>
<td>2/3</td>
<td>Acute/subacute Duke classification</td>
</tr>
<tr>
<td>12</td>
<td>2/3</td>
<td>3/3</td>
<td>2/3</td>
<td>2/3</td>
<td>2/3</td>
<td>Acute/subacute Duke classification</td>
</tr>
</tbody>
</table>

Abbreviations: —, absent; +, present; D, day; NK, not known; NS, not stated. Parentheses indicate negative findings that subsequently became positive later in presentation.

*CRP, C-reactive protein; ESR, erythrocyte sedimentation rate.
†x/7, no. days; x/12, no. months.

Although endocarditis caused by C. canimorsus is reported rarely in the literature, there are many reports of bacteraemia and sepsis in which a focus for the infection was never found. As with other fastidious, Gram-negative infections, the published record of cases may underestimate the true incidence of C. canimorsus infection. Since 2000, the Laboratory of Healthcare-associated Infections, Colindale, London, has received (on average) one isolate of C. canimorsus for identification per year, one of which was from a patient with endocarditis (M. E. Kaufmann, personal communication). Prolonged periods with negative blood cultures and previous hospital admission occurred in several of the previously reported cases of endocarditis in this review (Shankar et al., 1980; Worthington et al., 1984; Archer, 1985; Newton & Sharma, 1986). Blood cultures may be negative in the early stages of infection by this organism and subcultures can take up to 7 days incubation in CO₂ before visible growth is apparent. Such slow growth explains how C. canimorsus may be a cause of apparently culture-negative endocarditis. C. canimorsus sepsis has also been associated with myocardial infarction (Newton & Sharma, 1986; Ehrbar et al., 1996) and post-mortem examination of two cases in a study from Denmark revealed myocarditis (Pers et al., 1996).

Susceptibility testing is difficult and standardized methods are not available. Penicillin is considered to be the treatment of choice, but C. canimorsus has also been reported to be susceptible to imipenem, clindamycin, erythromycin, vancomycin, chloramphenicol, third-generation cephalosporins, rifampicin, quinolones and doxycycline in vitro (Gill, 2000). A variety of antibiotic regimens have been used successfully to treat C. canimorsus endocarditis (Table 1).

It is clear that C. canimorsus can be a cause of acute or subacute, ‘culture-negative’ endocarditis and myocarditis. Clinical findings that are usually associated with endocarditis, such as heart murmur, fever and raised C-reactive protein, may be absent at presentation and infection may occur in individuals without previous cardiac pathology. A history of recent dog-bite in a patient presenting with clinical features of endocarditis should highlight the possibility of C. canimorsus endocarditis.
canimorsus infection. Although cases are few, prolonged use of a penicillin appears to be appropriate therapy. Perhaps C. canimorsus should be considered among the HACEK (Hae-
mophilus spp., Actinobacillus actinomycetemcomitans, Cardi-
obacterium hominis, Eikenella corrodens and Kingella spp.)
group of fastidious, Gram-negative organisms that are able
capable of causing endocarditis.

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