Perioperative Oral Management Prevents Complications of Heart Valve Surgery

Toshihiro Motoi, Kazuhisa Matsumoto, Yutaka Imoto, Takahiko Oho

Department of Preventive Dentistry, Kagoshima University Graduate School of Medical and Dental Sciences, Kagoshima, Japan
Department of Cardiovascular and Gastroenterological Surgery, Kagoshima University Graduate School of Medical and Dental Sciences, Kagoshima, Japan

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ABSTRACT

Objectives: The effect of perioperative oral management on the prevention of postoperative complications remains unclear in cardiac surgery. Exploratory factor analysis was performed to examine whether a lack of perioperative oral management was associated with postoperative complications of heart valve surgery.

Materials and methods: We retrospectively enrolled 365 patients who underwent heart valve surgery between April 2010 and March 2019. We extracted data on patient characteristics and set postoperative pneumonia and postoperative bloodstream infection as outcomes. A logistic regression analyses were performed to examine the effect of factors on the incidence of postoperative complications.

Results: Significant risk factors for postoperative pneumonia included dialysis, long operative time, and long-term intubation. Similarly, risk factors for postoperative bloodstream infection were long-term intubation and lack of perioperative oral management. Subsequently, we identified the risk factors for long-term intubation, which were common to both complications, and found they were emergency status, combined valvular disease, long operative time, and lack of perioperative oral management.

Conclusions: We demonstrated that a lack of perioperative oral management could be a risk factor for postoperative bloodstream infection and long-term intubation in heart valve surgery. The results suggest that perioperative oral management is effective in preventing postoperative complications of heart valve surgery.

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Introduction

Perioperative oral management (POM) has recently received much attention, because it can prevent and reduce complications during medical treatment and improve the quality of life of patients. This approach involves the education and practice of proper oral management by dental professionals before and after medical treatment. Epidemiologic evidence of POM for cancer surgeries has been accumulating. Previous studies have demonstrated that POM for cancer surgery significantly reduces postoperative pneumonia (PP), mortality, length of hospital stay, surgical site infection, and medical costs. On the other hand, the effect of POM in cardiovascular surgery has not been fully examined. A single-arm prospective study reported a significant reduction in PP when POM was introduced. Another single-arm retrospective and observational study demonstrated that POM was associated with reduced postoperative inflammatory marker levels following heart valve surgery.

In cardiac surgery, risk models have been developed. Preoperative evaluation and treatment are necessary to quantitatively analyse and reduce the risk of complications during and after cardiac surgery. Many studies have investigated the clinical factors affecting mortality and complications after cardiac surgery. However, POM was not included as a clinical factor for analysis in these reports.

In the present study, we extracted clinical risk factors and performed exploratory factor analysis to examine whether a lack of POM is associated with postoperative complications of...
heart valve surgery. We demonstrate that a lack of POM could be a risk factor for postoperative bloodstream infection (PBSI) and long-term intubation.

Materials and methods

Participants

The present study was a single-centre, retrospective, and observational study. The medical records of 365 adult patients who underwent heart valve surgery at Kagoshima University Hospital between April 1, 2010, and March 31, 2019, were enrolled in this study. Inclusion criteria are adults 20 years of age or older and undergoing open heart surgery for valvular heart disease. No exclusion criteria were set. The study protocol was approved by the ethics committee of the Kagoshima University Graduate School of Medical and Dental Sciences (number: 190057).

Perioperative oral management

Of the 365 patients, POM was performed in 180 patients who agreed to receive it. Antibiotic prophylaxis with 2-g amoxicillin capsules was administered to the patients 1 hour prior to the dental appointment for the prevention of bacteremia caused by dental treatment (eg, tooth extraction, caries treatment, infected root canal treatment, dental scaling). Before surgery, dentists performed periodontal and x-ray examinations to examine the patients’ oral condition. The dentists evaluated the severity of dental caries from the x-ray examination. If necessary, the dentist extracted teeth suspected to be a source of infection (eg, chronic apical periodontitis, fractured teeth, residual teeth roots, highly mobile teeth) and fixed mobile teeth to prevent them from falling out during intubation. The dental hygienists gave oral hygiene instructions, including smoking cessation guidance, to the patients; removed dental plaque using a toothbrush and adjunctive aids, including interdental brush and uni-tuft brush; and eliminated dental calculus using an ultrasonic scaler. After the surgery, an oral examination and oral care were performed to maintain oral hygiene in the intensive care unit. Dental professionals removed dental plaque and oral secretions using a tooth brush and adjunctive aids. During these procedures, they used a suction to avoid aspiration. Thus, they improved the oral hygiene in the group of patients who agreed to receive POM. In contrast, the remaining 185 patients who did not agree to receive POM received no dental examination, treatment, or oral hygiene prophylaxis by dental professionals. All patients received routine oral care by nurses. The nurses suctioned the oral secretions and wiped the oral cavity with gauze or a sponge brush. After discharge from the hospital, oral health care was continued in our department or the patient’s family dental clinic (Figure).

Outcomes

Outcomes were set for incidence of PP and PBSI. PP was diagnosed according to the following standard criteria: fever (body temperature of ≥37.5 °C), high C-reactive protein levels, and an infiltration shadow on chest computed tomography. PBSI is infectious disease defined by the presence of viable bacterial or fungal microorganisms in the bloodstream that elicit or have elicited an inflammatory response characterised by the alteration of clinical, laboratory, and hemodynamic parameters. When PBSI was suspected, arterial and venous blood samples were collected from patients and examined to identify microbial species using a culture method followed by matrix-assisted laser desorption/ionisation-time of flight mass spectrometry. In this study, PBSI was defined as positivity of 1 or more blood cultures.

Variables

Clinical risk factors were extracted from medical records according to previous studies. All continuous variables were replaced with binary categorical variables, which made all the variables categorical. Age (>65 years), sex, body surface area (>1.8 m²), New York Heart Association functional classification (NYHA) class IV, reduced left ventricular ejection fraction (LVEF; <50%), emergency status, combined valve disease, concomitant coronary artery bypass grafting, past cardiac surgery experience, infective endocarditis, hypertension, diabetes, dialysis, long operative time (>5 hours), long-term intubation (>48 hours), and lack of POM were extracted.
Emergency status indicated that emergency surgery was performed. Hypertension was defined as use of antihypertensive medication before admission or confirmed blood pressure ≥140/90 mm Hg. Diabetes mellitus was defined as a hemoglobin A1c level ≥6.5%, fasting blood glucose level ≥126 mg/dL, or use of antidiabetes medication. There was no data loss for any of these factors.

Data analysis

The statistical method was a multivariate analysis model. First, we performed a univariate analysis with the $\chi^2$ test or Fisher's exact test. Factors with a statistical significance level of 5% or less were extracted, and stepwise multivariate logistic regression analysis was performed. Finally, receiver operating characteristic (ROC) analysis was performed to evaluate the model. We used EZR (Saitama Medical Center, Jichi Medical University, Saitama, Japan) for statistical analysis, which is a graphical user interface for R (The R Foundation for Statistical Computing). The statistical significance level was set at 5%.

Results

Patient demographics and clinical characteristics

Table 1 shows patient demographics and clinical characteristics between the group who agreed to receive POM and the group who refused. After a univariate analysis with the $\chi^2$ test or Fisher’s exact test, significant differences were observed in emergency status and hypertension between the 2 groups.

Factors associated with complications

The results of univariate analysis to identify the associated factors with PP and PBSI incidence are shown in Table 2. Overall, 40 patients (11.0%) had PP and 25 patients (6.8%) had PBSI. Factors associated with PP incidence were reduced LVEF, emergency status, concomitant coronary artery bypass grafting, dialysis, long operative time, long-term intubation, and lack of POM. For PBSI incidence, the associated factors were emergency status, long operative time, long-term intubation, and lack of POM. The results of logistic regression analysis using these factors are shown in Table 3. Factors including dialysis, long operative time, and long-term intubation were significantly associated with PP incidence. Furthermore, factors including long-term intubation and lack of POM

Table 1 – Patient demographics and clinical characteristics.

| Factors                        | POM (+) group | POM (−) group | P value |
|--------------------------------|---------------|---------------|---------|
| Age, y (>65)                   | 113 (62.8)    | 125 (67.6)    | .380    |
| Sex (male)                     | 92 (51.1)     | 98 (53.0)     | .754    |
| Body surface area (>1.8 m²)    | 30 (16.7)     | 20 (10.8)     | .128    |
| NYHA class IV                  | 28 (15.6)     | 37 (20.0)     | .277    |
| Reduced LVEF (<50%)            | 36 (20.0)     | 52 (28.1)     | .086    |
| Emergency status               | 23 (12.8)     | 41 (22.2)     | .020    |
| Combined valvular disease      | 66 (36.7)     | 57 (30.8)     | .268    |
| Concomitant coronary artery bypass grafting | 37 (20.6) | 43 (23.2)     | .613    |
| Past cardiac surgery experience| 30 (16.7)     | 28 (15.1)     | .775    |
| Infective endocarditis         | 23 (12.8)     | 19 (10.3)     | .513    |
| Hypertension                   | 130 (72.2)    | 105 (56.8)    | .002    |
| Diabetes                       | 15 (8.3)      | 25 (13.5)     | .132    |
| Dialysis                       | 21 (11.7)     | 32 (17.3)     | .139    |
| Long operative time (>5 hours) | 93 (51.7)     | 100 (54.1)    | .676    |

Values are mean n (%).

LVEF, left ventricular ejection fraction; NYHA, New York Heart Association functional classification; POM, perioperative oral management.

Table 2 – Univariate analysis of factors associated with PP and PBSI.

| Factors                              | Number (%) | P value | Number (%) | P value |
|--------------------------------------|------------|---------|------------|---------|
| PP (−)                               | PP (+)     |         | PBSI (−)   | PBSI (+) |
| Age, y (>65)                         | 210 (64.6) | .599    | 219 (64.4) | .283    |
| Sex (male)                           | 169 (52.0) | 1.000   | 180 (52.9) | .222    |
| Body surface area (>1.8 m²)          | 45 (13.8)  | .122    | 48 (14.1)  | .552    |
| NYHA class IV                        | 54 (16.6)  | .006    | 59 (17.4)  | .417    |
| Reduced LVEF (<50%)                  | 71 (21.8)  | .014    | 53 (15.6)  | .001    |
| Emergency status                     | 51 (15.7)  | 1.000   | 114 (33.5) | .828    |
| Combined valvular disease            | 110 (33.8) | 1.000   | 9 (36.0)   | .828    |
| Concomitant coronary artery bypass grafting | 65 (20.0) | .015    | 75 (22.1)  | 1.000    |
| Past cardiac surgery experience      | 47 (17.2)  | .015    | 37 (10.9)  | .188    |
| Infective endocarditis               | 38 (11.7)  | .297    | 221 (65.0) | .391    |
| Hypertension                         | 206 (63.4) | .062    | 35 (10.3)  | .200    |
| Diabetes                             | 32 (9.8)   | <.001   | 48 (14.1)  | .385    |
| Dialysis                             | 39 (12.0)  | <.001   | 174 (51.2) | .021    |
| Long operative time (>5 hours)       | 160 (49.2) | <.001   | 45 (13.2)  | <.001   |
| Long-term intubation (>48 hours)     | 40 (12.3)  | <.001   | 19 (76.0)  | .001    |
| Lack of perioperative oral management| 158 (48.6) | .029    | 164 (48.2) | .001    |

LVEF, left ventricular ejection fraction; NYHA, New York Heart Association functional classification; PBSI, postoperative bloodstream infection; PP, postoperative pneumonia.
were significantly associated with PBSI incidence. ROC analysis indicated that the area under the curve was 0.819 (95% confidence interval [CI], 0.744-0.894) for PP incidence and 0.887 (95% CI, 0.822-0.951) for PBSI incidence.

**Factors associated with long-term intubation**

Since long-term intubation was associated with PP and PBSI, we further analysed the risk factors related to long-term intubation. Sixty-four patients (17.5%) had long-term intubation. According to univariate analysis, the factors associated with long-term intubation were age, NYHA class IV, reduced LVEF, emergency status, combined valvular disease, dialysis, long operative time, and lack of POM (Table 4). Logistic regression analysis identified 4 risk factors for long-term intubation: emergency status (odds ratio [OR], 4.65; 95% CI, 2.39-9.05; P < .001), combined valvular disease (OR, 2.24; 95% CI, 1.18-4.04; P = .015), long operative time (OR, 3.63; 95% CI, 1.86-7.06; P < .001), and lack of POM (OR, 2.18; 95% CI, 1.21-4.16; P = .013). ROC analysis showed that area under the curve was 0.788 (95% CI, 0.724-0.852).

**Discussion**

In the present study, we conducted an exploratory factor analysis using multivariate analysis. The significant finding of this study is that lack of POM could be a risk factor for PBSI following heart valve surgery. Bloodstream infection is a common complication after cardiac surgery. A previous study reported a shorter duration of high fever in patients undergoing heart valve replacement who received preoperative periodontal treatment. Bacteremia can be induced following gingival bleeding during toothbrushing and chewing in daily life. Therefore, preoperative dental checkups are recommended for patients undergoing cardiac surgery. Our results indicate that improving oral health before heart valve surgery is important to prevent PBSI. In addition to a lack of POM, long-term intubation was also shown to be a risk factor for PBSI. In a previous prospective study of 5158 patients, ventilation exceeding 48 hours was associated with an increased risk of postoperative infection including bloodstream infection and endocarditis. Our results coincide with this finding. Long-term intubation induces decrease in stimulated salivary flow, which may contribute to the development of mucositis. Once bleeding occurs from inflamed mucous membranes, oral microorganisms can easily enter the bloodstream. In addition, long-term intubation causes traumatic ulcers, the surface of which could be an entrance for oral microorganisms into the bloodstream.

Regarding the incidence of long-term intubation, lack of POM, emergency status, and combined valvular disease were identified to be risk factors. Long-term intubation has been shown to be significantly associated with mortality and complications after cardiac surgery. Regarding oral condition, Băgyi et al. reported that untreated teeth and periodontal disease are risk factors for postoperative respiratory infections, which may cause long-term intubation. In addition, the longer the intubation period lasts, the greater the risk of dysphagia after endotracheal tube removal. To improve these high-risk conditions, POM is necessary to prevent long-term intubation. In addition to a lack of POM, emergency status, combined valvular disease, and long operative time were also shown to be risk factors for long-term intubation. Patients in an emergency state are in a poor general condition, and combined heart valve surgery is more invasive than single heart valve surgery; these types of patients may have increased

### Table 3 – Logistic regression analysis of factors associated with PP and PBSI.

| Factors                                     | PP                        | PBSI                      |
|---------------------------------------------|---------------------------|---------------------------|
| Odds ratio                                  | 95% confidence interval   | Odds ratio                |
|                                             | P value                   | 95% confidence interval   | P value          |
| Dialysis                                    | 3.74                      | 1.62-8.65                 | 17.8             |
| Long operative time (>5 hours)              | 3.44                      | 1.38-8.56                 | 6.67-47.70       |
| Long-term intubation (>48 hours)            | 7.83                      | 3.70-16.60                | <.001            |
| Lack of perioperative oral management       | 4.14                      | 1.31-13.10                | <.001            |

PBSI, postoperative bloodstream infection; PP, postoperative pneumonia.

### Table 4 – Univariate analysis of factors associated with long-term intubation.

| Factors                                      | Number (%)     | P value          |
|----------------------------------------------|----------------|-----------------|
| Age, y (> 65)                                |                | .043            |
| Sex (male)                                   | 159 (52.8)     | .582            |
| Body surface area (>1.8 m²)                  | 41 (13.6)      | 1.000           |
| NYHA class IV                                |                | .004            |
| Reduced LVEF (>50%)                          | 63 (20.9)      | .003            |
| Emergency status                             | 39 (13.0)      | <.001           |
| Combined valvular disease                    | 93 (30.9)      | .019            |
| Concomitant coronary artery bypass grafting  | 61 (20.3)      | .133            |
| Past cardiac surgery experience              | 40 (15.7)      | .123            |
| Infective endocarditis                       | 33 (11.0)      | .517            |
| Hypertension                                 | 199 (66.1)     | .151            |
| Diabetes                                     | 32 (10.6)      | .661            |
| Dialysis                                     | 38 (12.6)      | .032            |
| Long operative time (>5 hours)               | 143 (47.5)     | <.001           |
| Lack of perioperative oral management        | 142 (47.2)     | .004            |

LVEF, left ventricular ejection fraction; NYHA, New York Heart Association functional classification.
risk of long-term intubation. Longer surgery has been demonstrated to be a risk factor for postoperative infection in cardiac surgery.\textsuperscript{15} Considering that postoperative infection is associated with prolonged mechanical ventilation after surgery,\textsuperscript{24} long operative time may also be a risk factor for long-term intubation.

Regarding the incidence of PP, univariate analysis showed that lack of POM was associated with it, but multivariate analysis did not identify the lack of POM as a risk factor. Inhibitory effects of POM on the incidence of PP have been demonstrated in cancer surgery\textsuperscript{7,12} and cardiac surgery.\textsuperscript{5} In these reports, long-term intubation was not included as a factor to be analysed. The difference in the effect of POM on PP incidence seen in these and our studies seems to be caused by the difference in clinical factors analysed.

Our study has several limitations. First, the study design was a single-centre, retrospective observational study, which may limit the generalisability of the findings. Large-scale research by multiple centres will be required in the future. Second, factors regarding oral conditions including the number of teeth and oral hygiene status were not included. This is because no oral information was available for patients who did not receive POM. In the future, we plan to survey oral conditions in detail. Third, there were significant differences in 2 parameters of emergency status and hypertension between 2 groups in patient demographics and clinical characteristics, which may be possible confounding factors. In addition, data on socioeconomic status were not available from medical records. In the future, we need to collect these data and adjust all background covariates to improve the results. In conclusion, we have demonstrated that a lack of POM could be a risk factor for PBSI and long-term intubation in heart valve surgery. Therefore, it is recommended that patients undergoing heart valve surgery should receive POM to prevent postoperative complications.

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**Conflict of interest**

None disclosed.

**References**

1. Ishimaru M, Matsu H, Ono S, et al. Preoperative oral care and effect on postoperative complications after major cancer surgery. Br J Surg 2018;105:1688–96.
2. Shin J, Kunisawa S, Fushimi K, et al. Effects of preoperative oral management by dentists on postoperative outcomes following esophagectomy: multilevel propensity score matching and weighting analyses using the Japanese inpatient database. Medicine (Baltimore) 2019;98:e15376.
3. Akutsu Y, Matsubara H, Shuto K, et al. Pre-operative dental brushing can reduce the risk of postoperative pneumonia in esophageal cancer patients. Surgery 2010;147:497–502.
4. Shigeishi H, Ohta K, Fujimoto S, et al. Preoperative oral health care reduces postoperative inflammation and complications in oral cancer patients. Exp Ther Med 2016;12:1922–8.
5. Nobuhara H, Yanamoto S, Funahara M, et al. Effect of perioperative oral management on the prevention of surgical site infection after colorectal cancer surgery: a multicenter retrospective analysis of 698 patients via analysis of covariance using propensity score. Medicine (Baltimore) 2018;97:e12545.
6. Bergan EH, Tura BR, Lamas CC. Impact of improvements in preoperative oral health on nosocomial pneumonia in a group of cardiac surgery patients: a single arm prospective intervention study. Intensive Care Med 2014;40:23–31.
7. Nishi H, Takahashi S, Ohta K, et al. Effects of perioperative oral care on postoperative inflammation following heart valve surgery. Oral Dis 2021;27:1542–50.
8. Paiment B, Pelletier C, Dydra I, et al. A simple classification of the risk in cardiac surgery. Can Anaesth Soc J 1983;30:61–8.
9. Nashef SA, Roques F, Michel P, et al. European system for cardiac operative risk evaluation (EuroSCORE). Eur J Cardiothorac Surg 1999;16:9–13.
10. Rankin JS, He X, O’Brien SM, et al. The Society of Thoracic Surgeons risk model for operative mortality after multiple valve surgery. Ann Thorac Surg 2013;95:1484–90.
11. Shahian DM, O’Brien SM, Filardo G, et al. The Society of Thoracic Surgeons 2008 cardiac surgery risk models: part 3—valve plus coronary artery bypass grafting surgery. Ann Thorac Surg 2009;88:543–62.
12. O’Brien SM, Shahian DM, Filardo G, et al. The Society of Thoracic Surgeons 2008 cardiac surgery risk models: part 2—isolated valve surgery. Ann Thorac Surg 2009;88:S23–42.
13. Wilson W, Taubert KA, Gewitz M, et al. Prevention of infective endocarditis: guidelines from the American Heart Association: a guideline from the American Heart Association Rheumatic Fever, Endocarditis, and Kawasaki Disease Committee, Council on Cardiovascular Disease in the Young, and the Council on Clinical Cardiology, Council on Cardiovascular Surgery and Anesthesia, and the Quality of Care and Outcomes Research Interdisciplinary Working Group. Circulation 2007;116:1736–54.
14. The Committee for The Japanese Respiratory Society guidelines in management of respiratory infections. Severity rating of hospital-acquired pneumonia and classification. Respirology 2004;9(Suppl 1):S13–5.
15. Gelijns AC, Moskowitz AJ, Acker MA, et al. Management practices and major infections after cardiac surgery. J Am Coll Cardiol 2014;64:372–81.
16. Kanda Y. Investigation of the freely available easy-to-use software ‘EZR’ for medical statistics. Bone Marrow Transplant 2013;48:452–8.
17. Suzuki H, Matsuo K, Okamoto M, et al. Preoperative periodontal treatment and its effects on postoperative infection in cardiac valve surgery. Clin Exp Dent Res 2019;5:485–90.
18. Lockhart PB, Brennan MT, Cook WH, et al. Concomitant surgical treatment of dental and valvular heart diseases. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2009;107:71–6.
19. Lockhart PB, Brennan MT, Sasser HC, et al. Bacteremia associated with toothbrushing and dental extraction. Circulation 2008;117:3118–25.
20. Roberts GJ, Gardner P, Simmons NA. Optimum sampling time for detection of dental bacteraemia in children. Int J Cardiol 1992;35:311–5.
21. Yasny J. The importance of oral health for cardiothoracic and vascular patients. Semin Cardiothorac Vasc Anesth 2010;14:38–40.
22. Dennesen P, van der Ven A, Vlasveld M, et al. Inadequate salivary flow and poor oral mucosal status in intubated intensive care unit patients. Crit Care Med 2003;31:781–6.
23. Silva AP, Caruso P, Jaguar GC, et al. Oral evaluation and procedures performed by dentists in patients admitted to the intensive care unit of a cancer center. Support Care Cancer 2014;22:2645–50.
24. Fernandez-Zamora MD, Gordillo-Brenes A, Banderas-Bravo E, et al. Prolonged mechanical ventilation as a predictor of mortality after cardiac surgery. Respir Care 2018;63:550–7.
25. Bágyi K, Haczku A, Márton I, et al. Role of pathogenic oral flora in postoperative pneumonia following brain surgery. BMC Infect Dis 2009;9:104.
26. Brodsky MB, Gellar JE, Dinglas VD, et al. Duration of oral endotracheal intubation is associated with dysphagia symptoms in acute lung injury patients. J Crit Care 2014;29:574–9.