Management of deep neck infections in adults and importance of clinical and laboratory findings

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ABSTRACT

This study aimed to analyze laboratory and radiological imaging results in the prediction of treatment strategy in patients with deep neck infections. Eighty-three patients (55 (66.3%) men, mean age: 38.2±14.5 years) were included in the study. Patients were divided into three groups according to the treatment strategy: group 1 received only antibiotic treatment, group 2 underwent abscess drainage with needle puncture in addition to antibiotic treatment, and group 3 underwent surgical drainage with antibiotic treatment. Laboratory outcomes, imaging methods, duration of hospital stay, treatment strategy, and clinical outcomes were analyzed.According to the laboratory results, complete blood count values did not vary among the three groups, but C reactive protein (CRP) and erythrocyte sedimentation rate (ESR) values were higher in group 3 (p<0.01). Based on receiver operating characteristic (ROC) analysis, the cut-off levels for CRP and ESR associated with the need for surgical drainage were 133 mg/L and 42.5, respectively. According to radiological imaging results, the number of involved neck spaces was significantly different among the three groups (p=0.03), and group 3 had more spaces involved when compared with groups 1 and 2 (p=0.04). Gas formation in the neck tissues was noted in 10 patients in group 3 and 5 patients in groups 1 and 2 (p=0.02). ESR and CRP levels were higher in patients who underwent surgical drainage. In patients with deep neck space infections, the involvement of two or more neck spaces and gas formation on radiological images might indicate surgical drainage as a treatment strategy.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ The treatment strategy of deep neck space infections (DNIs) which is dangerous and fatal if left untreated includes airway control, effective antibiotic therapy, and adequate and timely surgical drainage.

WHAT THIS STUDY ADDS

⇒ Erythrocyte sedimentation rate (ESR) (>42 mm/hour) and/or C reactive protein (CRP) (>133 mg/L) levels at the admission indicates need for surgical drainage in patients with DNI.

⇒ Gas formation and involvement of two or more neck spaces in radiological images should guide the clinician to surgical drainage as treatment strategy.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ If ESR and CRP values at the time of admission are above a certain threshold value, conservative treatment should not be insisted on.

INTRODUCTION

Deep neck space infections (DNIs) occur in the potential fascial planes of the head and neck and are characterized by either abscess formation or cellulitis.[1 2] High fever, local signs of erythema, edema, fluctuations in the neck, trismus, and oral intake restrictions are common symptoms of DNI that have a rapid onset and can progress to life-threatening complications.

DNIs may arise from several foci in the head and neck area, including teeth, adenotonsillar tissues, salivary glands, and other components of the upper aerodigestive tract. Despite improved diagnostic techniques and the widespread availability of antimicrobial therapy, these infections can be dangerous and fatal if left untreated. They can lead to mediastinitis, airway loss, necrotizing fasciitis, and sepsis due to their progression and uncontrolled spread. Therefore, timely and accurate identification and treatment of these serious conditions are critical.[3]

The treatment strategies for DNIs include airway control, effective antibiotic therapy, and adequate and timely surgical drainage. The clinical course and treatment strategies for DNIs have been well-described in the literature. However, most of these studies were limited because of the inclusion of all age groups, patients with uncomplicated peritonsillar abscess, and failure to include the laboratory results and radiological characteristics of patients with DNI to evaluate the clinical outcome.[4 5]

This study aimed to review our recent experience with DNIs in the adult population and determine the effectiveness of laboratory and clinical findings, along with imaging methods in the planning of treatment strategies.

MATERIALS AND METHODS

The medical records of patients who were admitted to our clinic and treated for DNI between January 2015 and August 2020 were retrospectively reviewed. This study was designed retrospectively; therefore, informed consent was not obtained from patients who participated in the study. DNI was diagnosed in these patients using clinical, radiographic, and laboratory findings. The evaluation of patients to identify the location and extension of DNI is usually performed with ultrasonography (US), owing to its cost-effectiveness, and if necessary, CT with contrast or MRI with contrast was used. Laboratory results, including complete blood count, erythrocyte sedimentation rate (ESR), and C reactive protein (CRP), were also recorded.

Patients were divided into three groups based on the treatment applied. Group 1 patients were followed up with antibiotic treatment only, group 2 patients underwent abscess drainage via needle aspiration in addition to antibiotic treatment, and group 3 patients underwent surgical drainage using a sterile technique with antibiotic treatment. Patients were treated with empirical intravenous broad-spectrum antimicrobial therapy, which was directed by microbiological culture findings. Supportive medical treatments (analgesics, antipyretics, intravenous fluids, and mouthwashes) were administered when required. Patients with isolated peritonsillar abscesses without DNI, those with only skin infection—cellulitis, those undergoing oncological treatments, and anergic patients were excluded from the study. Demographic findings, symptoms, laboratory results, disease etiology, seasonal distribution, microbiology, imaging methods and findings, duration of hospital admission, treatment strategy, complications, and outcomes were evaluated.

Statistical analysis

Analysis of the results was performed using IBM SPSS Statistics software (V.21.0; IBM, Armonk, New York, USA). Data were tested for normal distribution using the Kolmogorov-Smirnov test. Analysis of variance was used to investigate differences among groups. In cases where $p<0.05$ was found in the analysis of variance test, the post hoc Tukey test was used to compare all the groups with each other. $P<0.017$ was considered significant in the post hoc tests. ROC analysis was used to determine the cut-off values for CRP and ESR.

RESULTS

Eighty-three patients (28 (33.7%) female; 55 (66.3%) male) were included in this study. Of these patients, 35 (42.1%) were in group 1, 17 (20.5%) were in group 2, and 31 (37.4%) were in group 3 according to treatment strategy. The male/female ratio was 1.96:1, and the mean age was 38.3±15.8 years (range 18–82 years). There was no difference in sex among the three groups ($p=0.35$), and also there was no difference in smoking habits among the groups ($p=0.71$). One patient was a drug addict, and there were no alcohol users. Only two patients had diabetes mellitus, and the other three patients had hypertension. Demographic data, symptoms, and laboratory outcomes of patients (complete blood count, ESR, CRP, and neutrophil-to-lymphocyte ratio (NLR)), and duration of hospital admission are summarized in tables 1–3. Based on receiver operating characteristic (ROC) analysis, the cut-off level for CRP that was associated with the need for surgical drainage was 133 mg/L. The area under the ROC curve was 0.688, with a sensitivity of 73% and specificity of 63% (figure 1). The cut-off level for ESR associated with the need for surgical drainage was 42.5. The area under the ROC curve was 0.819, with a sensitivity of 91% and specificity of 63% (figure 2).

Autumn (33 cases, 39.8%) was the most common season for DNIs, followed by spring (25 cases, 30.1%), summer (14 cases, 16.8%), and winter (11 cases, 13.3%). There was no difference in the treatment protocol in terms of seasonal

Table 1 Demography and laboratory outcomes on hospital admission of all patients in the study

	Overall (n=83)	Group 1 (n=35)	Group 2 (n=17)	Group 3 (n=31)	P value
Age	38.1±15.9	37.03±16	34.5±13.6	41.2±16.9	**0.35***
					0.32†
Female sex (n,%)	28 (33.7%)	13 (37.1%)	4 (23.5)	11 (35.5)	**0.35***
					0.98†
WBC (10^3/µL)	14.2±4.9	13.3±3.4	13.8±5.1	15.2±5.3	**0.36***
					0.28†
Neutrophil (10^3/µL) count	11.5±4.9	10.4±3.4	10.9±4.9	12.8±5.6	**0.2***
					0.17†
Lymphocyte (10^3/µL) count	1.6±0.7	1.8±0.8	1.6±0.7	1.4±0.8	**0.2***
					0.32†
NLR	10.9±12.7	7.5±5.9	10.4±13.9	13.5±13.9	**0.3***
					0.38†
ESR	40.4±19.4	30.5±11.4	40.7±13.5	51.2±23.4	**<0.01***
					<0.01†
CRP (mg/L)	148.1±116.2	105.6±83.1	126.4±95.8	199.5±128.2	**<0.01***
					0.012†

*Between all study groups.
†Group 1 versus group 2.
CRP, C reactive protein; ESR, erythrocyte sedimentation rate; NLR, neutrophil-to-lymphocyte ratio; WBC, white blood cell.

Table 2 Symptoms, duration of the hospital admission, and hospital stay of all patients in the study

	Overall (n=83)	Group 1 (n=35)	Group 2 (n=17)	Group 3 (n=31)	P value
Time between onset of complaints and hospitalization (days)	8.3±8.1	5.9±5.9	8.8±4.9	10.6±10.6	**0.07***
					0.03†
Number of patients with trismus (%)	50 (60.2%)	17 (47%)	9 (53%)	24 (77.0%)	**0.03***
					0.41†
Number of patients with oral intake restriction (%)	46 (55.4%)	14 (40%)	10 (59%)	22 (77%)	**0.04***
					0.63†
Length of stay in hospital	9.8±8.4	6.8±3.1	8.4±4.2	14.1±11.9	**0.001***
					0.001†

*Between all study groups.
†Group 1 versus group 2.

distribution among the three groups (p=0.4). However, the majority were observed in spring and autumn.

The most common cause of DNI was odontogenic (46 cases, 55.4%), followed by upper airway infections (24 cases, 28.9%), and sialadenitis (13 cases, 15.7%). Again, there was no difference in the causes of DNIs among the three groups (p=0.17).

Radiological evaluation was performed on all patients to identify the localization, extension, and diagnosis (cellulitis, lymphadenitis, or abscesses) of the infections. In 20 patients (24.1%), US was the only imaging procedure. In 44 patients, CT with contrast was the only imaging procedure (53.0%), and in 17 of the patients, both US and CT were performed (20.5%). For two complicated patients, additional MRI was also performed (2.4%). There was no difference in the selection of imaging methods among the three groups (p=0.21), but there was a significant difference in imaging results among the three groups (p<0.01), which guided the clinician for the treatment methods: abscess drainage by syringe or surgical incision in addition to medical treatment. As expected, there was a significant correlation between US and CT results in terms of the spaces involved (rho: 0.79; p<0.01). However, in some patients, CT showed additional spaces that could not be determined with US.

According to imaging studies, 45 patients (54.2%) had one space involved. Twenty-three (65.7%) patients in group 1, 12 (70.6%) patients in group 1, and 10 (32.3%) patients in group 3 had only one involved space. In 32 patients (38.6%), the infection involved two spaces. In group 1, 11 (31.4%) patients in group 1, 5 (29.4%) patients in group 2, and 16 (51.6%) patients in group 3 had two involved spaces. In six patients (7.2%), the infection involved more than two spaces, and 83.3% of these patients were in group 3, where a surgical approach was used. There was a significant difference among the three groups in terms of the number of involved spaces (p=0.02), and group 3 had more spaces involved than groups 1 and 2 (p=0.03).

The most commonly involved site was the submandibular space (n=64, 77.1%), followed by the parapharyngeal space (n=34, 40.9%). The most common space involvement, which included more than two spaces (tria), was the combination of the submandibular, parotid, and parapharyngeal spaces. There was no difference in the involved spaces among the three groups (p=0.18).

Gas formation in neck tissues was noted in 15 (18.1%) patients in the initial radiological investigations. Ten (66.7%) of these 15 patients with gas formation were in group 3, whereas 4 (26.7%) were in group 2, and 1 (6.7%) was in group 1 (p=0.02).

The mean time of invasive treatment was 2.3±0.7 days in group 2 and 1.8±0.9 days in group 3 (p=0.08).

Table 3 Laboratory outcomes at discharge for all patients in the study

	Overall (n=83)	Group 1 (n=35)	Group 2 (n=17)	Group 3 (n=31)	P value
WBC (10^3/µL)	7.7±2.7	7.14±1.8	7.49±3.1	8.3±2.7	**0.29***
					0.26†
ESR	28.9±18.7	21.4±15	25.4±14.4	39.1±20.2	**<0.01***
					<0.01†
CRP (mg/L)	26.3±31.5	22.5±25.1	25.5±31.5	34.3±41	**0.46***
					0.68†

*Between all study groups.
†Group 1 versus group 2.
CRP, C reactive protein; ESR, erythrocyte sedimentation rate; WBC, white blood cell.

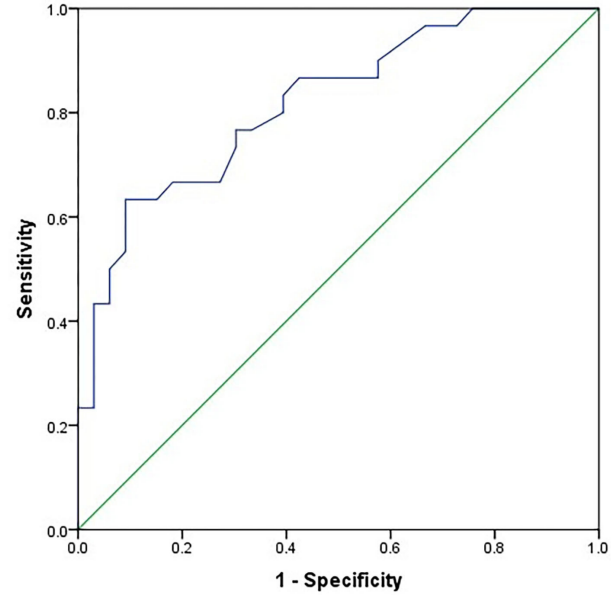

Figure 1 Receiver operating characteristic analysis for erythrocyte sedimentation rates.

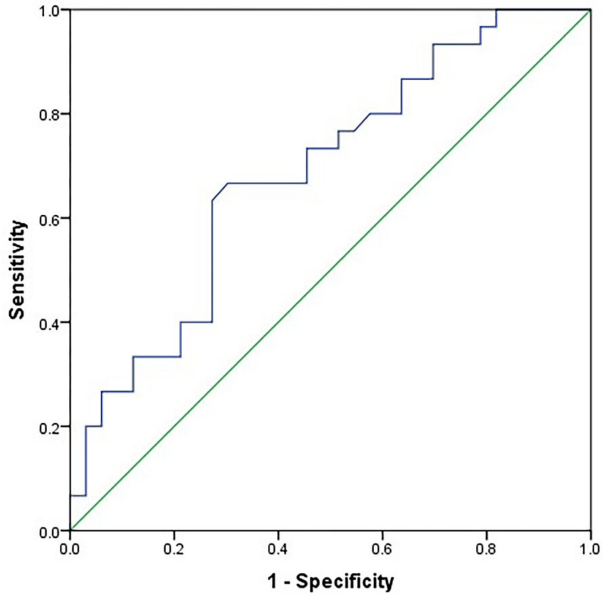

Figure 2 Receiver operating characteristic analysis for C reactive protein.

Material for culture was obtained in 42 of 48 patients (87.5%) who underwent surgical drainage or needle aspiration. Material for culture could not be obtained from four (23.5%) patients in group 2 and two (6.5%) patients in group 3. There was no bacterial growth in culture of 3 (17.6%) patients in group 2 and 12 (38.7%) patients in group 3. The most commonly identified bacteria were *Streptococcus* (n=14; 29.2%) species, followed by polymicrobial (n=8; 16.7%) etiologies. *Staphylococcus aureus* was cultivated in one patient in group 2, *Klebsiella* was cultivated in two patients and *Enterococcus* and *Eikinella corrodens* were cultivated in two different patients in group 3.

All patients, except penicillin-allergic patients, received empirical wide spectrum intravenous antibiotic therapy (ampicillin/sulbactam 1.5 g, four times per day with metronidazole 500 mg three times per day) after hospital admission. In 55 (66.3%) patients, this antibiotic treatment was not changed during their stay at hospital. The administration of different antibiotic treatments parallel to the culture results and clinical findings did not differ among the three groups (p=0.51). Seventy-one (85.5%) of the included patients had already received oral antibiotic therapy before hospitalization, and nine (10.8%) patients who had not received any antibiotic treatment before hospitalization were in group 1 (p=0.02).

In one patient, DNI was complicated by upper airway obstruction, and tracheotomy with abscess drainage of the submandibular and parapharyngeal spaces was performed simultaneously. The tracheotomy was closed on postoperative day 7, and the patient was discharged 3 days later. In one patient, DNI was complicated by mediastinitis, and mediastinotomy was performed on the third postoperative day of abscess drainage in the submandibular and retropharyngeal spaces. The patient was discharged on the 38th day of hospitalization. No patient died due to DNIs in our series, and all patients were discharged home after the completion of their treatments.

DISCUSSION

DNI is the free spread of infection along the deep neck fascial planes and the concomitant infection of adjacent spaces and structures. Previous studies in adults reported a female-to-male ratio in the range 1:1.2–1.77,[6–8] and the mean age of patients was 30–40 years,[9 10] which was consistent with our study. The symptoms of DNI, such as neck swelling, fever, trismus, and oral intake restriction, were similar to those reported in previous studies.[2] In our study, the number of patients with trismus and oral intake restrictions was higher in groups 1 and 3 than in group 2. Therefore, the symptoms of patients are important for the diagnosis of DNIs, but not enough to determine treatment options. The seasonal distribution of DNI varies in different studies, but in this study, there was a preponderance of the autumn season, which did not affect the treatment protocol.[2]

DNIs most commonly arise from a nearby infectious site, with odontogenic and upper airway sources being the most common. In the literature, dental infections account for 30% of DNIs cases[6 11]; however, we found that dental infections were the leading cause (55.4%), followed by upper airway infections (28.9%), and sialadenitis (15.7%). The ratio of upper airway infections in this study was lower than that reported in the literature, which could be attributed to our exclusion criteria. As this study included only hospitalized adults, patients with uncomplicated peritonsillar abscesses were excluded.

In the literature, NLR and CRP were reported to predict the presence of mediastinitis or necrotizing fasciitis.[12 13] In this study, we evaluated the roles of WBC count, NLR, ESR, and CRP level in DNIs. Our results showed that CBC parameters were not useful for determining the treatment strategy. However, the novel findings of this study were that the determination of ESR and CRP levels at admission could help clinicians plan the treatment strategy. Patients with ESR >42 and/or CRP >133 mg/L were the acceptable cut-off points for clinicians to define infection severity and the need for surgical drainage.

Deep neck infections occur in the potential spaces between the layers of the deep cervical fascia, either with abscess formation or cellulitis. The submandibular space was the single most frequent location of DNIs in our study (42.5%), which is consistent with the literature.[11] Previous studies reported that many DNI cases spread into more than one fascial space, which can lead to life-threatening complications[2]; in our study, infections that involved at least two neck spaces were found in 45.8% of patients, and surgical drainage was usually needed in those patients. This ratio was significantly higher than that in patients with single-space involvement, and it can be concluded that involvement of more than one neck space affects the choice of treatment method.

Therefore, DNIs require prompt diagnosis and treatment. US examination is useful for differentiating between phlegmon and abscesses.[12] If the US results are questionable, a CT scan with contrast should be obtained, as it is safe to do.[14] In addition, it may be appropriate to evaluate CT findings in patients with trismus, involvement of more than one space, and airway distress.

Cross-sectional imaging with intravenous contrast is valuable as the first choice for the evaluation of deep abscesses

and pathways of spread. CT can localize a process and define its extent, particularly its extension into the mediastinum or cranial vault. It is also an invaluable tool for planning and guiding aspirations for culturing or open drainage. MRI is useful for assessing the extent of soft tissue involvement, and delineating vascular complications.[7 8] We used only US in 24.1% of patients, only CT scan with contrast in 53.0% of patients, and both US and CT scan with contrast in 20.5% of patients. There was a correlation between the US and CT findings in terms of abscess formation. In choosing the treatment approach, we used CT in groups 2 and 3 more frequently than in group 1. Gas formation is another important finding in radiological examinations, which was reported to be related to a higher complication rate, longer hospitalization, and necrotizing fasciitis in previous studies.[3 14] Similar to previous studies, in this study, most patients with gas formation (66.7%) were treated with surgical drainage. Gas formation may be useful in predicting serious infection and worse prognosis, if there is a delay in drainage.

Airway management always comes first in the treatment of DNIs. Patients with DNIs should have their airways adequately secured. In patients with DNIs with respiratory distress, awake fiberoptic intubation is recommended, and if intubation fails, emergency local tracheotomy should be performed.[15] We had to perform tracheotomy in only one patient (1.2%), and this patient was decannulated on the postoperative day 7. The number of patients who underwent tracheotomy in our study was much lower than that reported in the literature, which may be related to the efficient use of fiberoptic intubation by the anesthesia clinic in our hospital.

DNIs often have rapid onset and can progress to life-threatening complications. Therefore, clinicians should not underestimate the potential extent or severity of the disease. The patients in this study (groups 2 and 3) underwent surgery on the 2.3rd and 1.8th days of hospitalization, respectively. Knowledge of the anatomical compartments and spaces of the neck is essential for correct diagnosis, and appropriate operative plans. Reports and images of cross-sectional imaging procedures can also guide clinicians. Clinicians should be aware that a delay in surgical intervention can result in increased complications, morbidity, and mortality.[16]

After ensuring airway safety, all patients with DNIs should be evaluated for surgical drainage at the first admission to the hospital. Surgical drainage may be necessary if there is fluctuation or abscess formation. Neck abscesses typically warrant drainage, while small or questionable abscesses and phlegmon often respond well to appropriate intravenous medical management.[17–19] Oral antibiotic treatment should be continued for 2–3 weeks after discharge from the hospital. All patients in this study continued oral antibiotic treatment for at least 2 weeks after discharge.

DNIs may be lethal, especially in intravenous drug abusers, which may induce hematogenous spread of infections.[13 19] In our study, one patient was an intravenous drug user, and his condition was complicated with mediastinitis. No mortality was observed in any of the patients included in this study.

Despite the availability of antibiotics, DNIs still have the potential for significant morbidity and mortality if treatment is delayed. Of the patients who underwent surgical drainage in this study, 63.8% had a history of antibiotic usage before hospitalization. This rate was higher than that in patients managed without any surgical procedure.[20] Inappropriate antibiotic use may predispose to complications.[21]

Usually, the results of cultures are polymicrobial, but *Streptococcus* species are the microorganisms most commonly cultured from deep neck abscesses, and these patients require a higher rate of surgical intervention for resolution.[22 23] Similar to previous studies, in our study, the most common organism cultured from abscesses was *Streptococcus* species (29.2%), followed by polymicrobial (16.7%) etiologies.

The mean length of hospital stay was 10 days in this study, which is similar to that reported in the literature. Presentation with compromise in airway is associated with prolonged hospital stay.[3 20] Mortality rates ranged from 1% to 25% in the literature. No mortality occurred in this study, which may be related to prompt diagnosis and treatment planning, as well as the urgent implementation of the interventions.

The major limitation of this study was its retrospective design; however, it was very difficult to set up a prospective single-center study with this heterogeneous and uncommon patient population. This study indicated that clinicians managing patients with DNIs were paying attention to the severity of the infection in terms of ESR, CRP level, and radiological findings. Further research, including multicenter prospective studies with a higher number of patients with DNI using laboratory and radiological results, would be much more beneficial.

In conclusion, ESR (>42 mm/hour) and/or CRP (>133 mg/L) levels at admission are critical for choosing the treatment strategy. Higher ESR and CRP levels were correlated with severe infection and the need for surgical drainage in our study. These parameters may be of value in decision making; however, further data are needed to accurately assess their role in determining the need for surgical intervention. In patients with DNI, radiological involvement of two or more neck spaces and gas formation might suggest the need for surgical drainage, in addition to supportive medical treatments and antibiotherapy.

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REFERENCES

1 Vieira F, Allen SM, Stocks RMS, *et al*. Deep neck infection. *Otolaryngol Clin North Am* 2008;41:459–83.
2 Bakir S, Tanriverdi MH, Gün R, *et al*. Deep neck space infections: a retrospective review of 173 cases. *Am J Otolaryngol* 2012;33:56–63.
3 Velhonoja J, Lääveri M, Soukka T, *et al*. Deep neck space infections: an upward trend and changing characteristics. *Eur Arch Otorhinolaryngol* 2020;277:863–72.
4 Huang T-T, Liu T-C, Chen P-R, *et al*. Deep neck infection: analysis of 185 cases. *Head Neck* 2004;26:854–60.
5 Wang L-F, Kuo W-R, Tsai S-M, *et al*. Characterizations of life-threatening deep cervical space infections: a review of one hundred ninety-six cases. *Am J Otolaryngol* 2003;24:111–7.
6 Boscolo-Rizzo P, Stellin M, Muzzi E, *et al*. Deep neck infections: a study of 365 cases highlighting recommendations for management and treatment. *Eur Arch Otorhinolaryngol* 2012;269:1241–9.
7 Babu VR, Ikkurthi S, Perisetty DK, *et al*. A prospective comparison of computed tomography and magnetic resonance imaging as a diagnostic tool for maxillofacial space infections. *J Int Soc Prev Community Dent* 2018;8:343.
8 Nurminen J, Velhonoja J, Heikkinen J, *et al*. Emergency neck MRI: feasibility and diagnostic accuracy in cases of neck infection. *Acta radiol* 2021;62:735–42.
9 Parhiscar A, Har-El G. Deep neck abscess: a retrospective review of 210 cases. *Ann Otol Rhinol Laryngol* 2001;110:1051–4.
10 Meher R, Jain A, Sabharwal A, *et al*. Deep neck abscess: a prospective study of 54 cases. *J. Laryngol. Otol.* 2005;119:299–302.
11 Kataria G, Saxena A, Bhagat S, *et al*. Prevalence of odontogenic deep neck space infections (DNSI): a retrospective analysis of 76 cases of DNSI. *Int J Otorhinolaryngol Head Neck Surg* 2015;1:11–16.
12 Marioni G, Fasanaro E, Favaretto N, *et al*. Are panels of clinical, laboratory, radiological, and microbiological variables of prognostic value in deep neck infections? an analysis of 301 consecutive cases. *Acta Otolaryngol* 2019;139:214–8.
13 Kimura A, Miyamoto S, Yamashita T. Clinical predictors of descending necrotizing mediastinitis after deep neck infections. *Laryngoscope* 2020;130:E567–72.
14 Lin R-H, Huang C-C, Tsou Y-A, *et al*. Correlation between imaging characteristics and microbiology in patients with deep neck infections: a retrospective review of one hundred sixty-one cases. *Surg Infect* 2014;15:794–9.
15 Potter JK, Herford AS, Ellis E. Tracheotomy versus endotracheal intubation for airway management in deep neck space infections. *J Oral Maxillofac Surg* 2002;60:349–54.
16 Cramer JD, Purkey MR, Smith SS, *et al*. The impact of delayed surgical drainage of deep neck abscesses in adult and pediatric populations. *Laryngoscope* 2016;126:1753–60.
17 Sanz Sánchez CI, Morales Angulo C. Retropharyngeal abscess. clinical review of twenty-five years. *Acta Otorrinolaringologica* 2021;72:71–9.
18 Chen MK, Wen YS, Chang CC. Predisposing factors of life–threatening deep neck infection: logistic regression analysis of 214 cases. *J Otolaryngol* 1999;27:141–4.
19 Russell MD, Russell MS. Urgent infections of the head and neck. *Med Clin North Am* 2018;102:1109–20.
20 Lee J-K, Kim H-D, Lim S-C. Predisposing factors of complicated deep neck infection: an analysis of 158 cases. *Yonsei Med J* 2007;48:55–62.
21 Santos Gorjón P, Blanco Pérez P, Morales Martín AC, *et al*. Deep neck infection: review of 286 cases. *Acta Otorrinolaringologica* 2012;63:31–41.
22 Huang T-T, Tseng F-Y, Yeh T-H, *et al*. Factors affecting the bacteriology of deep neck infection: a retrospective study of 128 patients. *Acta Otolaryngol* 2006;126:396–401.
23 Beka D, Lachanas VA, Doumas S, *et al*. Microorganisms involved in deep neck infection (DNIs) in Greece: detection, identification and susceptibility to antimicrobials. *BMC Infect Dis* 2019;19:850.