Clinical Study

The Factors Contributing to Efficiency in Surgical Management of Purulent Infections of Deep Neck Spaces

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Abstract
Deep neck infections (DNIs) are still emergency conditions in otorhinolaryngology. Due to rapid disease progression and life-threatening complications, the accurate surgical and medical treatment must be promptly applied. In the present study, we analyzed treatment protocols of 46 adults to assess efficacy of the treatment and search for prognostic factors of the outcomes. We performed retrospective analysis of medical data of 46 patients, who underwent surgical treatment in our department due to purulent DNI in the period from 2009 to 2017. Data investigated included age, sex, hospitalization time, duration of symptoms before drainage, comorbidities, selected laboratory tests results, location and the number of abscesses, results of microbiological cultures, and antibiotic treatment options. The study group consisted of 33 (71.7%) men and 13 (28.3%) women. Patients age ranged from 18 to 82 years. The mean duration of hospital stay was 13.2 ± 8.4 days. The most common site involved was submandibular space (43.5%), followed by parapharyngeal space (28.3%). The majority of patients had single abscess (81.2%), the multiple abscesses were revealed in 8 (18.8%) cases. The mean size of the abscesses was 42 mm. C-reactive protein level was increased in 96.7% patients (mean level 155.5 ± 146.7 mg/L), but the white blood cell count exceeded the normal in 60.9% cases (mean level 16.89 ± 5.59 × 10⁹/L). Staphylococcus aureus (20.7%) and Peptostreptococcus (20.7%) were the most common species cultured from swabs. The antibiotic treatment included most commonly a combined ceftriaxone and metronidazole (n = 23). Two patients died due to complications. The correlation between different variables and the duration of hospitalization revealed only the hemoglobin level below 12.5 g/dL, a significant predictor of longer hospitalization (16.23 days vs 12.09 days, \( P = .017 \)). Patients with purulent DNIs and decreased hemoglobin level are predisposed to prolonged recovery following the surgical drainage.

Keywords
deep neck infection, neck abscess, surgical drainage, prognostic factor

Introduction
Deep neck infection (DNI) is defined as bacterial infection in the potential spaces and fascial planes of the neck, including submandibular, lateral cervical, visceral, carotid, parapharyngeal, and retropharyngeal spaces. The critical aspect in DNI is the possible obstruction of the airway passage and the rapid spread of the infection continuously from the neck to the mediastinum. The availability of the antibiotics and improved dental care decreased the incidence and mortality due to DNI. However, the DNI is still an emergent condition in otorhinolaryngology, which can lead to serious complications such as airway obstruction, jugular vein thrombosis, carotid artery erosion, cranial nerve paresis, meningitis, mediastinitis, vertebrae osteomyelitis, and sepsis.1-4 Deep neck infections are usually originating from upper aerodigestive tract diseases, especially tonsillitis and dental infections. In children, the predominant

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focus of DNI is infection of the tonsils and pharynx, while in adult patients, the increase in the dental etiology is observed. High number of the unknown primary origin of the DNI is an important aspect and, according to the literature, may reach up to 50% of cases. The ultrasonography (US) and computed tomography (CT) of the neck are standard imaging methods to confirm the diagnosis and evaluate the extension of the infection prior to surgical management. The treatment plan of DNI includes surgical drainage of the involved space to ensure adequate ventilation and systemic administration of broad-spectrum antibiotics. Usually, the result of microbiological culture proves the presence of mixed flora. Streptococcus is the most commonly isolated pathogen in nondiabetic group and Klebsiella is most common in diabetic patients. The unfavorable course of the disease and complications are related to comorbidities such as diabetes, alcohol, or drug abuse. In the present study, we analyzed treatment protocols of 46 adults to assess the effectiveness of the treatment and to identify the prognostic factors that contribute to complications and prolonged hospitalization.

**Material and Methods**

We performed retrospective analysis of medical records of 46 patients, who underwent surgical treatment in our department, due to purulent DNIs in the period from 2009 to 2017. Patients with superficial skin abscesses, infected lateral cysts, peritonsillar abscesses, epiglottis abscesses, cellulitis, and infected or necrotic head and neck tumors were excluded from the study. The protocol of the study was approved by the local ethical review board.

Data extracted and analyzed include age, sex, hospitalization time, duration of symptoms to drainage, comorbidities, the level of hemoglobin, C-reactive protein (CRP), fibrinogen, white blood cell (WBC) count, location and the number of abscesses, microbiological results, and antibiotic treatment options.

Data were analyzed using GraphPad Prism 5 (GraphPad Software Inc, San Diego, California). For pairwise comparisons, the Mann-Whitney U test or Kruskal-Wallis test with post hoc Dunn test was used. A P value less than .05 was considered statistically significant.

**Results**

A total of 33 (71.7%) men and 13 (28.3%) women were included in the analysis. Patients age ranged from 18 to 82 years (mean age: 47.4 ± 17.1 years). The major complain was neck swelling (98%) and pain, ipsilateral to the DNI (86.9%; Figure 1).

A higher percentage of patients (45.6%) had dysphagia and odynophagia. Trismus was diagnosed in 13% of cases. Fever was the symptom in 41.3% of patients. Four patients had severe dyspnea at the admission. An acute dental inflammation was diagnosed in 14 (30.4%) patients. A history of pharyngitis preceding DNI was found in 12 (26%) patients.

Twenty (43.5%) patients had unknown origin of DNI. The CT and US were performed under routine investigation: both methods in 16 patients, only US in 9, and only CT in 21 (Figures 2 and 3).

The most common site involved was submandibular space (20/46), followed by parapharyngeal space (13/46) and carotid space (9/46). The abscesses were more common on the left side of the neck (57.8%). The majority (81.2%) of patients had single abscess; multiple abscesses were revealed in 8 (18.8%) cases. The mean dimensions of abscesses were 35.2 ± 37.5 mm × 40.4 ± 89.5 mm, ranging from 10 to 130 mm. Blood tests revealed increased levels of CRP in 96.7% of patients, with the mean level of 155.5 ± 146.7 mg/L (range: 1-478 mg/L). Reference number of WBC count (normal range: 4-8×10⁹/L) was increased in 60.9% of patients, with a mean count of 16.89 ± 5.59×10⁹/L (range: 7-170×10⁹/L). The mean hemoglobin level was 11.5 ± 3.9 g/dL, ranging from 8.3 to 15.2 g/dL. The mean fibrinogen level was 487.8 ± 742.7 mg/dL (range: 149-1294 mg/dL; Table 1).

All patients underwent a surgical drainage of the neck abscess under general anesthesia. During the procedure, a silicone drains were inserted into the wound to allow later abscess rinsing with local disinfectants twice a day (Figure 4).

Drains were removed after 2 days, with no purulent content found during rinsing. The patients were discharged 2 days after the removal of drains. In 2 cases, there was a second revision operation necessary with re-drain, due to the reocurrence of the symptoms post drainage removal and radiological confirmation of reformation of the abscess. Both reoperated patients had primary multiple space process. The mean hospital stay was 13.2 ± 8.4 days. The material for microbiological culture was collected during surgical drainage in 29 (63%) patients. The aerobic bacteria were isolated in 13 cases, anaerobic in 4, and the mixed flora in 12 patients. Staphylococcus aureus (n = 6) was the most commonly isolated aerobic bacteria and Peptostreptococcus sp. (n = 6) were the most common anaerobic bacteria. The results of bacterial cultures were polymicrobial in 16 patients. Overall, 28 different pathogens were isolated (Table 2).
All patients were treated with broad-spectrum intravenous antibiotics. The most commonly used empirical antibiotic therapy option was a combination of ceftriaxone and metronidazole (n = 23). Amoxicillin/clavulanic acid combined with metronidazole was used less often (n = 11). The other treatment options included clindamycin or amoxicillin/clavulanic acid. Neither of these therapeutic options proved to significantly reduce hospital stay; however, patients treated with combined ceftriaxone and metronidazole were hospitalized for 10.43 days and those treated with combined amoxicillin/clavulanic acid and metronidazole for 15.82 days. The correlation result between antibiotic therapy options and hospitalization period is presented in Table 3.

The major comorbidities in our group were cardiovascular diseases (8/46). Only 2 diabetic patients were present. Two (4.3%) patients died during hospitalization due to mediastinitis and sepsis. Patients who died despite treatment were malnourished at the admission, the one had mental disorders and the other was homeless. The sign of the upper and lower mediastinitis was demonstrated in CT scan performed on the fourth day after neck drainage due to reported thoracic pain. The patient underwent thoracic surgery for drainage, complicated with sudden cardiac arrest with ineffective resuscitation. In the second lethal case, although the sensitive antibiotics were administered after neck drainage, deterioration in general condition of the patient was observed with continuous decrease in blood pressure, diuresis, and oxygen saturation. The patient was transferred to the intensive care unit; however, due to multiple-organ dysfunction and disseminated intravascular coagulation, the treatment measures were found to be ineffective. This patient had also history of hematological treatment 5 years ago due to chronic myeloid leukemia and was observed in remission.

Statistical analysis of variables such as sex, age, dental diseases, location, size, side of abscess, CRP level, hemoglobin level, WBC count, fibrinogen level, the bacterial etiology, and the duration of hospitalization was performed. Table 4 shows that only patients with hemoglobin level below 12.5 g/dL were hospitalized significantly longer (16.23 days vs 12.09 days, \( P = .02 \)).

**Discussion**

Deep neck infection seems to be a well-studied issue in otolaryngological practice, but it is still a serious life-threatening disease. Thanks to wide availability of antibiotics that the incidence is much lower than 30 years ago and the treatment results more predictable and controlled. The important aspect is to
Table 1. Correlation of Different Variables With the Duration of Hospitalization in the Study Population.a

| Variable                        | N (%)         | Duration of Hospitalization (Days) | P Value |
|---------------------------------|---------------|-----------------------------------|---------|
| **Sex**                         |               |                                   |         |
| Male                            | 33 (71.7)     | 13.38                             | .48b    |
| Female                          | 13 (28.3)     | 13.21                             |         |
| **Age (years)**                 |               |                                   | .31c    |
| 0-40                            | 16 (34.8)     | 11.06                             |         |
| 41-60                           | 19 (41.3)     | 13.05                             |         |
| >61                             | 11 (23.9)     | 16.82                             |         |
| **Duration of symptoms before surgical drainage (days)** |       |                                   | .71c    |
| 0-3                             | 15 (37.5)     | 14.73                             |         |
| 4-7                             | 17 (42.5)     | 12.06                             |         |
| >7                              | 8 (20.0)      | 11.25                             |         |
| **Odontogenic origin**          |               |                                   | .14b    |
| Confirmed                       | 16 (43.2)     | 10.67                             |         |
| Absent                          | 21 (56.8)     | 13.63                             |         |
| **Location of the abscess**     |               |                                   | .75c    |
| Submandibular space             | 20 (43.5)     | 12.40                             |         |
| Carotid space                   | 9 (19.5)      | 12.56                             |         |
| Parapharyngeal space            | 13 (28.3)     | 13.77                             |         |
| Other                           | 4 (8.7)       | 17.50                             |         |
| **Extent of the abscesses**     |               |                                   | .58b    |
| Single abscess                  | 36 (82.6)     | 13.25                             |         |
| Multiple abscesses              | 8 (17.4)      | 14.63                             |         |
| **Side on the neck**            |               |                                   | .10b    |
| Left                            | 26 (57.5)     | 11.15                             |         |
| Right                           | 20 (43.5)     | 16.16                             |         |
| **Size of abscess (mm)**        |               |                                   | .56c    |
| <30                             | 15 (32.6)     | 16.33                             |         |
| 30-50                           | 16 (34.8)     | 11.73                             |         |
| >50                             | 15 (32.6)     | 13.83                             |         |
| **White blood cells count (10^9/L)** |       |                                   | .34c    |
| <10                             | 15 (32.6)     | 11.60                             |         |
| 10-15                           | 17 (37.0)     | 13.35                             |         |
| 15-20                           | 7 (15.2)      | 13.57                             |         |
| >20                             | 7 (15.2)      | 16.29                             |         |
| **Hemoglobin level (g/dL)**     |               |                                   | .02b    |
| <12.5                           | 13 (28.3)     | 16.23                             |         |
| >12.5                           | 33 (71.7)     | 12.09                             |         |
| **Fibrinogen level (mg/dL)**    |               |                                   | .90b    |
| <500                            | 5 (14.7)      | 11.20                             |         |
| >500                            | 29 (85.3)     | 13.69                             |         |

aP value <.05 is considered statistically significant.
bMann-Whitney U test.
cKruskal-Wallis test.

identify factors that may influence the course of treatment and therefore give some indications for optional or supplementary therapy.

According to the literature, DNI in adult patients moderately predominate in men, with the highest incidence ranging from 40 to 60 years.12,13 The most common location of DNI is not defined, due to different eligibility criteria in published researches. Some authors present the data such as the peritonsillar abscesses that are of high incidence, but generally not recognized as infection of deep space. The submandibular space is the most commonly identified location of DNI, followed by parapharyngeal space.12,14,15 These locations predominated in our study group; however, we did not found the difference between the duration of hospitalization and different abscess site. Some authors report that the multiple spaces involved in DNI are prognostic factors for increased complication rate, but not for the long-term hospitalization.16 In our population, we also did not observe significantly longer hospitalization among 8 patients with more than 1 space involved. The precise identification of the inflammatory process cause may be difficult in some cases due to previous antibiotic treatment and delayed occurrence of DNI. However, the majority of studies confirm odontogenic disease as a most common cause of DNI in adult patients.7,17-19 There is an agreement among authors concerning the increasing rate of unknown primary origin of DNI that stands for 16% to 50% of cases.6,7,16,17 In our study, the patients with confirmed tooth decay have 43.2% of cases and their hospitalization stay was compared to those with other causes of DNI. On the contrary, Staffieri et al found that DNI with odontogenic origin had significantly shorter hospitalization; however, the complication rate did not differ among study groups.16 Interestingly, the duration of symptoms before admission and therefore the delay in surgical drainage did not correlate in our patients with the final hospitalization period. It is also surprising that the level of inflammatory proteins (CRP, fibrinogen) and the WBC count had insignificant difference between the duration of hospitalization and different abscess site. Some authors report that the multiple spaces involved in DNI are prognostic factors for increased complication rate, but not for the long-term hospitalization.16 In our population, we also did not observe significantly longer hospitalization among 8 patients with more than 1 space involved. The precise identification of the inflammatory process cause may be difficult in some cases due to previous antibiotic treatment and delayed occurrence of DNI. However, the majority of studies confirm odontogenic disease as a most common cause of DNI in adult patients.7,17-19 There is an agreement among authors concerning the increasing rate of unknown primary origin of DNI that stands for 16% to 50% of cases.6,7,16,17 In our study, the patients with confirmed tooth decay have 43.2% of cases and their hospitalization stay was compared to those with other causes of DNI. On the contrary, Staffieri et al found that DNI with odontogenic origin had significantly shorter hospitalization; however, the complication rate did not differ among study groups.16 Interestingly, the duration of symptoms before admission and therefore the delay in surgical drainage did not correlate in our patients with the final hospitalization period. It is also surprising that the level of inflammatory proteins (CRP, fibrinogen) and the WBC count had insignificant difference between the duration of hospitalization and different abscess site. Some authors report that the multiple spaces involved in DNI are prognostic factors for increased complication rate, but not for the long-term hospitalization.16 In our population, we also did not observe significantly longer hospitalization among 8 patients with more than 1 space involved. The precise identification of the inflammatory process cause may be difficult in some cases due to previous antibiotic treatment and delayed occurrence of DNI. However, the majority of studies confirm odontogenic disease as a most common cause of DNI in adult patients.7,17-19 There is an agreement among authors concerning the increasing rate of unknown primary origin of DNI that stands for 16% to 50% of cases.6,7,16,17 In our study, the patients with confirmed tooth decay have 43.2% of cases and their hospitalization stay was compared to those with other causes of DNI. On the contrary, Staffieri et al found that DNI with odontogenic origin had significantly shorter hospitalization; however, the complication rate did not differ among study groups.16 Interestingly, the duration of symptoms before admission and therefore the delay in surgical drainage did not correlate in our patients with the final hospitalization period. It is also surprising that the level of inflammatory proteins (CRP, fibrinogen) and the WBC count had insignificant
inflammation, diagnosis of parapharyngeal space abscesses, and identification of complications. The widely accepted therapeutic method in neck abscesses is surgical drainage of pus from external incisions combined with empirical, broad-spectrum intravenous antibiotic. The first-line treatment recommended is amoxicillin with clavulanic acid or other β-lactam–resistant antibiotic combined with a drug of high efficacy against anaerobes (such as metronidazole and clindamycin). Rare practice is conservative treatment with intravenous antibiotics combined with CT-based monitoring. However, Boscolo-Rizzo et al presented successful therapeutic results of such approach in 226 of 365 adult patients with DNI. Another custom method is US-guided drainage of deep neck space abscesses. Several authors recommend US-guided technique as an effective, less invasive, and cost-effective

Figure 4. Steps of surgical drainage of cervical abscess. A, Vertical incision medial to the sternocleidomastoid muscle and drainage of abscess with pus evacuation. B, Central vertical and additional lateral incision for placement of rinsing drains. C, Intraoperative rinsing drains placement. D, Drains localization after skin suturing.

Table 2. List of Pathogens Identified in 29 Microbiological Examinations From Neck Abscesses.

| Aerobic Bacteria | N | % | Anaerobic Bacteria | n | % |
|------------------|---|---|--------------------|---|---|
| Staphylococcus aureus | 6 | 21 | Peptostreptococcus sp. | 6 | 21 |
| Streptococcus pyogenes | 5 | 17 | Prevotella sp. | 5 | 17 |
| Streptococcus constellatus | 4 | 14 | Fusobacterium nucleatum | 4 | 14 |
| Streptococcus C (β-hemolytic) | 3 | 10 | Propionibacterium acnes | 2 | 7 |
| Streptococcus anginosus | 3 | 10 | Parvimonas micra | 2 | 7 |
| Streptococcus intermedius | 2 | 7 | Bacteroides uniformis | 2 | 7 |
| Streptococcus intermedius | 2 | 7 | Prevotella nigrescens | 1 | 3 |
| Streptococcus mitis | 2 | 7 | Prevotella ruminicola | 1 | 3 |
| Corynebacterium striatum | 1 | 3 | Fusobacterium necrophorum | 1 | 3 |
| pseudomonas aeruginosa | 1 | 3 | Veillonella sp. | 1 | 3 |
| Garnella haemolyans | 1 | 3 | Prevotella intermedia | 1 | 3 |
| Streptococcus oralis | 1 | 3 | Slackia exigua | 1 | 3 |
| Staphylococcus epidermidis | 1 | 3 | Parvimonas asaccharolytica | 1 | 3 |
|                          |   |   | Bacteroides distasonis | 1 | 3 |
|                          |   |   | Atopobium rimae | 1 | 3 |

Table 3. Comparison of Hospital Stay Duration in Relation to Applied Antibiotic Option in the Study Population.

| Antibiotic treatment | N | Mean Duration of Hospitalization (Days) | P Value |
|----------------------|---|----------------------------------------|---------|
| Ceftriaxone + metronidazole | 26 | 10.43 | .13* |
| Amoxicillin/clavulanic acid + metronidazole | 11 | 15.82 | |
| Other options | 7 | 14.12 | |

*Kruskal-Wallis test.

Table 4. Comparison of Hospital Stay Duration (Days), Level of Inflammatory Parameters (C-Reactive Protein, White Blood Cell Count), and Hemoglobin level in 3 Groups of Identified Microbial Pathogens (Aerobic, Anaerobic, Mixed Flora).

| Pathogen Category | n | Variable | P Value |
|-------------------|---|----------|---------|
| Aerobic | 13 | Mean duration of hospitalization (days) | .77* |
| Anaerobic | 4 | 15.0 | |
| Mixed | 12 | 14.75 | |
| Anaerobic | 10 | C-reactive protein mean level (mg/L) | .48* |
| Mixed | 11 | 102.3 | |
| Aerobic | 13 | Mean white blood cell count (10⁶/L) | .25* |
| Anaerobic | 4 | 206.5 | |
| Mixed | 12 | 13.89 | |
| Anaerobic | 13 | Hemoglobin mean level (g/dL) | .14* |
| Mixed | 12 | 13.86 | |

*Kruskal-Wallis test.

*Mann-Whitney U test.
procedure; however, we do not have experience with the method.\textsuperscript{20,21}

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