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ORIGINAL ARTICLE

Severe odontogenic deep neck space infections: risk factors for difficult airways and ICU admissions

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Abstract

Purpose The purpose of this retrospective study was to evaluate perioperative risk factors concerning difficult airway management, primary tracheostomy, and need for intensive care unit (ICU) admission in severe odontogenic space infections.

Methods Perioperative risk factors were retrospectively analyzed in 499 cases. Fisher's exact test and analysis of variance were performed to analyze associations between categorical and continuous variables. Univariate regression analysis was used for estimating predictors for ICU admission. A risk model for ICU admission was performed using multivariate regression analysis. Area-under-the-curve (AUC) was calculated by receiver-operating-characteristic (ROC) curve.

Results Airway securing in patients with restricted mouth opening led to significant use of the video laryngoscope ($p < 0.001$) or fiberoptic bronchoscope ($p < 0.001$). The use of fiberoptic bronchoscopy was significantly increased in patients with dysphagia ($p = 0.005$) and dyspnea ($p = 0.04$). Four patients (0.8%) needed primary tracheostomy. ICU admission was significantly associated with higher levels of C-reactive protein (CRP, $p = 2.78 \times 10^{-5}$), white blood cell count (WBC, $p = 0.003$), dyspnea ($p = 9.95 \times 10^{-6}$), and higher body mass index (BMI, $p = 0.0003$). American Society of Anesthesiologists physical status (ASA PS) class III patients ($p = 0.04$) and the need for the use of a video laryngoscopy ($p = 0.003$) or fiberoptic bronchoscopy ($p = 6.58 \times 10^{-5}$) resulted in a more frequent ICU admission. The AUC of the model was 0.897.

Conclusion Difficult airway management was mainly dependent on limited mouth opening and elevated CRP. Elevated CRP, BMI, ASA PS III, and dyspnea were important risk factors for ICU admission. These predictors should be considered preoperatively for proper planning and preparation.

Keywords Deep neck space infections · Risk factors · Airway management · ICU admission

Introduction

Deep neck space infections are mainly associated with an odontogenic origin and represent a therapeutic challenge due to the complex anatomy and the possible spread along adjacent neck spaces [1]. Despite early surgical intervention and calculated antibiotic therapy, life-threatening complications such as mediastinitis, airway obstruction, vascular ruptures, and septic shock occur repeatedly and can lead to fatal outcome of the disease [2]. The symptoms are often characterized by fever, dysphagia, and trismus. C-reactive protein (CRP) and white blood cell (WBC) count are regularly elevated [3, 4]. Airway securing can be challenging in patients suffering from odontogenic space infection due to upper airway obstruction, edema, and restricted mouth opening. Airway restriction is often attended by dyspnea, which requires adequate airway management in addition to prompt surgical intervention [5]. Reasons for difficult airways are a dynamic progress of the disease accompanied by limited mouth opening, edema, distorted anatomy and tissue immobility [6]. Beside direct laryngoscopy, management of difficult airways can be performed using video laryngoscopy, blind nasal intubation, fiberoptic bronchoscopy as well as tracheotomy on awake patients under local anesthesia [7].

The aim of this retrospective study was to evaluate patient's characteristics and perioperative risks concerning difficult airway management, primary tracheostomy, and need for ICU admission in severe odontogenic space infections.

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Materials and methods

Patients

This retrospective study was conducted in accordance with the ethical principles of the declaration of Helsinki. Five hundred fifty-seven patients with severe odontogenic infections received medical attention between 2010 and 2017 in the Department of Oral Maxillofacial Plastic Surgery and the Department of Anesthesiology and Intensive Care Medicine of the University Hospital of Cologne. Severe odontogenic infections were defined as infection of odontogenic origin requiring hospitalization, extraoral incision under general anesthesia, and antibiotic therapy [8]. All patients showed signs of systemic inflammation and received extraoral incision and drainage of all affected anatomic deep fascial spaces as soon as possible [3]. All cases were identified in the electronic hospital database. Duplicate records ($n = 30$) or incomplete records ($n = 2$), patients who did not receive extraoral incision or general anesthesia ($n = 18$), and patients suffering from solid cancer in the head-neck area ($n = 4$) were excluded. Records of 499 patients were analyzed in detail.

Treatment

All patients underwent extraoral incision and drainage under general anesthesia with oral- or nasal-tracheal intubation. The method for successful airway management and need for a procedural change in difficult upper airway conditions were recorded. Airway management was divided into four groups depending on the final method for airway securing: direct Macintosh laryngoscope (HEINE Optotechnik®, Herrsching, Germany); video laryngoscope (GlideScope, VERATHON®, Bothell, USA), fiberoptic bronchoscope (Ambu® aScope™ Slim 3.8/1.2 or Regular 5.0/2.2, Ambu GmbH, Bad Nauheim, Germany), or direct tracheostomy. The choice of the primary airway management method was determined by the attending anesthesiologist considering physical examination, mouth opening, trismus, and respiratory symptoms. Patient's data were analyzed regarding sex, age, American Society of Anesthesiologists physical status (ASA PS) classification, body mass index (BMI), presence of diabetes, preoperative use of antibiotics, palpability of the lower jaw edge, restricted mouth opening, dysphagia, dyspnea, CRP levels, WBC count, involved fascial spaces, intraoperative tooth extraction, dental focus, and need for ICU admission. The involved fascial spaces were categorized in accordance with the Topazian classification [9] (Table 1).

Statistical analysis

Statistical analysis was performed using SPSS (IBM SPSS 25.0, IBM Corp.; New York, USA). The Fisher's exact test was performed to evaluate the significance of differences between categorical variables. Continuous variables were analyzed using the Mann-Whitney U test or the Kruskal-Wallis one-way analysis of variance. Univariate regression analysis was performed for estimating predictors for ICU admission. p values less than 0.05 were considered statistically significant. Statistically significant clinical parameters were selected for a multivariate regression model for ICU admission. Based on multivariate analysis, area-under-the-curve (AUC) was calculated by receiver-operating-characteristic (ROC) curve.

Results

Patient characteristics

In this study, 491 patients were included. Eight patients underwent two independent surgical treatments of severe odontogenic infections in different hospital stays. Patients' characteristics are summarized in Table 1. Mean duration of hospitalization was 7.39 ± 4.21 days. Mean duration before general anesthesia and start of the surgical procedure was 9.20 ± 12.88 h. The final procedure of airway management is summarized in Table 2. Only 31 cases (6.3%) required an admission on the intensive care unit (ICU). Procedure of airway management in this subgroup is demonstrated in Table 2. Causes for ICU admission were edematous airway in 26 cases, respiratory insufficiency in 2 cases, aspiration, prolonged drug effect, and independent accompanying diseases in one case, respectively. Twenty-seven patients were transferred mechanically ventilated to the ICU.

Airway management

Airway securing in patients with restricted mouth opening led to significant use of the video laryngoscope ($p < 0.001$) or fiberoptic bronchoscope ($p < 0.001$). Acute dyspnea was documented in 26 patients. Subgroup analysis showed that patients with acute dyspnea were significantly more frequently intubated using fiberoptic bronchoscopy than direct laryngoscopy ($p = 0.04$). No significant differences were found between direct laryngoscopy and video laryngoscopy ($p = 0.73$). However, three of the four patients with primary tracheostomy suffered from dyspnea, whereas only 4.1% in the group of direct laryngoscopy ($p < 0.001$) complained acute dyspnea. In patients with dysphagia, the necessity for fiberoptic bronchoscopy was significantly increased ($p = 0.005$). No differences were seen concerning video laryngoscopy ($p = 0.11$) or tracheotomy ($p = 0.58$). Male patients were intubated more often using the video laryngoscope ($p = 0.002$). Advanced airway management was associated with higher CRP levels ($p < 0.001$). Highest CRP levels were measured in cases with primary tracheostomy (details see Fig. 1).

Table 1 Baseline characteristics

Patient characteristics ($n = 499$)	
Sex (male/female)	290 (58.1%) / 209 (41.9%)
Age (years)	45.36 (± 17.95)
Body mass index	26.66 (± 5.96)
ASA PS classification (I/II/III)	196 (39.3%) / 205 (41.1%) / 98 (19.6%)
Diabetes	Yes 48 (9.6%) / no 448 (89.8%) / unknown 3 (0.6%)
Lower jaw edge palpable	Yes 76 (15.2%) / no 296 (59.3%) / unknown 127 (25.5%)
Restricted mouth opening	Yes 374 (74.9%) / no 101 (20.2%) / unknown 24 (4.8%)
Dysphagia	Yes 323 (64.7%) / no 98 (19.6%) / unknown 78 (15.6%)
Dyspnea	Yes 26 (5.2%) / no 400 (80.2%) / unknown 73 (14.6%)
Odontogenic focus	Yes 472 (94.6%) / no 20 (4.0%) / unknown 7 (1.4%)
Tooth extraction	Yes 324 (64.9%) / no 175 (35.1%)
CRP (mg/l)	108.5 (89.6)
WBC count (10^9/l)	13.36 (4.97)
Involved fascial spaces	
Submandibular/sublingual	444 (89.0%)
Submental	18 (3.6%)
Lateral pharyngeal	11 (2.2%)
Pterygomandibular	9 (1.8%)
Buccal	3 (0.6%)
Unknown	14 (2.8%)

ASA PS classification, American Society of Anesthesiologists Physical Status Classification System; *CRP*, C-reactive protein; *WBC*, white blood cell

The need for a procedural change in airway management was significantly increased in patients with restricted mouth opening ($p < 0.001$) and elevated CRP values ($p = 0.03$). A significant correlation was seen between gender and need for a procedural change in airway securing (male 20%, female 10.5%, $p = 0.004$). Airway management method ($p = 0.71$) or the need for a procedural change ($p = 0.54$) was not affected by the ASA PS classification.

ICU admission

ICU admission was significantly associated with higher levels of CRP ($p = 2.78 \times 10^{-5}$), WBC count ($p = 0.003$), and dyspnea ($p = 9.95 \times 10^{-6}$). Mean CRP levels in patients with ICU admission were 179.4 (± 122.9) mg/l and 103.5 (± 84.6) mg/l in patients without ICU admission. Higher body mass index (BMI) led to a significantly more frequent ICU admission ($p = 0.0003$) whereas BMI showed no differences in the airway management method ($p = 0.20$) or need for a procedural change in airway securing ($p = 0.41$). Mean BMI without ICU admission was 26.39 (± 5.79) with respect to a mean BMI of 30.84 (± 7.01) in patients needed further treatment on the ICU. Age or diabetes mellitus (DM) were not significant correlated with ICU admission, airway management method (age $p = 0.18$; DM $p = 0.85$), or need for a procedural change in airway securing (age $p = 0.54$, DM $p = 1.00$). Subgroup analysis showed a significant correlation for ASA PS class III patients needed ICU admission ($p = 0.04$). Using advanced airway management such as video laryngoscopy ($p = 0.003$) or fiberoptic bronchoscopy ($p = 6.58 \times 10^{-5}$) led to more frequent ICU admission. The need for a procedural change in airway management was significantly associated with the ICU admission ($p = 0.004$). Length of preoperative hospital stay was not associated with more frequent ICU admission. Detailed results for ICU admission are summarized in Table 3.

Table 2 Airway management and ICU admission

	Direct laryngoscope	Video laryngoscope	Fiberoptic bronchoscope	Tracheostomy
Airway management	339 (67.9%)	79 (15.8%)	77 (15.4%)	4 (0.8%)
ICU admission	8 (25.8%)	8 (25.8%)	11 (35.5%)	4 (12.9%)

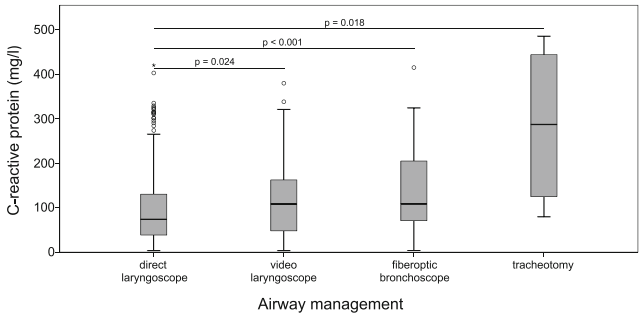

Fig. 1 Median levels of C-reactive protein in different airway management methods

Statistically significant variables of univariate regression analyses for ICU admission with p values ≤ 0.05 (Table 3) were used for a multivariate regression model (Table 4). Receiver-operation-characteristic (ROC) curve showed an area under the curve (AUC) of 0.897.

Table 3 Univariate regression analysis for ICU admission

	p levels	OR	95% CI
Sex	$p = 0.07$	2.16	0.95–4.94
Age	$p = 0.37$	1.01	0.99–1.03
BMI	$p = 0.0003$*	1.12	1.05–1.18
ASA PS classification	$p = 0.08$		
ASA PS II	$p = 0.72$	1.18	0.48–2.91
ASA PS III	$p = 0.04$*	2.63	1.05–6.57
Diabetes	$p = 0.22$	1.89	0.69–5.17
Involved fascial spaces	$p = 0.68$	0.91	0.60–1.40
Preoperative use of antibiotics	$p = 0.69$	0.85	0.39–1.86
Lower jaw edge Palpable	$p = 0.96$	1.03	0.37–2.84
Restricted mouth opening	$p = 0.47$	1.43	0.54–3.84
Dysphagia	$p = 0.05$	4.20	0.98–18.03
Dyspnea	$p = 9.95 \times 10^{-6}$*	8.44	3.28–21.76
CRP	$p = 2.78 \times 10^{-5}$*	1.01	1.00–1.01
WBC count	$p = 0.003$*	1.10	1.04–1.17
Odontogenic focus	$p = 0.83$	1.24	0.16–9.62
Tooth extraction	$p = 0.66$	0.85	0.40–1.79
airway management	$p = 0.001$*		
Video laryngoscope	$p = 0.003$*	4.66	1.69–12.84
Fiberoptic bronchoscope	$p = 6.58 \times 10^{-5}$*	6.90	2.67–17.80
Tracheostomy	n.a.	n.a.	n.a.
Alternating anesthesia procedure	$p = 0.004$*	3.18	1.46–6.93

BMI, body mass index; *ASA PS*, American Society of Anesthesiologists Physical Status Classification System; *CRP*, C-reactive protein; *WBC*, white blood cell

*Used for multivariate regression model

Discussion

We present a retrospective study of 491 adult patients with deep space neck infections. All patients were exposed to a severe health risk leading to a potentially life-threatening situation requiring hospitalization [10, 11]. Airway securing can be challenging in patients suffering from odontogenic space infection due to upper airway obstruction, edema, and restricted mouth opening [5, 12]. Critically ill patients requiring intensive care monitoring after surgery were associated with higher complications rates, increased mortality, and a greater organizational effort [13, 14]. Therefore, we evaluated patient's characteristics and perioperative procedures to identify risk factors for difficult airways and need for ICU admission.

Airway management

Common symptoms, revealed in our study, were restricted mouth opening, elevated CRP and WBC count, and dysphagia. Beside limited neck mobility and edema, these are the most common factors that contribute to a difficult airway management situation in these patients [12, 15]. We identified a significant relationship between restricted mouth opening and difficult airway. A restricted mouth opening led to more frequent use of advanced airway management methods after failure of the primary procedure. Therefore, preoperative restricted mouth opening is an important indicator for difficult airway, as stated before [7, 16].

Compared to direct laryngoscopy, patients suffering from dysphagia were intubated more frequently using a fiberoptic

Table 4 Multivariate regression model for ICU admission

	p levels	OR	95% CI
ASA	0.52		
ASA II	0.54	0.68	0.20–2.32
ASA III	0.60	1.43	0.38–5.34
BMI	0.0004	1.18	1.08–1.29
Dyspnea	0.01	6.98	1.50–32.44
CRP	0.08	1.01	1.00–1.01
WBC count	0.36	1.04	0.95–1.14
Airway management	0.04		
Video laryngoscope	0.04	5.14	1.09–24.20
Fiber optic bronchoscope	0.008	5.63	1.58–20.09
Tracheostomy	n.a.	n.a.	n.a.
Alternating anesthesia procedure	0.58	1.52	0.34–6.82

ASA PS, American Society of Anesthesiologists Physical Status Classification System; *BMI*: body mass index; *CRP*, C-reactive protein; W*BC*, white blood cell

bronchoscope. Concerning the video laryngoscopy, no significant difference could be seen. However, dysphagia had no influence on the frequency of a change of the anesthesia procedure. In summary, dysphagia appears to be an important factor for the airway management. Restrictively, this symptom was present in a large number of patients; therefore, the probability for a difficult airway remains inconsistent.

Patients presenting with acute dyspnea were more frequently intubated using fiberoptic bronchoscopy. However, a change in the anesthesia procedure was not seen more frequently. All patients with dyspnea except of one individual also showed limited mouth opening. These critically ill patients have probably been intubated more frequently using fiberoptic bronchoscopy primarily resulting in less frequent changes in airway securing.

All patients undergoing primary tracheostomy showed a reduced mouth opening and reported dysphagia. Additionally, 75% showed symptoms of acute dyspnea. Number of patients with primary tracheostomy was small but these three factors seem to increase the risk of tracheostomy.

Systemic inflammation evidenced by higher CRP levels were associated with advanced airway management and led to a more frequent procedural change. In male patients, the use of advanced airway management was increased and the intubation procedure had to be changed more frequently. Reasons could be found in the unequal gender distribution with male dominance or a later presentation in hospital. In contrast to the necessity of ICU admission, the need for advanced airway management was not increased in obese patients. There were no significant differences with respect to the airway management or need for a procedural change.

In our study, we could identify limited mouth opening and elevated CRP values as risk factors for difficult airways. Elevated CRP, predicting disease severity, must be considered as an indirect prognostic factor for difficult airways. Results for acute dyspnea and dysphagia remain inconsistent but fiberoptic bronchoscopy was more frequently needed.

ICU admission

We have identified several risk factors leading to a more frequent ICU admission. Edematous swelling of the respiratory tract was a main cause for ICU admission with an overall need for postoperative mechanical ventilation. Higher CRP levels seem to be associated with severity of deep space infections of odontogenic origin. Stathopoulos et al. showed that the concentration of CRP was a significant predictor of hospital stay [17]. Sharma et al. confirmed that CRP was an effective marker for determining severity of infection in fascial space infections of odontogenic origin [18]. In addition, we found higher CRP and WBC levels associated with a more frequent ICU admission.

Besides systemic inflammation, acute dyspnea was often associated with the necessity of ICU admission. Due to improved medical care and early antibiotic therapy, only 26 patients suffered from acute dyspnea. Interestingly, nearly one third of this subgroup had to be admitted to ICU. Therefore, CRP, WBC levels, and dyspnea are indicators of a severe health risk and as such, important factors regarding the risk of ICU admission and further complications.

The ASA PS classification assigns different risk groups to patients based on systemic diseases. A higher ASA PS class is associated with a greater likelihood of unplanned ICU admission following surgery [19]. Concerning ICU admission, we found a uniform distribution of ASA PS class I and class II patients whereas ASA PS class III patients were admitted significantly more frequent to the ICU.

In our study population, obesity led to a more frequent ICU admission. Our results show that the ASA PS classification and the BMI should be taken into account in the risk stratification of these patients.

Advanced airway management increases the likelihood of ICU admission. The same applies to the need for a procedural change in airway management. Advanced airway management as well as the procedural change could be an expression of disease severity. However, edematous upper airway swelling with consecutive postoperative mechanical ventilation can be aggravated by multiple manipulation attempts.

Further investigations showed an increased incidence of diabetes in individuals with deep space infections associated with an extended hospital stay [20]. In contrast, in our study, no increased ICU admission was detected in patients suffering from diabetes.

Systemic inflammation recognized by elevated CRP and WBC levels, BMI, ASA PS III, dyspnea, the necessity for advanced airway management, and the need for a procedural change in airway securing were important risk factors for ICU admission.

Our study has several strengths: we could evaluate a high number of possibly relevant factors in a large and consistent cohort. Anesthesia and surgical procedures were performed in one clinic with identical standards. Limitations are the retrospective design with missing information in some cases.

In summary, we could identify important risk factors for difficult airway and ICU admission in patients suffering from severe odontogenic infections. Difficult airway management was mainly dependent on limited mouth opening and elevated CRP. Edematous swelling of the respiratory tract followed by postoperative mechanical ventilation is the main cause for ICU admission. As further risk factors, we could identify elevated CRP, BMI, ASA PS III, and preoperative dyspnea. The participating physicians should consider these predictors in their

planning and preparation. Further prospective studies should be performed to verify our findings.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in this study were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments.

References

1. Boscolo-Rizzo P, Marchiori C, Montolli F, Vaglia A, Da Mosto MC (2006) Deep neck infections: a constant challenge. ORL J Otorhinolaryngol Relat Spec 68(5):259–265. https://doi.org/10.1159/000093095
2. Wang LF, Kuo WR, Tsai SM, Huang KJ (2003) Characterizations of life-threatening deep cervical space infections: a review of one hundred ninety-six cases. Am J Otolaryngol 24(2):111–117. https://doi.org/10.1053/ajot.2003.31
3. Flynn TR, Shanti RM, Levi MH, Adamo AK, Kraut RA, Trieger N (2006) Severe odontogenic infections, part 1: prospective report. J Oral Maxillofac Surg 64(7):1093–1103. https://doi.org/10.1016/j.joms.2006.03.015
4. Alotaibi N, Cloutier L, Khaldoun E, Bois E, Chirat M, Salvan D (2015) Criteria for admission of odontogenic infections at high risk of deep neck space infection. Eur Ann Otorhinolaryngol Head Neck Dis 132(5):261–264. https://doi.org/10.1016/j.anorl.2015.08.007
5. Tapiovaara L, Back L, Aro K (2017) Comparison of intubation and tracheotomy in patients with deep neck infection. Eur Arch Otorhinolaryngol 274(10):3767–3772. https://doi.org/10.1007/s00405-017-4694-5
6. Chen SJ, Ji N, Chen YX, Zhao SJ, Xiao JR, Lin XM, Han XX (2015) Management and maintenance of the airway in cervical necrotising fasciitis: a retrospective analysis of 15 cases. Br J Oral Maxillofac Surg 53(7):642–646. https://doi.org/10.1016/j.bjoms.2015.04.017
7. Karkos PD, Leong SC, Beer H, Apostolidou MT, Panarese A (2007) Challenging airways in deep neck space infections. Am J Otolaryngol 28(6):415–418. https://doi.org/10.1016/j.amjoto.2006.10.012
8. Poeschl PW, Spusta L, Russmueller G, Seemann R, Hirschl A, Poeschl E, Klug C, Ewers R (2010) Antibiotic susceptibility and resistance of the odontogenic microbiological spectrum and its clinical impact on severe deep space head and neck infections. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 110(2):151–156. https://doi.org/10.1016/j.tripleo.2009.12.039
9. Topazian RG, Goldberg MH (2002) Odontogenic infections and deep fascial space infections of dental origin. In: Goldberg MH, Topazian RG, Hupp JR (eds) Oral and maxillofacial infections, 4rd edn. Saunders, Philadelphia, pp 158–187
10. DeAngelis AF, Barrowman RA, Harrod R, Nastri AL (2014) Review article: maxillofacial emergencies: oral pain and odontogenic infections. Emerg Med Australas 26(4):336–342. https://doi.org/10.1111/1742-6723.12266
11. Daramola OO, Flanagan CE, Maisel RH, Odland RM (2009) Diagnosis and treatment of deep neck space abscesses. Otolaryngol Head Neck Surg 141(1):123–130. https://doi.org/10.1016/j.otohns.2009.03.033
12. Cho SY, Woo JH, Kim YJ, Chun EH, Han JI, Kim DY, Baik HJ, Chung RK (2016) Airway management in patients with deep neck infections: a retrospective analysis. Medicine (Baltimore) 95(27):e4125. https://doi.org/10.1097/MD.0000000000004125
13. Kinzer S, Pfeiffer J, Becker S, Ridder GJ (2009) Severe deep neck space infections and mediastinitis of odontogenic origin: clinical relevance and implications for diagnosis and treatment. Acta Otolaryngol 129(1):62–70. https://doi.org/10.1080/00016480802008181
14. Obregon-Guerrero G, Martinez-Ordaz JL, Moreno-Aguilera E, Ramirez-Martinez M, Pena-Garcia JF, Perez-Alvarez C (2013) Deep neck abscess. Factors related to reoperation and mortality. Cir Cir 81(4):299–306
15. Paix AD, Williamson JA, Runciman WB (2005) Crisis management during anaesthesia: difficult intubation. Qual Saf Health Care 14(3):e5. https://doi.org/10.1136/qshc.2002.004135
16. Bali RK, Sharma P, Gaba S, Kaur A, Ghanghas P (2015) A review of complications of odontogenic infections. Natl J Maxillofac Surg 6(2):136–143. https://doi.org/10.4103/0975-5950.183867
17. Stathopoulos P, Igoumenakis D, Shuttleworth J, Smith W, Ameerally P (2017) Predictive factors of hospital stay in patients with odontogenic maxillofacial infections: the role of C-reactive protein. Br J Oral Maxillofac Surg 55(4):367–370. https://doi.org/10.1016/j.bjoms.2016.11.004
18. Sharma A, Giraddi G, Krishnan G, Shahi AK (2014) Efficacy of serum prealbumin and CRP levels as monitoring tools for patients with fascial space infections of odontogenic origin: a clinicobiochemical study. J Maxillofac Oral Surg 13(1):1–9. https://doi.org/10.1007/s12663-012-0376-4
19. Quinn TD, Gabriel RA, Dutton RP, Urman RD (2017) Analysis of unplanned postoperative admissions to the intensive care unit. J Intensive Care Med 32(7):436–443. https://doi.org/10.1177/0885066615622124
20. Kauffmann P, Cordesmeyer R, Troltzsch M, Sommer C, Laskawi R (2017) Deep neck infections: a single-center analysis of 63 cases. Med Oral Patol Oral Cir Bucal 22(5):e536–e541. https://doi.org/10.4317/medoral.21799