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Emergency management protocols for major complications after oral and maxillofacial surgery: emphasis on airway and bleeding control

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Abstract (J Korean Assoc Oral Maxillofac Surg 2026;52:187-195)

Objectives: Postoperative hemorrhage and airway obstruction remain major life-threatening complications following oral and maxillofacial surgery despite advances in surgical techniques and perioperative care. This study aimed to retrospectively characterize the clinical patterns, timing, and management of postoperative hemorrhagic and airway emergencies over a 15-year period and, based on these institutional data and a review of the literature, to propose a practical integrated framework for postoperative emergency management.

Materials and Methods: A retrospective review was conducted of patients who underwent major oral and maxillofacial surgery at a university dental hospital between 2010 and 2025. Major bleeding events were defined as postoperative hemorrhage requiring reoperation or embolization, while major airway events included unplanned airway intervention or emergency tracheostomy. For airway analysis, patients undergoing malignant tumor resection were divided into an emergency tracheostomy group and an elective tracheostomy group. The Cameron scoring system was retrospectively applied.

Results: Twenty patients required intervention for postoperative bleeding, with 70% of events occurring after major surgery. Five of eight orthognathic surgery patients developed hemorrhage within 72 hours postoperatively and required surgical hemostasis. Most bleeding events occurred independently of coagulation disorders. Transarterial embolization was performed in 13 patients, although only one case was directly related to emergency postoperative hemorrhage. Tracheostomy was performed in 24 patients, including 13 following oral cancer surgery. Emergency tracheostomy was most frequently required in patients with malignant tumors or severe infections. Mean Cameron scores were comparable between the emergency and elective tracheostomy groups (6.00 and 6.17, respectively).

Conclusion: Postoperative hemorrhage and airway compromise remain significant complications in oral and maxillofacial surgery. Bleeding events were more closely associated with surgical extent than patient-related comorbidities. While the Cameron score may assist preoperative airway planning, postoperative clinical assessment remains essential. A structured approach incorporating bleeding control, airway protection, and selective use of embolization may improve patient safety and postoperative outcomes.

Key words: Hemorrhage, Airway obstruction, Tracheostomy

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I. Introduction

Surgical management in the field of oral and maxillofacial surgery, including orthognathic surgery, oral cancer resection and reconstruction, trauma surgery, and treatment of severe infections, is anatomically closely associated with the airway and major vascular structures. Consequently, these procedures carry a relatively high risk of acute postoperative complications. In particular, acute airway obstruction and massive hemorrhage may occur immediately after surgery or during the postoperative inpatient period. Without prompt recognition and immediate intervention, these complications can result in catastrophic outcomes, including hypoxic brain injury and death[1-4].

Massive hemorrhage following oral and maxillofacial surgery is often unpredictable due to extensive surgical dissection, the rich vascular supply of the maxillofacial region, and osteotomy sites associated with tumor resection or orthognathic surgery. In addition, postoperative airway obstruction may arise from hematoma formation, edema, active bleeding,

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retention of secretions, or exacerbation of underlying respiratory diseases. Although it may initially present as relatively mild respiratory discomfort, it can rapidly progress to severe respiratory failure within a short period[5]. In such situations, complex clinical decision-making is required, extending beyond simple local hemostasis to include airway securing, blood transfusion, imaging-based vascular evaluation, and, when necessary, transarterial embolization[6,7].

Despite these risks, comprehensive management guidelines or standardized response protocols for postoperative airway obstruction and hemorrhagic emergencies in oral and maxillofacial surgery have not yet been adequately established. Existing reports are largely limited to individual case reports or analyses of specific surgical populations, and studies proposing comprehensive, stepwise emergency response algorithms applicable to real-world clinical practice remain scarce. In particular, long-term data analyzing criteria for determining the timing of tracheostomy, indications distinguishing emergency vs. elective tracheostomy, and the actual clinical application of interventions such as transarterial embolization are lacking.

Given the nature of postoperative emergencies in oral and maxillofacial surgery, close multidisciplinary collaboration among surgeons, anesthesiologists, and nursing staff is essential, and pre-shared risk assessments and response strategies have a critical impact on patient outcomes. Therefore, an analysis of emergency occurrence patterns based on real-world clinical data, together with the establishment of management guidelines derived from these findings, may contribute to enhanced patient safety and reduced delays in emergency care.

This study retrospectively analyzed cases requiring airway management and/or bleeding control during or after oral and maxillofacial surgery at a single university dental hospital between 2010 and 2025. The primary objective was to characterize the clinical patterns, timing, and management of postoperative hemorrhagic and airway emergencies. In addition, patients requiring emergency airway intervention were compared with those undergoing planned airway management to evaluate factors associated with postoperative airway compromise. Based on these institutional findings and a review of the existing literature, we further sought to propose a practical integrated framework for postoperative emergency management in oral and maxillofacial surgery.

II. Materials and Methods

1. Study population and study period

This retrospective study analyzed the medical records of patients who underwent elective surgery, emergency admission, or intensive care unit management in the Department of Oral and Maxillofacial Surgery at Pusan National University Dental Hospital, Yangsan, over a 15-year period from August 2010 to July 2025. Among these patients, cases in which emergency interventions were required due to acute airway compromise or massive hemorrhage during or after surgery were included. A total of 57 cases were identified, consisting of 20 cases requiring bleeding control, 24 cases requiring tracheostomy, and 13 cases managed with transarterial embolization.

2. Classification of case and control groups

To minimize confounding by infectious etiologies, age and airway risk analyses were restricted to patients who underwent tracheostomy following malignant tumor resection. For the development of airway management guidelines, patients who underwent tracheostomy following oral cancer surgery were classified into the following groups and comparatively analyzed:

Case group: Patients who underwent emergency tracheostomy due to unexpected acute respiratory distress occurring after malignant tumor resection surgery (n=6).

Control group: Patients who underwent planned elective tracheostomy before the completion of malignant tumor resection surgery based on preoperative or intraoperative risk assessment (n=7).

3. Variables and outcome measures

1) Postoperative bleeding cases

For cases involving postoperative hemorrhage, the following variables were investigated: type of surgery (malignant tumor resection, orthognathic surgery, or minor surgery), timing of hemorrhage occurrence expressed as postoperative day (POD), involved bleeding vessels, and the presence of underlying comorbidities such as coagulation disorders. In cases managed with transarterial embolization, the indication for embolization (vascular malformation, trauma, or postoperative bleeding) and the timing of the procedure were analyzed.

2) Airway management indicators

To assess the risk of postoperative upper airway obstruction in patients undergoing oral cancer surgery, the Cameron scoring system was retrospectively applied[3]. A total Cameron score of 5 points or higher indicates a high risk of postoperative airway obstruction and suggests the need for elective tracheostomy prior to surgery.(Table 1)

3) Other complications and outcomes

Patient demographic characteristics, clinical circumstances at the time of emergency intervention, and post-intervention outcomes were comprehensively analyzed.

4) Statistical analysis

Differences in age and Cameron scores between the experimental and control groups were evaluated using an independent samples *t*-test. Statistical significance was set at $P<0.05$ for all analyses.

Table 1. Cameron scoring system

Cameron et al.[3] (2009)	
Variable	Score
1) Tumor site	
Cutaneous	0
Buccal mucosa	0
Maxilla	0
Mandibular alveolus	1
Anterior tongue	1
Floor of mouth	2
Soft palate	3
Anterior pillar	3
Tonsillar pililar	4
Posterior tongue	4
Hypopharynx	4
2) Mandibulectomy	
No	0
Yes	1
3) Bilateral neck dissection	
No	0
Yes	3
4) Reconstruction	
None	0
Radial forearm free flap	2
Other	3
Tracheostomy recommended score	≥5

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III. Results

1. Postoperative bleeding control

During the study period, a total of 20 cases required bleeding control due to postoperative hemorrhage. Among these, 6 cases were associated with oral cancer resection and reconstruction, and 8 cases were related to orthognathic surgery. Bleeding following major surgery accounted for 70% of all postoperative hemorrhagic events.

In patients who underwent oral cancer surgery, bleeding control was performed at a mean of 5.67 POD, whereas in patients who underwent orthognathic surgery, intervention was performed at a mean of 5.25 POD. Notably, 5 of the 8 orthognathic surgery patients experienced bleeding within 72 hours after surgery, requiring surgical re-exploration and direct hemostasis of the bleeding site.

In the oral cancer surgery group, rupture of the external jugular vein, superior thyroid artery, and lingual artery was identified in one case each. In addition, two patients developed postoperative disseminated intravascular coagulation (DIC), which manifested as diffuse, uncontrolled surgical-site bleeding requiring emergency hemostatic intervention despite the absence of a discrete bleeding vessel. One patient also experienced arterial bleeding from the fibula flap donor site. Most patients were managed with direct surgical hemostasis; however, one patient with DIC unfortunately died despite aggressive treatment.

Among the 14 patients who experienced postoperative bleeding following major surgery, two patients had underlying hypertension. Apart from these cases, no individual bleeding predispositions, such as anticoagulant use or coagulation factor abnormalities, were identified.

Six patients required emergency reoperation for postoperative bleeding related to minor outpatient procedures, and among these, two patients were receiving anticoagulant therapy due to underlying cardiac disease.(Table 2)

Table 2. Classification of patients requiring postoperative bleeding control

Category	Number	Postoperative day (mean±standard deviation)	Note
Cancer op.	6	5.67±6.86	-
Jaw op.	8	5.25±5.23	-
Minor op.	6	-	Two patients were taking anticoagulant for heart disease

(op.: operation, -: not available)

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Table 3. Classification of patients undergoing postoperative tracheostomy

Category	Indication	Number	Age, yr
Emergency tracheostomy	Abscess (Ludwig angina, parapharyngeal space abscess etc.)	9	-
	Fracture	1	-
	Cancer (case group)	6	70.67±5.05
Elective tracheostomy	Maxillary medication-related osteonecrosis of the jaw	1	-
	Cancer (control group)	7	57.57±11.16

Values are presented as number only or mean±standard deviation.
(-: not available)
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Table 4. Comparison of Cameron scores in patients undergoing tracheostomy after malignant tumor resection

Category	Number	Cameron score (mean±standard deviation)	Note
Case group (emergency)	5	6.00±1.58	4 of 5 scored ≥5 Excluding 1 unsuitable case
Control group (elective)	6	6.17±1.94	5 of 6 scored ≥5 Excluding 1 unsuitable case

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2. Airway management and tracheostomy

Tracheostomy was performed in a total of 24 cases, of which 13 were associated with oral cancer surgery.

Among the 16 cases requiring emergency tracheostomy, 9 were performed in patients with infectious conditions, including Ludwig's angina and parapharyngeal space abscess. Six cases were associated with malignant tumor resection, and one case was related to maxillofacial fracture.

Of the 8 cases in which elective tracheostomy was performed, 7 were associated with malignant tumor resection, and one case was performed in a patient with medication-related osteonecrosis of the jaw involving the maxillary sinus. (Table 3)

Patients in the case group (both diagnosed with squamous cell carcinoma) who underwent emergency tracheostomy due to postoperative acute airway compromise (n=6) were, on average, 13.10 years older than those in the control group who underwent planned elective tracheostomy (n=7). Although statistical power was limited due to the small sample size, it suggested a tendency toward older age in the emergency tracheostomy group. Except for one patient who was readmitted due to pneumonia after discharge, emergency tracheostomy in the case group was performed at a mean of 10.6 POD.

When the Cameron scoring system was retrospectively applied, the control group had a mean score of 6.17, with 5 of 6 patients meeting or exceeding the recommended threshold of 5 points. The case group had a mean score of 6.00, and 4 of 5 patients scored more than 5 points. Among emergency tracheostomy cases associated with major surgery, 2 cases required simultaneous bleeding control for massive hemorrhage. No significant correlation was observed between preoperative airway assessment parameters, such as the Mallampati grade, and the occurrence of postoperative airway emergencies. (Table 4)

Table 5. Classification of patients undergoing prophylactic transarterial embolization

Category	Number
Hemangioma	6
Venous malformation	6
Fracture (motorcycle traffic accident)	1

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3. Transarterial embolization

A total of 13 cases underwent transarterial embolization. However, emergency embolization performed for the management of postoperative complications was limited to a single case involving emergency hemostasis in a patient with facial bone fracture, which was performed on the day of admission. The remaining 12 cases were performed for the treatment of hemangiomas or venous malformations and were unrelated to emergency management.(Table 5)

IV. Discussion

This study aimed to characterize the clinical patterns, timing, and management of postoperative hemorrhagic and airway emergencies following oral and maxillofacial surgery using 15 years of accumulated clinical data from a single university dental hospital. Based on these findings and a review of the literature, we sought to propose a practical integrated framework for postoperative emergency management applicable to real-world clinical practice. By analyzing the timing of postoperative emergencies, their association with surgical procedures, and the actual clinical application of airway management and bleeding control strategies, this study was able to identify critical decision-making points in postoperative management after oral and maxillofacial surgery.

In this study, a substantial proportion of postoperative massive bleeding events occurred within 72 hours after orthognathic surgery or extensive malignant tumor resection. This finding suggests that the risk of hemorrhage is highest during the early recovery phase following major oral and maxillofacial surgery and supports the necessity for intensive monitoring during the first 72 hours. In orthognathic surgery, bleeding was presumed to originate from osteotomy sites and exposed cancellous bone, whereas in malignant tumor surgery, extensive soft tissue dissection and a higher likelihood of vascular injury may result in more abrupt clinical deterioration once bleeding occurs. In addition, bleeding tended to develop when intraoperative hypotension under general anesthesia was followed by normalization of blood pressure after surgery, highlighting the importance of meticulous intraoperative hemostatic control.

Notably, all 14 cases of postoperative bleeding following major surgery occurred independently of anticoagulation and/or antiplatelet therapies. This finding suggests that postoperative hemorrhage may be influenced more by surgical extent, technique, and anatomical characteristics than by patient-related systemic factors, emphasizing the importance of procedure-based risk assessment when establishing bleeding management strategies. Furthermore, bleeding control was required up to 5 POD on average in both cancer and orthognathic surgery patients, indicating that strict monitoring is necessary not only during the initial 72 hours.

Although only one case in this cohort required transarterial embolization for postoperative bleeding, numerous studies have demonstrated a high hemostatic success rate with protocol-based embolization approaches[8-10]. Accordingly, future management guidelines should incorporate a stepwise embolization protocol that mandates prompt angiographic evaluation and transarterial embolization when local hemostasis fails or deep vascular injury is suspected.(Fig. 1)

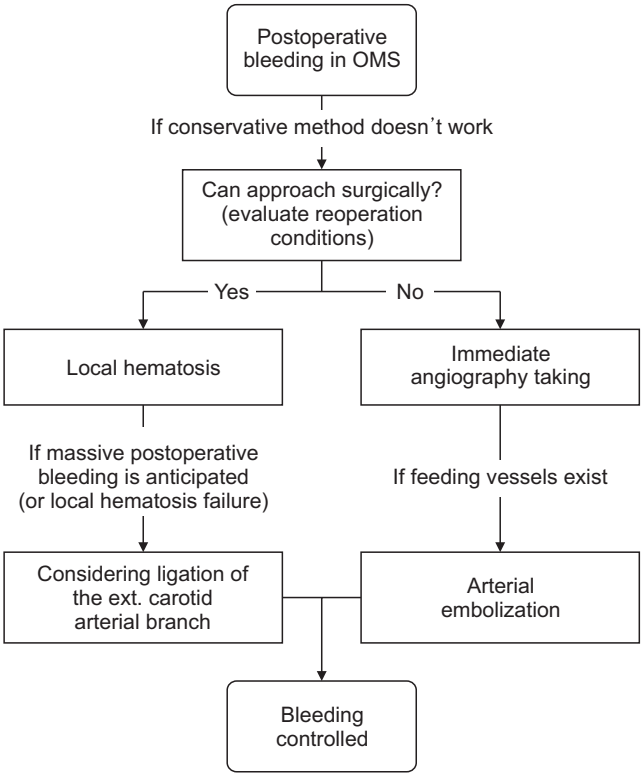


Fig. 1. Stepwise protocol for postoperative bleeding management in oral and maxillofacial surgery (OMS).
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Also, experimental hemodynamic studies have demonstrated that ligation of the external carotid artery alone can reduce arterial blood flow by approximately 73%. Furthermore, additional ligation of major external carotid branches, including the superior thyroid, lingual, and facial arteries, has been reported to further decrease hemorrhage by up to 85%, supporting the rationale for proximal arterial flow control in surgeries with a high risk of perioperative bleeding[11].

Airway protection is one of the most critical components in the management of postoperative emergencies in oral and maxillofacial surgery. In this study, tracheostomy was performed in 24 cases, and the higher mean age observed in the case group suggests that elderly patients may be particularly vulnerable to postoperative airway compromise. Age-related reductions in soft tissue elasticity, the presence of underlying respiratory diseases, and diminished compensatory capacity for edema may all contribute to an increased risk of acute airway obstruction in older patients.

When tracheostomy cases were analyzed according to

emergency vs. elective indications, emergency tracheostomy was most frequently performed in patients undergoing malignant tumor surgery or in those with severe infections. This finding indicates that, despite preoperative risk stratification, there remains a subset of patients in whom airway deterioration is difficult to predict. These results suggest that preoperative risk assessment should integrate not only the type of surgery but also tumor location, extent of infection, and the potential for postoperative soft tissue edema[12-14].

The Cameron scoring system, which was introduced to predict postoperative upper airway obstruction after oral cancer surgery, was also shown to be a meaningful indicator in this study[3]. The mean score of 6.71 in the elective tracheostomy group exceeded the recommended threshold of 5 points, consistent with the findings of Kim et al.[15].

Although alternative airway risk assessment tools such as TRACHY and clinical assessment scoring system for tracheostomy (CASST) have been proposed[16-18], Kim et al.[15] demonstrated that the Cameron scoring system most closely reflects real-world clinical decision-making. In addition, the lack of correlation between the Mallampati grade and postoperative airway emergencies observed in this study suggests that postoperative airway compromise is determined not only by anatomical airway characteristics but also by surgical invasiveness and overall patient condition.

In cases of acute postoperative upper airway obstruction, rapid airway stabilization must be prioritized. Continuous vital sign monitoring should be accompanied by immediate consideration of endotracheal intubation or emergency tracheostomy, depending on the clinical scenario. In patients with chronic upper airway obstruction, maintaining a nasotracheal tube during hospitalization and closely monitoring for pneumonia is critical.

In particular, for high-risk patients with potential airway compromise, such as those with oral cancer, many studies and clinical guidelines suggest that when the duration of endotracheal intubation is expected to approach approximately 7 to 10 days, selective tracheostomy should be considered during the preoperative evaluation to ensure airway stability rather than maintaining prolonged translaryngeal intubation[19,20].(Fig. 2)

In this study, only one case underwent transarterial embolization as a direct emergency hemostatic intervention. This reflects the institutional tendency to manage most postoperative bleeding through local hemostasis or surgical re-exploration, with embolization reserved as a final or salvage therapy.

Nevertheless, accumulating evidence indicates that when persistent hemorrhage is anticipated or injury to major vessels is suspected, early interventional management, including the combination of surgical hemostasis and transarterial embolization, may offer superior outcomes with respect to both hemostatic efficacy and patient safety. From this perspective, the relatively limited use of prophylactic or early embolization during the study period represents a potential area for improvement. Future practice at our institution aims to incorporate a more proactive approach to embolization in appropriate clinical scenarios.

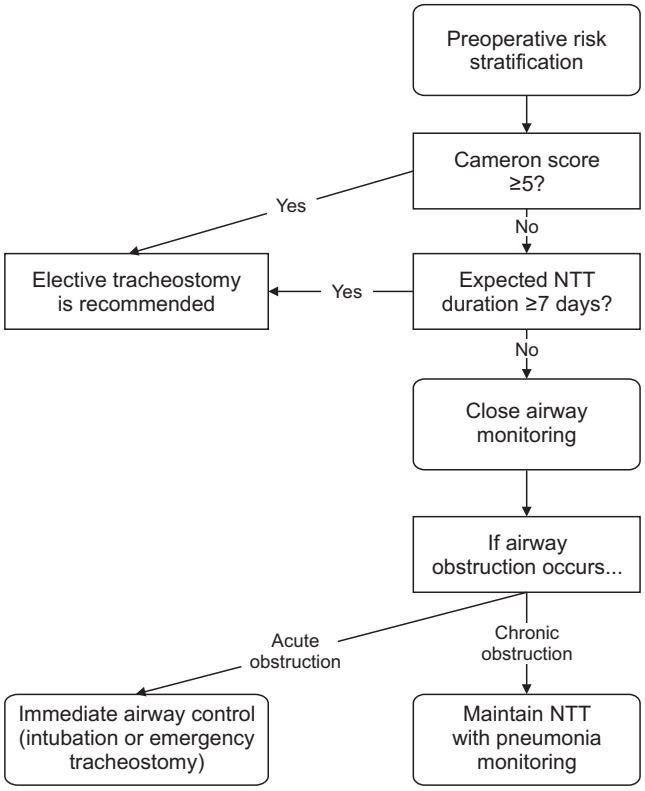


Fig. 2. Stepwise protocol for airway management in oral and maxillofacial surgery. (NTT: nasotracheal tube)
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Accordingly, future bleeding management strategies should maintain a stepwise approach while also considering earlier imaging-based evaluation and transarterial embolization in patients with anticipated repeated hemostatic failure or radiologic suspicion of vascular lesions, in parallel with surgical intervention.

The findings of this study demonstrate that postoperative emergencies in oral and maxillofacial surgery tend to cluster within specific timeframes and patient populations, supporting the need for standardized response systems. Clarifying the indications for elective tracheostomy during preoperative

risk assessment, promptly considering emergency embolization when initial hemostatic measures fail, and implementing intensive monitoring and multidisciplinary collaboration during the early postoperative period for high-risk patients may substantially reduce progression to life-threatening emergencies.

This study has inherent limitations as a retrospective analysis conducted at a single institution, and some variables may have been constrained by the nature of medical record-based data. In addition, the relatively low incidence of emergency events limits the statistical power of certain analyses. Future multicenter studies and prospective data collection are warranted to develop more refined risk prediction models and detailed emergency response algorithms.

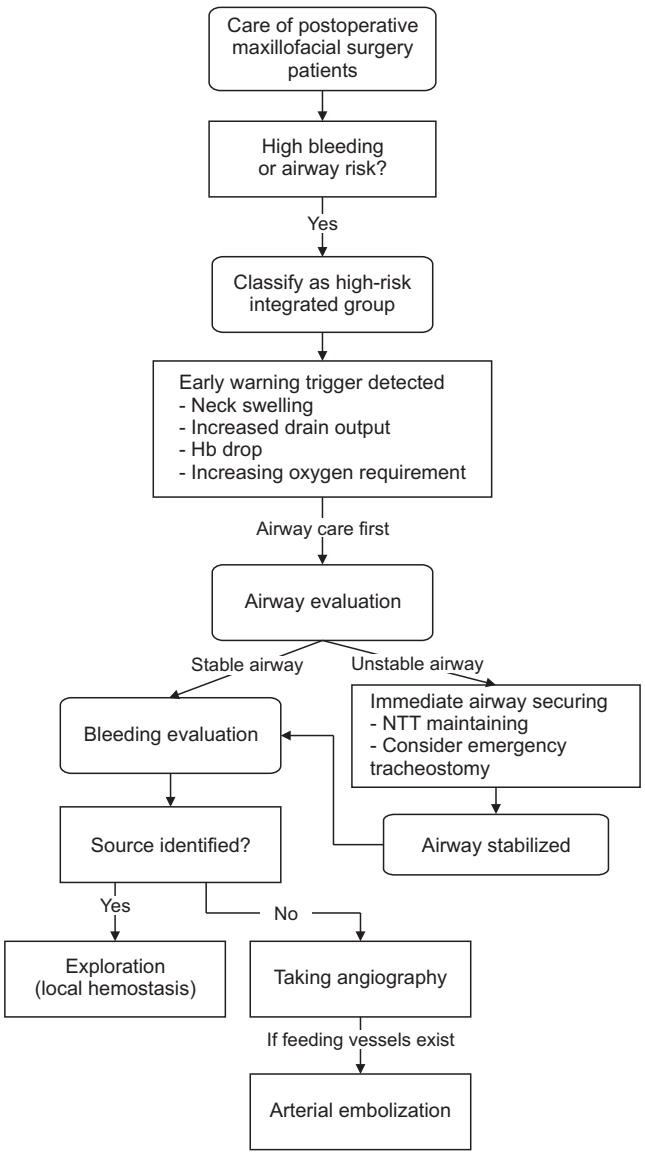


Fig. 3. Stepwise protocol for postoperative bleeding and airway management in oral and maxillofacial surgery. (NTT: nasotracheal tube)

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In actual clinical settings, postoperative bleeding and airway obstruction often present concurrently or progress in a sequential manner, necessitating a unified and adaptive approach to emergency management. Accordingly, by integrating the aforementioned airway- and bleeding-focused protocols, we propose a final comprehensive algorithm designed to guide the management of complex postoperative emergencies in oral and maxillofacial surgery.(Fig. 3)

Nevertheless, this study provides practical clinical evidence regarding airway management and bleeding control after oral and maxillofacial surgery based on long-term real-world data. These findings may serve as foundational data for the development of standardized emergency management guidelines in the field of oral and maxillofacial surgery.

V. Conclusion

Postoperative airway obstruction and massive hemorrhage following oral and maxillofacial surgery are relatively uncommon; however, when they occur, they constitute critical emergencies that are directly life-threatening. Based on 15 years of clinical data from a single university dental hospital[21]. The analysis demonstrated that postoperative bleeding may occur regardless of patient-related comorbidities, and that the period around 5 POD is clinically critical, particularly in patients undergoing orthognathic surgery or oral cancer surgery.

The first 72 hours following orthognathic surgery and extensive malignant tumor resection were identified as a high-risk period for both hemorrhagic and airway-related complications, underscoring the importance of intensive postoperative surveillance and prompt emergency response during this interval. Furthermore, tracheostomy should not be regarded solely as a last-resort intervention in emergency situations, but rather as a key management strategy that should be proactively considered based on preoperative risk factor assessment and the application of tracheostomy scoring systems[22,23].

This study recommends the following standardized emergency management guidelines. First, in patients undergoing oral cancer surgery, the Cameron score should be applied preoperatively, and elective tracheostomy should be considered in high-risk patients with scores of 5 or higher[3,24]. Even in patients with scores below 5, intensive airway monitoring is

essential when advanced age or reconstructive procedures are present. Second, postoperative hemorrhage should not be regarded as an isolated surgical complication because progressive bleeding may rapidly compromise the airway. Therefore, our proposed management framework emphasizes simultaneous reassessment of airway patency and bleeding severity, followed by stepwise intervention including local hemostasis, airway protection when necessary, and early angiographic evaluation with selective transarterial embolization for persistent or suspected deep vascular bleeding.

The emergency management algorithm proposed in this study is grounded in real-world clinical experience and facilitates rapid, standardized responses through coordinated collaboration among surgeons, anesthesiologists, and nursing staff. With further validation through multicenter and prospective studies, this algorithm has the potential to make a meaningful contribution to the management of high-risk patients and to the enhancement of patient safety following oral and maxillofacial surgery.

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Authors' Contributions

S.L. contributed to data collection, statistical analysis, interpretation of the results, and drafting of the manuscript. S.Y.H., K.B.K., S.S., J.R., C.M., J.Y.L., D.S.H., Y.D.K., and S.H.S. contributed to data acquisition and critically reviewed the manuscript for important intellectual content. U.K.K. participated in the study conception and design, supervised and coordinated the study, and critically revised the manuscript. All authors read and approved the final manuscript.

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Ethics Approval and Consent to Participate

This study was approved by the Institutional Review Board of Pusan National University Dental Hospital (IRB No. 2025-11-006-006). The written informed consent was waived by the IRB due to the retrospective nature of the study.

Conflict of Interest

Dae Seok Hwang is currently an editorial board member of *Journal of the Korean Association of Oral and Maxillofacial Surgeons*. He was not involved in the review process. Otherwise, no potential conflict of interest relevant to this article was reported.

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