Native and Prosthetic Valve *Staphylococcus capitis* Endocarditis: A Review of the Literature

Ravi A. Thakker¹, d, Khaled Chatila¹, David Reynoso², Bernard Karnath¹

Abstract

Infective endocarditis (IE) is a rare but serious disease. Coagulase-negative staphylococci (CoNS) are among the least prevalent causes of IE. *Staphylococcus capitis*, a species of CoNS, although described in the literature before has only been seen in a few cases. Even with such few cases, complications and mortality have still been demonstrated. In our review, we look at the epidemiology, diagnosis, management, and literature prevalence of CoNS in native and prosthetic valve IE.

Keywords: *Staphylococcus capitis*; Endocarditis; Native endocarditis; Prosthetic valve endocarditis

Introduction

Infective endocarditis (IE) is among the rarest forms of infections. Of the bacteria that are known to be causative, coagulase-negative staphylococci (CoNS) are among the least prevalent. Notwithstanding the low prevalence, CoNS can cause serious infections such as endocarditis, catheter-related bacteremia, and prosthetic joint infections [1, 2]. In this review of the literature, we look at the epidemiology, diagnosis, management, and outcomes of *Staphylococcus capitis* (S. capitis), a species of CoNS, in both native valve and prosthetic valve endocarditis.

Methods

PubMed was searched with all article types included. No date limitation was placed. All case reports and review articles pertaining to *S. capitis* were analyzed for review inclusion with exclusion being non-accessibility of the article. Pertinent search terms included “*Staphylococcus capitis*”, “*Staphylococcus capitis* endocarditis”, and “infective endocarditis”.

Epidemiology

Due to the wide presentation and affected populations, there is variability in the prevalence and incidence of IE. In recent studies, the incidence of IE has been described as anywhere from 3 to 7 per 100,000 person-years. The most common implicated pathogen has been *Staphylococcus aureus* [1]. CoNS are a heterogenous group of commensal organisms considered abundant in the skin flora. *S. capitis*, a species of CoNS that occupies a specific niche on the skin of the head, accounts for approximately 5% of CoNS clinical isolates. Its typical infection profile includes urinary tract infections, catheter-related bacteremia, and cellulitis [3].

In terms of prevalence, Murdoch et al looked at pathogen isolates of 2,781 patient with endocarditis in both drug and non-drug abusers. Native valve IE was seen in 1,881 patients, with 237 being due to persons who inject intravenous drugs and 1,644 being unrelated to intravenous drug injection. In patients with native valve IE, only 155 or 12% were due to CoNS, with 3% being secondary to intravenous drug abuse. In patients with prosthetic valve IE, 95 patients or 17% were due to CoNS with 3% being secondary to intravenous drug abuse. Intracardiac-device IE was seen in 735 patients. Of these 735 patients, the prevalence of prosthetic valve IE due to CoNS was 95 patients or 17% [4]. The risk factors for IE vary greatly. In terms of non-clinically acquired IE, intravenous drug usage is a significant etiology. Clinically acquired etiologies include need for vascular access especially for long-term therapies, valvular prosthesis, implantable intracardiac devices, and non-cardiac prosthesis [5]. IE has been described mostly in the elderly population with males being affected more than females [6, 7]. In a study by Jensen et al, looking at 8,905 patients over a 20-year interval, median age was 70.2. In terms of gender prevalence, males accounted for 65.2% of the study population [8].

Diagnosis

Diagnosis of IE consists of a clinical, laboratory, and imaging approach. In terms of clinical approach, the first step is...
obtaining a history. In our review, the patients had symptoms such as fever, dyspnea on exertion, cold intolerance [9], malaise [10], palpitations [11], and back pain [12]. The modified Duke criteria have been shown as one of the major diagnostic criteria for IE. According to the criteria, for definitive clinical IE diagnosis patients must meet two major criteria, one major criterion and three minor criteria, or five minor criteria. Major criteria include positive blood culture with typical microorganisms known for IE from two separate blood cultures, a single positive blood culture with Coxiella burnetii or anti-phase 1 immunoglobulin G (IgG) antibody titer 1:800 or greater, evidence of endocardial involvement, and echocardiogram with IE findings. Minor criteria include predisposition to IE such as intravenous drug use or prior heart condition, fever, any exam findings of septic emboli, immunologic phenomena, and positive blood culture inconsistent with major criteria or serology demonstrating active infection with IE organism. In terms laboratory approach, obtaining blood cultures are key in confirming the causative pathogen. Other laboratory markers that can help guide diagnosis include the complete blood count with differential and inflammatory markers such as C-reactive protein and erythrocyte sedimentation rate [1]. Aside from clinical and laboratory diagnosis, echocardiography has been shown to be a major imaging modality in confirming diagnosis. The two main echocardiographic modalities are transthoracic and transesophageal. The preliminary diagnostic choice due to feasibility is transthoracic echocardiography (TTE). The sensitivity of TTE is approximately 80%. Transesophageal echocardiography (TEE) has been shown to have approximately 95% sensitivity [13].

**S. capitis Native Valve Endocarditis**

Native valve endocarditis secondary to *S. capitis* infection has been described in 12 patients. In terms of patient demographics, all patients were male. The median age was 55.8 years, with the youngest patient age of 29 and oldest patient age of 79. Comorbidities among the patient population included coronary artery disease, hypertension, diabetes mellitus, prior cerebrovascular accident, renal insufficiency, cardiomyopathy, ventricular septal defect, prior endocarditis, mitral regurgitation with prior mitral annuloplasty, esophagitis, aortic sclerosis, and epilepsy. In regard to valvular location, the most prevalent was mitral with six cases. Aortic involvement was seen in five patients. Tricuspid valve was seen in one patient. Two patients underwent surgical management, while the other 11 underwent medical treatment alone with antibiotics. Vancomycin was the most commonly used antibiotic appearing in the regimen of seven patients. Gentamicin was used in five patients. Rifampin was used in four patients. Nafcillin, penicillin, ampicillin, and cloxacillin were used each in two patients. Amoxicillin, netilmicin, ceftriaxone, and pefloxacin were used each in one patient. Complications included heart failure in two patients, embolic phenomenon to the leg in two patients, arrhythmia in one patient, multiorgan failure in one patient, and facial nerve palsy with hemiplegia in one patient. In terms of mortality, two patients died with one patient having mitral involvement and the other aortic involvement (Table 1) [3, 14-22].

**S. capitis Prosthetic Valve Endocarditis**

Prosthetic valve endocarditis secondary to *S. capitis* infection has been described in 12 patients. In terms of demographics, seven patients were male and five were female. The median age was 68.6 years, with the youngest patient age of 48 and oldest patient age of 80. Comorbidities among the patients included coronary artery disease, atrial fibrillation, hypertension, cardiomyopathy, chronic obstructive pulmonary disease, chronic kidney disease, and peripheral artery disease. In regard to prosthetic valvular infection, the most prevalent was aortic with 10 cases. Mitral valve involvement was seen in four cases. One out of the 12 cases demonstrated both aortic and mitral valve endocarditis and four patients. All patients underwent surgical management which consisted mostly of valve replacement. All patients were treated with antibiotics. Vancomycin was used in 10 patients; rifampin was used in seven patients; gentamicin was used in six patients; linezolid, teicoplanin, minocycline, and levofloxacin were used each in two patients; imipenem and amikacin were used each in one patient. Complications included heart failure in three patients, aortic root abscess in two patients, shock in two patients, aortic annular abscess in one patient, mitral annular abscess in one patient, embolic phenomenon to the leg in one patient, embolic phenomenon to the spleen in one patient, and adverse cerebrovascular event in one patient. Mortality was seen in four patients with one having mitral valve involvement and three having aortic valve involvement (Table 2) [9-12, 23].

**Management**

The primary preventive measures against IE are avoidance of intravenous drug use, prudent use of bioprosthetic devices, judicious catheter placement, and removal of unnecessary catheters in patients particularly those who are immunosuppressed [24]. Medical management includes identifying the pathogenic isolate in order to tailor antibiotic regimen. The most commonly used antibiotics found in our review in both native and prosthetic valve endocarditis were vancomycin, gentamicin, and rifampin [3, 9-12, 14-23]. For patients with complicated right-sided IE and left-sided IE with methicillin- or oxacillin-susceptible isolates, nafcillin or oxacillin can be used for 6 weeks with dosing of 12 g per 24 h intravenously in four to six equally divided doses. Cefazolin can be used in patients with non-anaphylactoid penicillin allergy for 6 weeks duration. The dosage is 6 g per 24 h intravenously in three equally divided doses. If anaphylaxis is a concern for both penicillin and cephalosporins, then vancomycin can be implemented. For oxacillin-resistant species, vancomycin at 30 mg per kilogram per 24 h intravenously in two equally divided doses or daptomycin at greater or equal to 8 mg per kilogram per dose can be used for 6 weeks. In regard to dosing and duration for prosthetic valve IE the dose for nafcillin or oxacillin is 12 g
| Reference | Patient | Gender | Age | Comorbidities | Location | Vegetation | Abscess | Antibiotic management | In-hospital surgical management | Complications | In-hospital mortality |
|-----------|---------|--------|-----|----------------|----------|------------|---------|------------------------|-------------------------------|--------------|----------------------|
| [3]       | 1       | Male   | 35  | Epilepsy, hypertension, dilated cardiomyopathy | Aortic valve | Yes        | No      | Vancomycin, rifampin   | No                           | Heart failure | No                   |
| [14]      | 1       | Male   | 72  | Cerebrovascular accident, peripheral vascular disease | Mitral valve | Yes        | No      | Vancomycin, gentamicin | No                           | No            | No                   |
| [15]      | 1       | Male   | 53  | Not available | Mitral valve | Yes        | No      | Amoxicillin, netilmicin, ceftriaxone | No                          | Popliteal artery embolism | No                   |
| [16]      | 1       | Male   | 63  | Ventricular septal defect, prior endocarditis | Tricuspid valve | Yes        | No      | Cloxacillin | No                           | Heart failure | No                   |
| [17]      | 1       | Male   | 46  | End-stage renal disease | Aortic valve | Yes        | No      | Vancomycin, rifampin   | No                           | Lower extremity gangrene | No                   |
| [18]      | 1       | Male   | 73  | Hypertension, esophagitis | Mitral valve | Yes        | No      | Amoxicillin, cloxacillin, gentamicin | No                          | Hemiplegia, facial palsy | Yes                   |
| [19]      | 1       | Male   | 29  | Not available | Mitral valve | No         | No      | Penicillin, gentamicin | No                           | No            | No                   |
| 2         | Male    | 62    |     | Not available | Mitral valve | No         | No      | Vancomycin, gentamicin, pefloxacin, rifampin | Yes                          | No            | No                   |
| [20]      | 1       | Male   | 79  | Diabetes mellitus, renal insufficiency, coronary artery disease, hypertension, aortic sclerosis, mitral regurgitation | Aortic valve | Yes        | No      | Vancomycin, nafcillin | No                           | Multiorgan failure | Yes                   |
| [21]      | 1       | Male   | 70  | Hypertension, diabetes mellitus | Aortic valve | Yes        | No      | Nafcillin, gentamicin | No                           | Arrhythmia | No                   |
| [22]      | 1       | Male   | 53  | Mitral regurgitation (prior mitral annuloplasty) | Mitral valve | Yes        | No      | Ampicillin, vancomycin | Yes                          | No            | No                   |
### Table 2. Prosthetic Valve Endocarditis

| Reference | Patient | Gender | Age | Comorbidities                                                                 | Location          | Vegetation | Abscess | Antibiotic management | In-hospital surgical management | Complications                                                                 | In-hospital mortality |
|-----------|---------|--------|-----|--------------------------------------------------------------------------------|-------------------|------------|---------|-----------------------|---------------------------------|------------------------------------------------------------------------------|---------------------|
| [9] 1     | Male    | 72     |     | Coronary artery disease, hypertension, atrial fibrillation                      | Aortic valve      | No         | Yes     | Vancomycin, gentamicin, rifampin | Yes                             | Heart failure, aortic root abscess                                        | Yes                 |
| 2         | Female  | 48     |     | Hypertension                                                                    | Aortic valve      | Yes        | Yes     | Vancomycin, gentamicin, rifampin | Yes                             | Leg embolism, heart failure, shock, aortic root abscess                     | Yes                 |
| [10] 1    | Female  | 79     |     | Not available                                                                    | Aortic valve      | Yes        | Yes     | Vancomycin, gentamicin, rifampin, minocycline | Yes                             | None                                                                          | No                   |
| 2         | Female  | 79     |     | Not available                                                                    | Aortic valve      | Yes        | No      | Vancomycin, gentamicin, rifampin, minocycline | Yes                             | None                                                                          | No                   |
| 3         | Male    | 76     |     | Not available                                                                    | Aortic valve      | Yes        | Yes     | Teicoplanin, vancomycin, linezolid, levofoxacin | Yes                             | Aortic annular abscess                                                     | No                   |
| 4         | Female  | 68     |     | Not available                                                                    | Mitral valve      | No         | No      | Vancomycin, gentamicin, levofoxacin | Yes                             | Mitral annular abscess, heart failure                                      | No                   |
| [11] 1    | Female  | 65     |     | Not available                                                                    | Mitral valve      | No         | No      | Imipenem, vancomycin              | Yes                             | None                                                                          | No                   |
| [12] 1    | Male    | 55     |     | Not available                                                                    | Aortic and mitral valve | No        | No      | Vancomycin, gentamicin, rifampin | Yes                             | Spleen embolism, cerebral infarct                                           | No                   |
| [23] 1    | Male    | 74     |     | Dilated cardiomyopathy, chronic obstructive pulmonary disease, chronic kidney disease, peripheral artery disease | Mitral valve      | Yes        | No      | Rifampin, vancomycin              | Yes                             | Heart failure, shock                                                      | Yes                 |
| 2         | Male    | 69     |     | Diabetes mellitus, chronic obstructive pulmonary disease, peripheral artery disease, ischemic cardiomyopathy | Aortic valve      | No         | Yes     | Rifampin, vancomycin and gentamicin | Yes                             | None                                                                          | No                   |
| 3         | Male    | 80     |     | Chronic obstructive pulmonary disease, diabetes mellitus                          | Aortic valve      | Yes        | Yes     | Rifampin, vancomycin, and gentamicin | Yes                             | Shock                                                                        | Yes                  |
| 4         | Male    | 58     |     | None                                                                            | Aortic valve      | No         | No      | Amikacin, linezolid, teicoplanin, minocycline | Yes                             | None                                                                          | No                   |
per 24 h intravenously for 6 or greater weeks, rifampin 900 mg per 24 h intravenously or orally in three equally divided doses for 6 or greater weeks, and gentamicin 3 mg per kilogram per 24 h intravenously or intramuscularly divided into two or three doses for 2 weeks. For oxacillin-resistant strains, the dosing for vancomycin is 30 mg per kilogram per 24 h in two equally divided doses for 6 or greater weeks and rifampin and gentamicin with same dosing and duration as native valve IE [1]. For uncomplicated right-sided IE cases, a 2-week duration can be used. Surgical management is indicated in instances where a patient is presenting with acute heart failure, perianular abscess, large vegetation greater than 15 mm, or signs of cerebrovascular compromise [25].

Discussion

Aside from having a large clinical burden, the economic burden imposed by S. capitis IE has been shown to be upwards of $2.34 billion [26]. The aim of our study was to guide health care professionals by outlining the epidemiology, diagnosis, and management as it pertains not only to IE but specifically S. capitis IE. Furthermore, given its rarity we sought to consolidate the literature of prior described cases in order to appreciate the impact of S. capitis as a cause of IE. Our review of the literature looking at cases of S. capitis-related native and prosthetic valve endocarditis found that: 1) Although cases have been described in the literature of S. capitis causing endocarditis the quantity is small; 2) For cases involving the native valve medical management alone overall had good outcomes, with a few cases noted to have poor outcomes; 3) Surgical management was important in treating prosthetic valve IE; 4) The most common comorbidities in patients developing S. capitis IE was hypertension, diabetes mellitus, and renal insufficiency; and 5) The most common complication was heart failure. The antibiotics used for medical management were largely consistent with the recommendations in the American Heart Association (AHA) endocarditis treatment guidelines which recommend 6 weeks of therapy with vancomycin plus rifampin, with addition of gentamicin for the first 2 weeks for methicillin- or oxacillin-resistant CoNS involved in prosthetic valve endocarditis [1]. When complications did exist, they were devastating with shock and eventual death. Aside from characterizing cases of S. capitis IE, we looked at the epidemiology, diagnosis, and management of IE. Although, sample size was a major limitation of our study, from our knowledge we included most cases of S. capitis endocarditis reported in the literature.

Acknowledgments

None to declare.

Financial Disclosure

None to declare.

Conflict of Interest

None to declare.

Author Contributions

Dr. Thakker drafted and was the main editor of the manuscript, as well as, creation of tables. Drs. Chatila, Reynoso, and Karpathos played a key role in reviewing the quality of information, assisted in editing of the manuscript, and organization of information in the tables.

Data Availability

The authors declare that data supporting the findings of this study are available within the article.

References

1. Baddour LM, Wilson WR, Bayer AS, Fowler VG, Jr., Tleyjeh IM, Rybak MJ, Barsic B, et al. Infective endocarditis in adults: diagnosis, antimicrobial therapy, and management of complications: a scientific statement for healthcare professionals from the American Heart Association. Circulation. 2015;132(15):1435-1486.
2. Argemi X, Hansmann Y, Prola K, Prevost G. Coagulase-negative staphylococci pathogenomics. Int J Mol Sci. 2019;20(5):1215.
3. Al Hennawi HET, Mahdi EM, Memish ZA. Native valve Staphylococcus capitis endocarditis: a mini review. Infection. 2020;48(1):3-5.
4. Murdoch DR, Corey GR, Hoen B, Miro JM, Fowler VG, Jr., Bayer AS, Karchmer AW, et al. Clinical presentation, etiology, and outcome of infective endocarditis in the 21st century: the International Collaboration on Endocarditis-Prospective Cohort Study. Arch Intern Med. 2009;169(5):463-473.
5. Vincent LL, Otto CM. Infective Endocarditis: Update on Epidemiology, Outcomes, and Management. Curr Cardiof Rep. 2018;20(10):86.
6. Hill EE, Herijgers P, Claus P, Vanderschueren S, Herregods MC, Peetermans WE. Infective endocarditis: changing epidemiology and predictors of 6-month mortality: a prospective cohort study. Eur Heart J. 2007;28(2):196-203.
7. Polishchuk I, Stavi V, Awesat J, Ben Baruch Golan Y, Bartal C, Sagy I, Jotkowitz A, et al. Sex Differences in Infective Endocarditis. Am J Med Sci. 2021;361(1):83-89.
8. Jensen AD, Bundgaard H, Butt JH, Bruun NE, Voldstedlund M, Torp-Pedersen C, Gislason G, et al. Temporal changes in the incidence of infective endocarditis in Denmark 1997-2017: A nationwide study. Int J Cardiol. 2021;326:145-152.
9. Nalmas S, Bishburg E, Meuriljio J, Khooebiar S, Cohen
M. Staphylococcus capitis prosthetic valve endocarditis: report of two rare cases and review of literature. Heart Lung. 2008;37(5):380-384.
10. Takano T, Ohtsu Y, Terasaki T, Wada Y, Amano J. Prosthetic valve endocarditis caused by Staphylococcus capitis: report of 4 cases. J Cardiothorac Surg. 2011;6:131.
11. Terada Y, Mitsui T, Enomoto Y. Prosthetic valve endocarditis caused by Staphylococcus capitis. Ann Thorac Surg. 1996;62(1):324.
12. Dominguez Rodriguez A, Garcia Gonzalez MJ, Lara Padron A, Laynez Cerdena I, Barragan Acea A, Miralles Ibarra JM, Lacalzada Almeida J, et al. [Infectious endocarditis of prosthetic valves due to Staphylococcus capitis: a new case]. Rev Esp Cardiol. 1999;52(4):277-278.
13. Mihos CG, Nappi F. A narrative review of echocardiography in infective endocarditis of the right heart. Ann Transl Med. 2020;8(23):1622.
14. Bandres JC, Darouiche RO. Staphylococcus capitis endocarditis: a new cause of an old disease. Clin Infect Dis. 1992;14(1):366-367.
15. Lina B, Celard M, Vandenesch F, Ribier A, Delahaye JP, Etienne J. Infective endocarditis due to Staphylococcus capitis. Clin Infect Dis. 1992;15(1):173-174.
16. Latorre M, Rojo PM, Franco R, Cisterna R. Endocarditis due to Staphylococcus capitis subspecies ureolyticus. Clin Infect Dis. 1993;16(2):343-344.
17. Sandoe JA, Kerr KG, Reynolds GW, Jain S. Staphylococcus capitis endocarditis: two cases and review of the literature. Heart. 1999;82(3):e1.
18. Breuer GS, Yinnon AM, Halevy J. Infective endocarditis associated with upper endoscopy: case report and review. J Infect. 1998;36(3):342-344.
19. Mainardi JL, Lortholary O, Buu-Hoi A, Desplaces N, Goldstein F, Gutmann L, Acar JF. Native valve endocarditis caused by Staphylococcus capitis. Eur J Clin Microbiol Infect Dis. 1993;12(10):789-791.
20. Kamalesh M, Aslam S. Aortic valve endocarditis due to Staphylococcus capitis. Echocardiography. 2000;17(7):685-687.
21. al-Rashdan A, Bashir R, Khan FA. Staphylococcus capitis causing aortic valve endocarditis. J Heart Valve Dis. 1998;7(5):518-520.
22. Konishi T, Nishiara H, Ito T, Tanaka Y. Infective endocarditis presenting initially with ileus complicated by dehiscence of annuloplasty ring. BMC Cardiovasc Disord. 2015;15:124.
23. Tchana-Sato V, Hans G, Frippiat F, Zekhnini I, Dulgheru R, Lavigne JP, Defraigne JO. Surgical management of Staphylococcus capitis prosthetic valve infective endocarditis: Retrospective review of a 10-year single center experience and review of the literature. J Infect Public Health. 2020;13(11):1705-1709.
24. Rogers KL, Fey PD, Rupp ME. Coagulase-negative staphylococcal infections. Infect Dis Clin North Am. 2009;23(1):73-98.
25. Nappi F, Spadaccio C, Moon MR. A management framework for left sided endocarditis: a narrative review. Ann Transl Med. 2020;8(23):1627.
26. Alkhouli M, Alqahtani F, Alhajji M, Berzings CO, Sohail MR. Clinical and economic burden of hospitalizations for infective endocarditis in the United States. Mayo Clin Proc. 2020;95(5):858-866.