

Original Research Article

Ludwig's angina: analysis of clinical features and their management strategy: a study of 30 patients

Harpreet Singh¹, Rupinder Singh^{2*}, Gagandeep Goyal³, Vikas Dhillon¹,
Varun Arora¹, Asitama Sarkar⁴

¹Department of Otorhinolaryngology and Head and Neck Surgery, Park Hospital, Karnal, Haryana, India

²Department of Otorhinolaryngology and Head and Neck Surgery, Kalpana Chawla Govt. Medical College, Karnal, Haryana, India

³Department of General Surgery, MMIMSR, Mullana, Ambala Haryana, India

⁴Department of Otorhinolaryngology and Head and Neck Surgery, Rajawadi Hospital, Mumbai, Maharashtra, India

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*Correspondence:

Dr. Rupinder Singh,

E-mail: drupinderdhillon@gmail.com

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ABSTRACT

Background: Ludwig's Angina is rapidly progressing infection of submandibular space that can cause severe airway compromise and death. The present study was done to evaluate the clinical features and management strategies in Ludwig's angina.

Methods: Thirty patients presenting with clinical diagnosis of Ludwig's Angina were recruited in the study. All patients were given systemic antibiotics. Tooth extraction and surgical drainage was done wherever required. Patient records were reviewed for age, sex, duration of symptoms, clinical presentation, etiology, culture/sensitivity reports, requirement of surgical drainage or tracheostomy, hospital stay and complications.

Results: The most common age group was third decade of life. Caries tooth was most common etiology followed by gingivitis. Difficulty in swallowing and pain in neck were the most common symptoms. Diabetes was the most common associated co-morbidity followed by chronic renal failure. Surgical treatment was required in twenty-one cases. Eight cases were treated medically while one patient expired during medical treatment. Necrotizing fasciitis was the most common complication. For most patients the hospital stay was between 1-2 weeks.

Conclusion: We advocate that surgical management should be done at earliest in presence of respiratory difficulty as medical treatment alone can prove to be dangerous. It can be managed conservatively in younger patients without any associated co-morbidity or respiratory difficulty. However no single factor can predict the behaviour of this disease and it is advisable to be ready for immediate airway management.

Keywords: Ludwig's Angina, Neck swelling, Submandibular space

INTRODUCTION

Ludwig's angina was formally described in 1836 by Wilhelm Friedrich von Ludwig when he reported rapidly progressive soft tissue infection, involving the submandibular space and floor of the mouth in five patients. Angina is derived from the Latin word *angere* which means to strangle.¹ Ludwig's angina is a rapidly spreading cellulitis that usually begins in the

submandibular space, resulting from an infected lower molar, and then rapidly spreads to involve the sublingual space, usually on a bilateral basis. Swelling of critical spaces threatens to elevate the floor of the mouth, displace the tongue posteriorly and, thereby strangle the patient.²

Ludwig's angina usually develops from dental or periodontal infection, especially of the 2nd and 3rd

mandibular molars.³ The second and third molar roots are routinely below the mylohyoid ridge, and infection presenting on the lingual surface will enter the submandibular space.⁴ It has, however, been reported as a result of mandibular fracture, submandibular sialadenitis, peritonsillar abscess, epiglottitis and oral malignancies.^{5,6} Predisposing factors include dental caries, recent dental treatment, systemic illness such as diabetes mellitus, malnutrition, alcoholism, compromised immune system such as AIDS and organ transplantation.⁷

Ludwig's angina begins as a mild infection and can rapidly progress to brawny bilateral induration of the upper neck with pain, trismus, and tongue elevation. The major manifestations are pain in the area of the involved tooth, tender induration of the submandibular region, trismus, dysphonia, drooling and inability to swallow; and dyspnea and stridor from laryngeal oedema and tongue elevation. Patients may appear quite toxic, sitting upright, drooling and tachypneic. Fever, chills, and tachycardia are usually present. The patient develops a toxic condition, and respiration becomes difficult.⁴

The infection is often caused by a haemolytic *Streptococcus*, although the infection may be a mixture of aerobic and anaerobic organisms, which may account for the presence of gas in the tissues. The most commonly reported aerobes are alpha-haemolytic *Streptococci*, followed by *Staphylococcus*. As a rule, gram-negative organisms do not play a significant role in Ludwig's angina, although *Haemophilus influenzae*, *Escherichia coli*, and *Pseudomonas* have all been reported. Forty percent of Ludwig's angina cases involve anaerobes.⁷

Treatment of Ludwig's angina depends on the stage of disease when the patient presents. In the early stages of Ludwig's angina simple intravenous antibiotics and supportive measures may be sufficient. In patient with more advanced disease or any symptoms of airway compromise, early airway intervention is advocated. The choice of antibiotics must be tailored to the individual patient, but high-dose penicillin (12 to 16 million units/day) is considered the drug of choice.^{4,7} Surgical treatment is directed at securing an airway and providing surgical drainage. Classically, tracheostomy was considered as the standard of care for establishment of a definitive airway.⁸ Elective awake tracheostomy has been suggested for all patients with deep neck infections in order to avoid the dangers of emergency tracheostomy in a severely compromised airway.⁹ This notion has since been questioned.¹⁰ Flexible fiber optic nasal intubation is the preferred method of airway management in skilled and experienced hands and has a high rate of success.¹¹ The choice of airway manoeuvres must be individualized, depending on the judgment and experience of the physician in charge.¹² Once the airway is established, surgical drainage is performed. Drainage consists of a wide surgical decompression of the suprahyoid region.

The most serious complication of Ludwig's angina is asphyxia caused by expanding edema of soft tissues of the neck which may compromise the airway and may lead to the death of the patient.¹² The next major potential complication of Ludwig's angina is extension of the infection to the carotid sheath or retropharyngeal space with inferior extension into the mediastinum. Later findings of mediastinal extension include increasing signs of septic shock with tachycardia and decreasing blood pressure, crepitation of the lower neck or development of mediastinal crepitation.¹³ A computed tomography scan is helpful in assessing the extent of retropharyngeal extension of the abscess and may also help to decide when an artificial airway is required.¹⁴ Other complications can include asphyxiation, aspiration pneumonia, lung abscesses, and metastatic sepsis.

The present study was done to analyse the clinical features with which patients present and categorize them into mild, moderate and severe degree of Ludwig angina and to make a protocol when to do surgical drainage and tooth extraction if the cause is odontogenic.

METHODS

The present study was carried out in the patients presenting with clinical diagnosis of Ludwig's angina in the OPD/emergency of E.N.T. and Oro-Maxillary Surgery department of Government Medical and Dental College, Amritsar between March, 2014 to August, 2015. The patients were recruited in the study after an informed consent based on following inclusion and exclusion criteria and approval of ethical committee was taken.

Inclusion criteria

Rapidly progressive cellulitis; not an abscess. Involves bilateral submental, sublingual and submaxillary spaces. Absence of other deep neck space infections that could alter the treatment outcome.

Exclusion criteria

Fascial space infections involving deep neck and mediastinal infections. Unilateral submental, sublingual and submaxillary cellulitis.

All the patients were admitted and routine investigations of Hb, TLC, DLC, BT, CT, PBF, Fasting/Random Blood Sugar, Renal function tests (B. urea/S. creatinine) Urine examination, viral markers (HIV, Hbs Ag, HCV) were done. Besides as per need radiological investigations like antero-posterior and lateral X-rays of the neck, C.T. scan of neck if required, X-ray of teeth and panoramic tomography was done.

All patients were given systemic antibiotics (amoxycylav, amikacin and metronidazole) The regimen was changed later according to the sensitivity report. Vitals were monitored closely. Tooth extraction as and when required

was carried out. Wherever needed, surgical drainage was done to prevent emergency tracheostomy for airway compromise and the aspirate after drainage was sent for isolation of microorganism and their antibiotic sensitivity testing as per CLST guidelines. Follow up of the patients after discharge was done for a period of 3 weeks.

Patient records were reviewed for age, sex, duration of symptoms, clinical presentation, etiology, other systemic disease, culture/sensitivity of aspirated pus, treatment received, requirement of surgical drainage or tracheostomy, duration of hospital stay and complications. The data was statistically analysed using the statistical package for Social Science (SPSS) 21.0 (Copyright © SPSS Inc.) Statistical significance was accepted at $p < 0.05$.

RESULTS

Most common age group was 21-30 years (33.33%) followed by 31-40 years (20%). In this study of 30 patients, 13 (43.33%) patients were male, while 17 (56.67%) patients were female. Most of patients i.e. 25 (83.33%) were from rural areas, while only 5 patients (16.67%) were from urban areas. This difference is highly significant, likely reason being poor orodental hygiene.

Table 1: Distribution of patients according to etiology.

Etiology	No. of patients	Percentage (%)
Caries tooth	25	83.33
Post tooth extraction sepsis	1	3.33
Gingivitis	2	6.67
Submandibular gland abscess	1	3.33
Infectious mononucleosis	1	6.67
Total	30	100

Degree of freedom=4, $\chi^2=75.333$, $p=0.000$, highly significant

Most of cases (83.33%) were caused by caries tooth followed by gingivitis (6.67%). One case (3.33%) was caused by post extraction sepsis, submandibular abscess and infectious mononucleosis each. Second and third molars caused 92% of the infectious.

All patients (100%) presented with neck swelling, difficulty swallowing and pain in neck. 90 % patients presented with trismus. Fever was reported in 80% of the patients. Drooling of saliva was seen in 76.67% of the patients. While 12 (40%) patients presented with difficulty in breathing. 10 patients (33.33%) also complained of hoarseness of voice.

Associated co-morbidity was present in 18 patients (60%). Diabetes was the commonest of these, which was

seen in 6 patients (20%) of which one had co-existent chronic renal failure.

Table 2: Symptoms at the time of presentation.

Symptoms	No. of patients	Percentage (%)
Neck swelling	30	100
Difficulty in swallowing	30	100
Pain in neck	30	100
Difficulty in breathing	12	40
Trismus	27	90
Fever	24	80
Drooling of saliva	23	76.67
Hoarseness of voice	10	33.33



Figure 1: Classic features of Ludwig's angina-neck swelling, trismus, raised floor of mouth and tongue.

Table 3: Associated comorbidities.

Comorbidity	No. of patients	Percentage (%)
Diabetes mellitus	6	20
Chronic renal failure	3	10
Anaemia	2	6.67
Pregnancy	3	10
Congenital heart disease	1	3.33
Asthma	1	3.33
Cardiomyopathy	1	3.33
Hypertension	1	3.33
Total	18	60

Table 4: Treatment given.

Treatment	No. of patients	Percentage (%)
Conservative	9	30
Incision and drainage	21	70
Total	30	100

9 patients (30%) responded well to conservative treatment while 21 patients (70%) required both medical plus surgical treatment. Most number of patients

(42.86%) required incision and drainage on 2nd day of admission, while 6 patients (28.57%) required this procedure on first day of admission.

Table 5: Distribution of bacterial isolates in cases of Ludwig's angina where incision and drainage were done.

Bacterial isolate	No. of specimens	Percentage (%)
Aerobes	14	66.67
Anaerobes	2	9.52
No growth	5	23.81
Total	21	100

The above table shows that from total 21 specimens, 16 (76.19%) were found positive for bacterial isolates. Out of 16 positive specimens 14 (87.5%) had aerobic growth and 2 (12.5%) had anaerobic growth. Most common bacterial isolate seen was *Citrobacter* spp, seen in 4 (25%) isolates, followed by *pseudomonas aeruginosa*, *staphylococcus aureus*, *streptococcus viridians*, each seen in 2 (12.5%) cases. While Coagulase negative *Staphylococcus*, *Acinetobacter*, *Enterococcus* and *Spirochaetes* seen in one (6.25%) case each only. Two

(12.5%) cases of bacteroids were seen which is an anerobe.

Table 6: Complications during treatment.

Complication	No. of patients	Percentage (%)
Necrotising fasciitis	5	16.67
Parapharyngeal abscess	1	3.33
Death	1	3.33
Totals	7	23.33

The most common complication was necrotizing fasciitis which was seen in 5 patients (16.67%).

Table 7: Duration of hospital stay.

Duration of stay (week)	No. of patients	Percentage (%)
Up to 1	10	33.33
1-2	15	50
2-3	5	16.67

Maximum hospital stay was between 1-2 weeks in 15 patients (50%).

Table 8: Profile of three patients who developed respiratory difficulty during treatment.

Age (Years)	Duration of swelling (days)	Inter-incisor distance (cm)	consistency	hoarseness	TLC	Incision at day	Associated co-morbidity
25	10	1	Hard	No	10800	2	No
24	7	0.8	Hard	No	15400	2	No
25	5	1.3	Hard	Present	16500	3	Cardiomyopathy

Table 9: Profile of patients who developed complications during treatment.

Age (years)	Duration of swelling (days)	Associated co-morbidity	Difficulty in breathing	Hoarseness	Inter-incisor distance (cm)	Complication
60	10	Diabetes + chronic renal failure	Absent	No	2	Death
82	3	Diabetes	Absent	No	2.7	Necrotising fasciitis
55	2	Chronic renal failure	Present	Present	1.5	Parapharyngeal abscess
47	7	Diabetes	Absent	No	3.2	Necrotising fasciitis
60	4	Chronic renal failure	Present	Present	3.5	Necrotising fasciitis
65	10	Diabetes	Absent	No	1.7	Necrotising fasciitis
65	3	Chronic renal failure	Present	Present	3.2	Necrotising fasciitis

All three patients had higher duration of swelling combined with decreased inter-incisor distance (Table 8).

It shows that two main factors which increased morbidity in patients were associated systemic illness and age of the patient. Diabetes and chronic renal failure were most commonly associated comorbidity seen. (Table 9)

DISCUSSION

Ludwig's angina is an aggressive deep neck space infection often caused by dental infection from polymicrobial organisms. Ludwig's angina was formerly invariably fatal but now, with adequate surgical and antibiotic treatment, has a much-reduced rate of mortality. Treatment involves airway protection,

appropriate antibiotic therapy and surgical decompression.

Low oral hygiene among rural people is a predisposing factor. Patients of poor socioeconomic status comprised 70% in a study of 50 cases of Ludwig's angina.¹⁵ In the present study, most of patients were from rural background. The largest group consisted of patients in 21 to 30 years of age. The mean age of the study group was 40.43 years. The patients included in the present study were almost evenly divided on the basis of their gender.

Odontogenic cause was seen in 75% cases and post extraction sepsis was seen in other 25% in a study done on 16 cases of Ludwig's angina in Nigerian tertiary facility.¹⁶ In a study done to evaluate medical treatment of Ludwig's angina in 47 patients, the odontogenic cause was found in 85.1% followed by pharyngitis in 8.5% and submandibular sialadenitis in 6.4%.¹⁷ The main etiological factor in our study was found out to be caries tooth followed by gingivitis. Post dental extraction sepsis was causative factor in one case. Submandibular abscess and infectious mononucleosis were responsible for one case each. Thus, poor oral hygiene caused majority of the cases. Thus, it can be concluded that odontogenic causes are the commonest of the etiological factors in Ludwig's angina which is statistically highly significant.

A study done by Fakir et al on 50 cases of Ludwig's angina showed neck swelling, pain in neck and fever in 100% cases, whereas dysphagia was present in 80%.¹⁵ In another study done by V Sharma fever and neck swelling was present in 100% cases, halitosis was present in 68% cases, difficulty in swallowing was present in 63.8% of cases, hoarseness of voice was present in 61.7% cases. Trismus was present in 36.2% of cases and respiratory difficulty in 8.5% of cases.¹⁷ The foremost symptoms of patients presented in our study were neck swelling, difficulty in swallowing, pain neck, halitosis, inability to open mouth, fever and pain tooth. Few patients also complained of difficulty in breathing and hoarseness of voice. No patient had stridor at presentation.

In another study entitled deep neck infections: analysis of 185 cases, 34.1% had underlying systemic disease of which 88.8% had diabetes mellitus, 9.5% had chronic renal failure, 4.8% had liver cirrhosis, 2.4% had myelodysplastic syndrome and 1.2% had gastric malignancy.¹⁸ In our study more than half of patients had associated co-morbidities. Among them, most common was diabetes mellitus followed by chronic renal failure. Three patients were pregnant and two were anaemic. One patient each had chronic heart disease, hypertension, cardiomyopathy and asthma as associated co morbidity.

All patients were given systemic antibiotics (amoxyclav, amikacin and metronidazole). The regimen was changed later, according to the sensitivity report. Surgical drainage was done in majority of cases whereas remaining nine patients received medical treatment only.

Of these 9 patients, one patient died due to septicemic shock but the rest of patients did not show any signs of respiratory compromise, and there was no need of surgical treatment. In another study done in Dhaka, out of 50 cases, 40 (80%) had to be drained surgically, while only 10 cases could be treated medically, the reason for surgical drainage again being abscess formation and airway compromise.¹⁵

Out of 21 patients, incision and drainage was done in 3 cases when abscess had formed after giving medical treatment, so as to drain the pus and to prevent it causing airway compromise and other complications. The history of long duration of swelling and associated co-morbidities seem to be predisposing factor for abscess formation.

In 5 patients' surgical treatment was done when superficial necrotizing fasciitis had started, so as to avoid further complications and airway compromise. Of the rest 13 patients, 10 had difficulty in breathing at presentation, so surgical drainage was done to prevent emergency tracheostomy, while 3 patients developed difficulty in respiration during treatment, so incision and drainage had to be done to prevent emergency tracheostomy. These three patients did not improve upon medical treatment as evidenced by appearance of respiratory difficulty, persistent fever, local tenderness and inability to start liquid diet.

It was found that higher duration of swelling combined with decreased inter-incisor may be a risk factor for failure of medical therapy. Hoarseness of voice, if present, is due to oedema of vocal cords and may be a good predictor of impending airway failure. The incision and drainage relieved respiratory distress in all these patients. With this approach none of our patients had to be undergo tracheostomy or endotracheal intubation.

Septicaemia, mediastinitis, empyema thoracis, necrotising fasciitis, laryngeal spasm and renal failure were the complications recorded in 5 cases (31.3%) in a study done in Nigeria.¹⁶ In our study 7 patients had developed complications. Most common complication seen was necrotizing fasciitis. One patient developed parapharyngeal abscess which was later drained, and one patient died due to cardiopulmonary failure from concurrent diabetes mellitus and chronic renal failure. Most of the patients did not have any complication and recovered well. The complication was seen only in patients who had associated systemic illness.

It was observed that two main factors which increased morbidity in patients were associated systemic illness and age of the patient. Among systemic illnesses, diabetes and chronic renal failure were seen most commonly. These complications accounted for the death of 4 patients. Thus, even in presence of wonderful antibiotics in present era, systemic illnesses pose a major threat in patients to develop life threatening complications.



Figure 2: Necrotising fasciitis seen as complication of Ludwig's angina.

In another study done by V. Sharma, the mean duration of hospital stay was 10 days, with range of 6-15 days.¹⁷ In a retrospective analysis of 298 deep neck infections, the mean length of hospital stay was 12.6 days with a range of 4-33 days.¹⁹ In our study the duration of hospital stay was between 1-2 weeks in majority of patients. The mean duration of hospital stay was 9.3 days. It was found that associated co-morbidities played an important role in increasing the stay of patient in hospital, hence adding to the morbidity.

In a similar study by Ugboko et al, where 15 patients were surgically treated, aerobic bacteria were seen in 11 cases, 3 cases showed no growth while 1 showed anaerobic growth.¹⁶ In another study done by Sharma, 12 samples were cultured, anaerobic growth was not seen in any sample, while 5 samples showed no growth.¹⁷ In the present study, 21 patients were surgically treated. Of the 21 pus aspirates, majority showed growth of aerobic bacteria, very few showed anaerobic or no growth. Thus, the results of our study are in concordance with other studies.

In the study done by Fakir et al, out of 32 samples, most common organism was streptococcus (13 cases) followed by staphylococcus (6 cases) E. coli (4 cases) and Pseudomonas (3 cases).¹⁵ In the study done in Nepal, most common isolate was staph aureus (46.1%) followed by streptococcus (15.4%).¹⁷ In our study 16 samples showed bacterial growth. Gram positive were cultured in 6 samples while gram negatives in 8 samples. 2 cases were of anaerobes. Among Gram negative, *Citrobacter* spp was the commonest followed by *pseudomonas aeruginosa*. Among Gram positives, *staphylococcus aureus* and *streptococcus viridians*, were seen in few cases each. Coagulase negative *staphylococcus*, *acinetobacter*, *enterococcus* and *spirochaetes* were seen in one case each. The microorganisms seen in our study do not match with those seen in other studies. This may be due to use of pre-operative antibiotics which may have killed the more sensitive gram-positive bacteria allowing more resistant gram-negative bacteria to grow or there may be changing trend of microbiological profile of deep neck abscesses.

The clinical features with which patients presented can be divided into Mild Ludwig's angina such as age ≤ 40 years without difficulty in breathing or hoarseness, swelling neck, difficulty swallowing, trismus, pain in neck, drooling of saliva, halitosis, pain tooth and fever

Moderately severe Ludwig's angina such as age ≤ 40 years with difficulty in breathing or hoarseness, age $>40 \leq 60$ with or without difficulty in breathing or hoarseness, age >60 without difficulty in breathing or hoarseness, rest of features of mild Ludwig's angina, severe Ludwig's angina, age >60 years with difficulty in breathing or hoarseness, any age with systemic illness like diabetes, chronic renal failure, aplastic anaemia, HIV, etc. and rest of features of mild Ludwig's angina.

Based on the clinical features with which the patient presents and their outcome with respect to complications, length of hospital stays, morbidity to the patient, mortality and need for surgical drainage or not, it can be inferred that surgical drainage and tooth extraction in odontogenic cases should be done in following conditions:

- In patients presenting with any associated systemic illness like diabetes, chronic renal failure, SLE, HIV, aplastic anaemia etc.
- When patient presents with respiratory difficulty, stridor or cyanosis.
- When any complication has occurred such as necrotizing fasciitis, abscess formation in deep neck spaces such as parapharyngeal space, prelaryngeal, pretracheal or retropharyngeal space.
- When the patient age is above 60 years.
- If patient not responding to medical treatment as evidenced by appearance of respiratory difficulty, persistent fever and appearance of additional symptoms.
- Tooth extraction, if required should be done at the earliest when mouth opening is adequate.

CONCLUSION

It can be concluded that in today's modern era of improved antibiotics, Ludwig's Angina is still a morbid disease. Patients present with difficulty in swallowing, trismus, pain in neck, respiratory difficulty, hoarseness, halitosis and drooling of saliva. The most common cause is caries tooth although it can be caused by submandibular sialadenitis, oral cancer, epiglottitis etc. Diabetes, chronic renal failure and other systemic illnesses increase the risk of complications, hospital stay and can also lead to mortality. The disease has favourable outcome in children, but can be fatal if neglected. Respiratory difficulty if present warrants early surgical treatment to relieve the tension in neck spaces. Hoarseness indicates oedema of vocal cords and is a sign of impending airway compromise. If the patient is not improving on medical treatment or getting worse then the need for surgical drainage should be considered strongly.

Presence of difficulty in breathing makes it moderate to severe disease. Advanced age and associated systemic illness are two major factors that predict a poor outcome. The bacteria cultured in specimens indicate that there may be change in trends of microbiological profile of Deep Neck abscesses. Gram negative bacteria are increasingly found in these abscesses. Though, modern antibiotics have increased the outcome of Ludwig's Angina but it should be taken seriously especially in cases with associated systemic illnesses and advanced age. We advocate that surgical management should be done at earliest in presence of respiratory difficulty as medical treatment alone can prove to be dangerous. It can be managed conservatively in younger patients without any associated co-morbidity or respiratory difficulty. However no single factor can predict the behaviour of this disease and it is advisable to be ready for immediate airway management.

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REFERENCES

1. Tshiassny K. Ludwig's angina: an anatomic study of the lower molar teeth in its pathogenesis. *Arch Otolaryngol Head Neck Surg*, 1943;38:485-96.
2. Gerald Mandell John Bennett Raphael Dolin. *Principles and Practice of Infectious Disease*. 7th edi, Churchill Livingstone. 1994;870-1.
3. Mark Richardson, Paul Flint, Bruce Haughey, Valerie Lund, John Niparko, K. Robbins, J. Regan Thomas, Marci Lesperance. *Cummings Otolaryngology-Head and Neck Surgery*, 3 vol 5th Edi, 1993;1199-215.
4. Fritsch DE, Klein DG. Curriculum in critical care: Ludwig's angina. *Heart and Lung: J Critical Care*. 1992;21(1):39-47.
5. Stanley RE, Liang TS. Acute epiglottitis in adults. *J Laryngol Otol*. 1988;102:1017-21.
6. Ovassapian A, Tuncbilek M, Weitzel EK, Joshi CW. Airway management in adult patients with deep neck infections: A case series and review of the literature. *Anesth Analg*. 2005;100(2):585-9.
7. Har-El G, Aroesty JH, Shaha A, Lucente FE. Changing trends in deep neck abscess. A retrospective study of 110 patients. *Oral Surg Oral Med Oral Pathol*. 1994;77(5):446-50.
8. Linder HH. The anatomy of the fasciae of the face and neck with particular reference to the spread and treatment of intraoral infections that have progressed into adjacent fascial spaces. *Ann Surg*. 1986;204:705-14.
9. Barakate MS, Jensen MJ, Hemli JM, Graham AR. Ludwig's angina: report of a case and review of management issues. *Ann Otol Rhinol Laryngol*. 2001;110:453-6.
10. Loughnan TE, Allen D. Ludwig's angina: the anesthetic management of 9 cases. *Anesth*. 1985;40:295-7.
11. Saifeldeen K, Evans R. Ludwig's angina. *Emer Med J*. 2004;21:242-3.
12. Spitalnic SJ, Sucov A. Ludwig's angina: case report and review. *J Emerg Med*. 1995;13:499-503.
13. Parhisar A, Har-EL E. Deep neck abscess. A retrospective review of 210 cases. *Ann Otol Rhinol Laryngol*. 2001;110:1051-4.
14. Quinn FB Jr. Ludwig angina. *Arch Otolaryngol Head Neck Surg*. 1999;125:599
15. Fakir M A, Bhuyan M. Ludwig's Angina: a study of 50 cases. *Ban J Otorhinolaryngol* 2008;14(2):51-6.
16. Ugboko V, Ndukwe K. Ludwig's Angina: An Analysis of Sixteen Cases in a Suburban Nigerian Tertiary Facility. *Afr J oral Health*. 2005;2(1):16-23.
17. Sharma V. Ludwig's angina evaluation of its medical treatment in 47 cases. *J Col Med Sci Nep*. 2011;7(3):1-5.
18. Huang TT, Liu TC. Deep neck infection: analysis of 185 cases. *Head Neck*. 2004;26(10):854-60.
19. Khode S, Bhatt P. Retrospective Analysis of 298 Cases of Deep Neck Infections: Its Diagnosis and Management. *Sci J of Med and Clinical Trials* 2013;103(3):2012.

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