Research

Comparison of open and closed drainage in multiple deep neck abscesses

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ABSTRACT

Background: Management of deep neck abscesses includes evacuation of pus from the abscess location, which can generally be divided into open drainage and closed drainage. Data regarding their comparison in deep neck abscesses are still inadequate. **Purpose:** To compare open and closed drainage in the management of patients with multiple deep neck abscesses. **Method:** Observational research using a cross-sectional design on 71 subjects diagnosed with multiple deep neck abscesses at RSUP Dr. Mohammad Hoesin Palembang who underwent drainage. **Result:** 37 subjects underwent open drainage (52.1%) and 34 underwent closed drainage (47.9%). A statistically significant difference between the open and closed drainage groups was observed in length of stay, duration until drain removal, days until the pus changed color and pus drained per day. **Conclusion:** Open drainage had more favorable outcomes compared to closed drainage. Comorbid factors were found to be affecting the efficacy of abscess drainage.

Keywords: multiple deep neck abscesses, open drainage, closed drainage

ABSTRAK

Latar belakang: *Tatalaksana pada abses leher dalam mencakup evakuasi pus, yang dibedakan menjadi drainase terbuka* (open drainage) *dan tertutup* (closed drainage)*. Data mengenai perbandingan dua modalitas evakuasi pus ini masih belum memadai.* ***Tujuan:*** *Untuk membandingkan drainase terbuka dan drainase tertutup, pada tatalaksana pasien abses leher dalam multipel.* ***Metode:*** *Penelitian observasional dengan rancangan potong lintang pada 71 subjek dengan diagnosis abses leher dalam multipel, di RSUP Dr. Mohammad Hoesin Palembang, yang menjalani tindakan drainase.* ***Hasil:*** *Didapatkan 37 subjek menjalani drainase terbuka (52.1%) dan 34 menjalani drainase tertutup (47.9%). Terdapat perbedaan yang bermakna, di mana lama rawat inap, lama drain hingga drain dilepas dan jumlah hari hingga pus berubah warna pada kelompok drainase terbuka lebih singkat, dan jumlah pus per hari lebih banyak pada kelompok drainase terbuka.* ***Kesimpulan:*** *Kelompok drainase terbuka ditemukan memiliki luaran yang lebih baik. Faktor komorbid ditemukan mempengaruhi efektifitas dari drainase abses.*

Kata kunci: *abses leher dalam multipel, open drainage, closed drainage.*

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INTRODUCTION

Deep neck abscess (DNA) is an infection that occurs in the deep neck and facial potential space, and is characterized by the accumulation of pus in the potential space between the deep fascia of the neck. This accumulation of pus occurs as result of the expansion of various inflammatory processes, such as infections of the teeth, pharynx, tonsils, paranasal sinuses, and ears, or due to trauma.[1] The incidence was estimated at 10/100,000 in adults and 2/100,000 in children.[2] In the United States, the prevalence of deep neck infections was about 3,400 hospitalized patients each year, and retropharyngeal abscesses had increased significantly from 0.1 per 10,000 patients in 2000 to 0.22 per 10,000 patients in 2009.[3] Currently, the incidence of deep neck abscesses in various major hospitals in Indonesia is not yet known for certain. The incidence of deep neck abscesses in Indonesia was studied at Hasan Sadikin Hospital, Bandung during 2012 and found 28 cases of deep neck abscesses.[4] Research at Mohammad Hoesin Hospital Palembang found 91 cases of deep neck abscess from 2018 to 2021.[5]

The management of deep neck abscess neck include evacuation of pus, which can be differentiated to *open drainage* and *closed drainage*. Data regarding comparison of the two modalities was still not yet accurate. Retrospective research by Ramasamy et al.[6] in Malaysia, compared the use of *open* and *closed* techniques drainage, and found that the group undergoing *closed drainage* had a shorter hospital stay and better wound healing compared to the *open drainage* group. Hyun et al.[7] studied the use of *closed drainage* on neck abscess and found that the use of closed drains has been clinically proven to be good for the management of deep neck abscesses because of the minimal incision and relatively easy post-operative care. Karodpati et al.[8] found that 80% of patients with deep neck abscesses neck in Maharastra, India had good response when management began with open drainage. Abrahamet et al.[9] compared management of superficial abscesses and found that *closed drainage* had better outcomes to *open drainage*. Research by Raj et al.[10] found that in the breast abscesses, *closed drainage* had better outcomes than *open drainag*e.

METHOD

This was a retrospective observational study, using a *cross-sectional design* with secondary data, aimed to compare *open* and *closed drainage* in multiple deep neck abscess patients, conducted at the Medical Records Installation of Dr. Mohammad Hoesin Hospital, Palembang during the period September 2023 to October 2023. The research population were the medical record of deep neck abscess patients who underwent inpatient treatment at Dr. Mohammad Hoesin Palembang Hospital, who had fulfilled the inclusion criteria.

Inclusion criteria

Medical records of deep neck abscess patients who had undergone abscess drainage and had been installed either open or closed drainage under general anesthesia at Dr. Mohammad Hoesin General Hospital Palembang which had a complete data.

Exclusion criteria

1. Medical records of deep neck abscess patients who has undergone abscess drainage under general anesthesia with a drain at Dr. Mohammad Hoesin General Hospital Palembang but died or did not complete management.
2. Medical records of deep neck abscess patients who has undergone abscess drainage elsewhere.

RESULT

Univariate analysis result

Univariate analysis in this study included demographic factors of the subjects which were age, gender, history of comorbid factors and risk factors. In addition, factors related to deep neck abscesses were also presented, including the onset of symptoms before hospitalization, and the number of deep neck spaces involved.

Based on age category, most research subjects were in the 19-60 years age group, which was 62 patients (87.3%). In this study, there were more men (63.4%) than women (36.6%). Subjects with comorbidities were 40 subjects (56.3%), with the most comorbidities being diabetes mellitus as many as 25 subjects (62.5%), while without comorbidities were 31 people (43.7%). The most common risk factor found was dentin caries, which was found in majority of patients with multiple deep neck abscesses, as many as 61 subjects (85.9%). Based on onset of symptoms before hospital admission, the mean number of days of symptom onset before coming to the hospital was 10.10 days (SD±9.07). Based on the number of deep neck spaces involved, 41 subjects had involvements of 3 or more spaces (57.7%), and 30 subjects with 2 spaces (47.3%). Of the 71 study samples, 37 underwent *open drainage* (52.1%) and 34 underwent *closed drainage* (47.9%). The average length of hospitalization of the study sample was 13.76±8.59 days. The average number of days until the drain was removed in the study sample was 11.13±7.39 days. The average number of pus per day in the study sample was 12.58±6.66 cc/day. The average number of days until the pus changed color in the study sample was 8.39±6.03 days. The distribution of characteristics of the study subjects was presented in Table 1.

Table 1. Characteristics of research subjects

Variables	N	%	Med (Min-Max)	X±SD
Age			42 (16-78)	
0-18 years	1	1.4		
19-60 years	62	87.3		
>60 years	8	11.3		
Gender				
Male	45	63.4		
female	26	36.6		
Comorbid factor				
Yes	40	56.3		
No	31	43.7		
Comorbid Factors (+)				
Diabetes Melitus	25	62.5		
Hypertension	18	45.0		
Obesity	19	47.5		
Immunocompromised	5	12.5		
Risk factor				
Yes	62	87.3		
No	9	12.7		

Risk factor (+)				
Dentin caries	61	85.9		
Smoking	14	22.5		
Alcohol	2	0.03		
Trauma	9	12.7		
Respiratory tract infection	9	12.7		
Neck Space Involved			3 (2-5)	
2	30	42.3		
≥3	41	57.7		
Drainage				
Open Drainage	37	52.1		
Closed Drainage	34	47.9		
Length of stay				
Amount of day			11 (4-41)	13.76±8.59
Amounts of days until drain removed				
Drain time			9 (3-37)	11.13±7.38
Average amount of pus per days				
Amount of pus			12 (2-30)	12.58±6.66
Amounts of days until pus changed color				
Amounts of days			7 (1-35)	8.39±6.03

Bivariate analysis result

Bivariate analysis in this study was the analysis of the mean difference between two groups of independent variables using *the independent t-test* if the data was normally distributed, and if the data was not normally distributed using the *Mann-Whitney* test. Normality analysis of the of comorbid factors using the Shapiro-Wilk method sig values showed of all dependent variables was <0.05, which indicated that the data did not have a normal distribution, and required bivariate analysis using the *Kruskall-Wallis* method; in which sig value <0.05 indicateed the influence of comorbid factors on the tested variables.

Comparison of length of hospitalization between *open* and *closed drainage* in patients with multiple deep neck abscesses

In this study, 71 samples were divided into 37 *open drainage samples* and 34 *closed drainages. In the open drainage* group, the mean length of hospitalization was 9.78 days with an SD of 4.21. In the *closed drainage group,* the average value of the length of hospitalization was 14.32 days, with an SD of 6.51. *Mann-Whitney* analysis showed that there was a statistically significant difference in the length of hospitalization with an *asymp.sig value of* 0.001 (*asymp. sig <0.05*). Comparison of the length of hospitalization between open and closed drainage in patients with multiple deep neck abscesses could be seen in Table 2.

Table 2. Comparison of length of hospitalization between *open and closed drainage* in patients with multiple deep neck abscesses

Length of stay stay (day)	*Open drainage (n = 37)*	*Closed drainage (n = 34)*	*Asymp.sig*
X±SD	9.78 ± 4.21	14.32±6.51	**0.001* (<0.05)**
Med (min-max)	9 (4-24)	13 (6-35)	

**Mann-Whitney*

Comparison of days to drain removal between *open* and *closed drainage* in patients with multiple deep neck abscesses

In this study, 71 samples were divided into 37 *open drainage* samples and 34 *closed drainages*. In the *open drainage* group, the mean number of days until the drain was removed was 8.08 days, with an SD of 3.91. In the *closed drainage* group, the mean number of days until the drain was removed was 8.08 days, with an SD of 3.91. The mean value of the number of days until the drain was removed was 11.97 days with an SD of 5.70. The *Mann-Whitney* analysis showed that there was a statistically significant difference in the number of days until the drain was removed *with an asymp.sig value of* 0.001 (*asymp.sig <0.05*). Comparison of the number of days until the drain was removed between open and closed drainage in patients with multiple deep neck abscesses could be seen in Table 3.

Table 3. Comparison of the number of days until the drain is removed between *open* and *closed drainage* in patients with multiple deep neck abscesses

Amounts of days until drain removed	*Open drainage (n = 37)*	*Closed drainage (n = 34)*	*Asymp.sig*
X±SD	8.08±3.91	11.97±5.70	**0.001* (<0.05)**
Med (min-max)	7(4-24)	10 (3-25)	

**Mann-Whitney*

Comparison of the amount of pus drained per day between *open* and *closed drainage* in patients with multiple deep neck abscesses

In this study, 71 samples were divided into 37 *open drainage* samples and 34 *closed drainages*. In the *open drainage* group, the mean value of the amount of pus drained per day was 15.00cc, with an SD of 7.06. In the *closed drainage* group, the mean value of the amount of pus drained per day was 15.00cc with an SD of 7.06. The average value of the amount of pus drained per day was 9.94cc, with an SD of 5.10. *Mann-Whitney* analysis showed that there was a statistically significant difference in the number of days until the drain was removed with an *asymp.sig value of* 0.002 (*asymp.sig< 0.05*). Comparison of the amount of pus drained per day between *open* and *closed drainage* in patients with multiple deep neck abscesses could be seen in Table 4.

Table 4. Comparison of the amount of pus drained per day between *open* and *closed drainage* in patients with multiple deep neck abscesses

Pus drained per day (cc)	*Open drainage (n = 37)*	*Closed drainage (n = 34)*	*Asymp.sig*
X±SD	15.00±7.06	9.94±5.10	**0.002* (<0.05)**
Med (min-max)	15 (2-30)	9 (3-24)	

**Mann-Whitney*

Comparison of the number of days until pus changes color between *open* and *closed drainage* in patients with multiple deep neck abscesses

In this study, 71 samples were divided into 37 *open drainage* samples and 34 *closed drainages*. In the *open drainage* group, the mean number of days until the pus changed color was 5.32 days, with an SD of 2.67. In the *closed drainage* group, the mean number of days until the pus changed color was 5.32 days, with an SD of 2.67. The mean value of the number of days until the pus changes color was 10.08 days, with an SD of 4.69. *Mann-Whitney* analysis showed that there was a statistically significant difference in the number of days until the drain was removed with an *asymp.sig value of* 0.000 (*asymp.sig <0.05*). Comparison of the number of days until the pus changed color between *open* and *closed drainage* in patients with multiple deep neck abscesses could be seen in Table 5.

Table 5. Comparison of the number of days until pus changes color between *open* and *closed drainage* in patients with multiple deep neck abscesses

Days the pus changed color	*Open drainage (n = 37)*	*Closed drainage (n = 34)*	*Asymp.sig*
X±SD	5.32±2.67	10.08±4.69	**0.000* (<0.05)**
Med (min-max)	5 (2-13)	10 (1-20)	

**Mann-Whitney*

Comorbid factors in *open* and *closed procedures drainage* in patients with multiple deep neck abscesses

In this study, 71 samples were divided into 37 *open drainage samples* and 34 *closed drainages*. In the *open drainage* group, 17 samples were obtained with comorbid factors, and 20 samples without comorbid factors. Comorbid factors in the open drainage group were diabetes mellitus (DM) (58%, n=10), hypertension (41%, n=7), obesity (41%, n= 7), and immunocompromised (17%, n= 3). In the *closed group drainage*, 20 samples were obtained with comorbid factors, and 14 samples without comorbid factors. Comorbid factors in the *closed group drainage* were DM (75%, n=15), hypertension (55%, n=11), obesity (60%, n=12) and immunocompromised (10%, n= 2). The normality test showed that the data distribution was not normal, so the analysis was continued with *Kruskall-Wallis analysis*, which showed that there was a difference in the number of comorbid factors with *drainage* actions on multiple deep neck abscesses, with an *asymp.sig value <0.05*. The analysis was continued with *post-hoc analysis,* and it was found that there was an influence of comorbid factors on the research variables. *Open drainage* group *without* comorbid factors were found to have shorter hospital stays, number of days until the drain was

removed, and number of days until the pus changed color, as well as a greater amount of pus drained compared to the *closed group drainage* with comorbid factors (*sig <0.05*).

DISCUSSION

Length of stay is a multifactorial variable, and an important aspect of health care management, affecting not only the patient experience but also the overall efficiency of health care delivery. Longer hospital stays can lead to higher health care costs, reduced patient satisfaction, and increased risk of hospital-acquired infections. Conversely, shorter lengths of stay can improve patient satisfaction, free up hospital resources for other patients, and reduce costs. Striking a balance between providing appropriate care and minimizing length of stay is a critical challenge in health care. Comorbidities that weaken the immune system or chronic illness may contribute to a longer recovery period, and require more time in the hospital. Delay in diagnosis can result in the development of infection and the development of complications.[5,11]

Ramasamy et al.[6] found that closed drainage groups had shorter length of hospital stay (5.5 days) compared to the open drainage group (9.5 days). Hyun et al.[7] found that in *closed drainage* which was performed on patients with deep neck abscesses, the average length of hospitalization was 26 days, but did not compare the results with open drainage. The difference in findings showed the importance of further research with larger and bigger samples. Length of stay was longer in *closed drainage* in this study, which might be caused by complications after drain installation. *Closed drainage* streams pus from abscess to outside of the body, and if blockage either by clotting or necrotic tissue occured, it might hinder optimal drainage. Care of *closed drainage* also requires good coordination with patient. If patient moves a lot, the drain can shift and disrupts the vacuum nature of the drain, reducing the flow of pus to outside of the body.[12] Raj et al.[10] compared *open* and *closed drainage* on breast abscesses, and found that *closed drainage* had a shorter treatment period and less painful, compared to *open drainage*. According to this study result, deep neck abscess patients with *open drainage* had a shorter treatment period. This might be used as consideration for further studies, and clinical decision of physicians in treating deep neck abscess.

Drainage of a deep neck abscess is critical to the success of the patient's management and prognosis. There is an old adage in medicine "*never let the sun sets on an undrained abscess* ", or *"ubi pus, ibi evacua"* (if there is pus, then remove it) which is a guideline for doctors in the management of all types of abscesses, including deep neck abscesses.[13] The main point is to drain pus from the abscess cavity efficiently. In addition, drain can reduce pressure, reduce pain, prevent the spread of infection to surrounding tissues or organs by removing infected material from the body, and preventing re-accumulation of pus, and encouraging the formation of healthy granulation tissue which helps wound healing.[12,13]

Drain removal is performed based on clinical judgment on the production and consistency of pus, as well as other factors such as infection around the drain site, so that the clinician is able to decide to remove the drain. If the drain is pulled out too quickly before the abscess cavity is properly drained, or the infection is under control, this can lead to recurrent abscesses, complications, and prolonged healing times. This can result in prolonged patient discomfort and increased health care costs. Meanwhile, if drains are left in place for too long, there is a risk of complications such as scarring, increased risk of infection, and discomfort. All of this should be carefully considered to ensure that the abscess is drained properly, infection is

controlled, and healing is efficient. Proper timing will minimize patient discomfort, reduce the risk of complications, and speed up the patient's recovery to normal.[5,12,13]

As far as we know, there had been no research on the comparison of the length of time the drain was installed, the amount of pus drained, or the number of days until the pus changed color, in cases of deep neck abscesses, between *open* and *closed drainage.* Study by Lee et al.[14] on the characteristics of drains in Plastic Surgery patients, found that patients with *closed drainage* required longer drain installation (7.26±3.58 days) compared to *open drainage* (2.31±1.79 days). *Closed drainage* group had a higher secondary infection rate compared to *open drainages*. There was a risk of blockage on the closed drainage channel. If good post-operative care was not carried out, it could be one of the factors why *closed drainage* need to be longer installed, and had a higher rate of secondary infection. There was a risk of displacement in *closed drainage* by the patient during the treatment process, which could also cause loss of vacuum capacity of the *closed drainage*, and reduced the amount of pus that could be successfully evacuated evacuated from the abscess cavity, which will resulted in longer duration of installation. Unlike *open drainag*e, which has passive drainage and drains are routinely replaced, *closed drains* will remain in the patient during the treatment process, until the clinician assesses that the drain can be removed. According to research by Dower et al.[15] regarding *closed drainage* in general, bacterial biofilm could form within 2 hours after drain insertion. The formation of biofilm will increase the risk of secondary infection at the insertion site, which would be directly related to the patient's healing process.

The change in color of pus from purulent to serous, is one of the indicators of wound healing. In the wound healing process, there are several phases that occur, namely the inflammatory, proliferation and remodeling phases.[16] The inflammatory phase is the body's initial response to tissue damage. It begins immediately after injury, and can last for several days. Key processes during this phase include vasoconstriction and hemostasis to stop bleeding, recruitment of inflammatory cells (neutrophils and macrophages) to remove debris, and release of cytokines that coordinate the healing process. In this process, the pus that forms is still purulent. After the inflammatory phase, there is a proliferation phase characterized by active tissue reconstruction. This phase can last for several weeks and includes processes such as angiogenesis (formation of new blood vessels), fibroblast activity (production of collagen for tissue support), and epithelialization (recovery of the wound surface). In this phase, pus production has decreased, and the color of the pus will begin to change to serous. The final phase of wound healing is *remodelling*, which can last for several months. During this phase, the tissue matures and gains strength. The main processes include collagen remodelling to replace the original collagen with stronger fibers, scar formation, and functional recovery, which can vary depending on the location and severity of the wound. Research by Lee et al.[14] regarding *drain characteristics* in Plastic Surgery patients found that patients, the *closed drainage group* had a higher secondary infection rate (15%) compared to *open drainages* (8%), but did not describe the color of pus in both groups. The process of changing the color of pus from purulent to serous was faster in the *open drainage group.* This study illustrated that the wound healing process would be faster in *open drainage.* This could be caused by the risk of blockage and secondary infection in *closed drainages.*[14]

The research of Chi et al.[17] stated that the comorbid diseases found in cases of deep neck abscess were diabetes mellitus (59.4%) and hypertension (7.8%). Velhonoja et al.[18] reported 114 patients with deep neck abscesses who had one or more comorbid

factors, patients with psychiatric disorders or dementia were 55 (19.9%), patients with diabetes mellitus without treatment were 31 (11.2%), with insulin treatment 17 (6.1%) and *immunocompromised* patients as many as 23 (8.3%). Diabetes mellitus is a major public health problem worldwide. The relationship between diabetes mellitus and infection has been established for many years. In animal and in vitro studies, host immune function has been reported to be impaired by short-term or long-term hyperglycemia, including neutrophil function, cellular immunity, and complement activation, which put patients with diabetes mellitus at higher risk for severe and invasive infections, such as pyogenic infections, and viral, and fungal infections. Chi et al.[17] study reported that elderly patients and those with comorbid diabetes were susceptible to deep neck abscesses. Hyperglycemia could interfere with several humoral body defense mechanisms, such as neutrophil function that caused adhesion, chemotaxis, and phagocytosis; wich resulted in a predisposition to infection and complications. Microvascular damage by hyperglycemia would reduce blood flow to the wound site, so that the wound site would experience a slow tissue regeneration process. In addition, hyperglycemia would also reduce platelet function, where platelets played an important role in the hemostasis phase of the wound healing process. Hypertension and obesity were also associated with chronic low-grade inflammation that would reduce the function of the immune system, so that sufferers would be more susceptible to infection. Adipose tissue (fat) would produce inflammatory cytokines, which could cause chronic inflammation throughout the body. Hypertension was also associated with inflammation, where high pressure on the endothelium of blood vessels would release inflammatory cytokines. Chronic inflammation could interfere with the ability of immune cells to respond effectively to infection, making the body more susceptible to various diseases. High levels of pro-inflammatory cytokines would slow the transition of wound healing from the inflammatory phase to the proliferative phase.[5,16]

In this study it was found that the *open drainage group* without comorbid factors were found to have shorter hospital stays, number of days until the drain was removed, and number of days until the pus changed color, as well as a greater amount of pus drained compared to the *closed drainage group* with comorbid factors. This could be caused by several factors. Comorbid factors such as diabetes mellitus would worsen the ongoing infection, which could manifest with pus viscosity and necrotic tissues that had the potential to cause blockage in the *closed drainage*, so that drainage of pus from the abscess cavity was minimal. This could be avoided in the *open drainage technique*¸ where drainage was done passively but access for pus to come out of the abscess cavity was relatively greater.[12,14] Comorbid factors could also increase the risk of secondary infection, which will then affect the length of hospitalization and interfere with the healing process of deep neck abscesses. Research by Lee et al.[14] showed that *closed drainage* required a longer drain installation time, and a higher secondary infection rate compared to *open drainage*, and the presence of comorbid factors could further influence this.[5]

In conclusion, the result of this study suggested that *open drainage* had more favorable outcomes compared to *closed drainage*, and comorbid factors were found to be affecting the efficacy of abscess drainage. Future studies are needed to furtherly compare and assess each of the advantages and disadvantages of both methods.

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REFERENCE

1. Moor JW. Neck space infections. In: Watkinson JC, Clarke RW, editors. Scott-Brown's Otorhinolaryngology: Head and Neck Surgery. 8th ed. Boca Raton: CRC Press; 2018. p. 623–31.
2. Tiwana H, Gupta S, Prakash DN, Panda N, Chetan B, Angrup A, Ray P, et al. Current trends in pathogenesis, management, bacteriology and antibiotic resistance in deep neck space infections: an institutional review. Ann Indian Acad Otorhinolaryngol Head Neck Surg. 2020;4(1):5-9.
3. Woods CR, Cash ED, Smith AM, Smith MJ, Myers JA, Espinosa CM, et al. Retropharyngeal and parapharyngeal abscesses among children and adolescents in the United States: epidemiology and management trends, 2003-2012. J Pediatric Infect Dis Soc. 2016 Sep;5(3):259–68.
4. Imanto, Mukhlis. Evaluasi Penatalaksanaan Abses Leher Dalam di Departemen THT-KL Rumah Sakit Hasan Sadikin Bandung Periode Januari 2012- Desember 2012. Juke Unila. 2015.
5. Yanti LA, Lubis FM, Bahar E, Ghanie A. Factors associated with the length of stay of deep neck abscess patients. ORLI 2022; 52(1):1-6. doi: 10.32637/orli.v52i1.473
6. Ramasamy P, Kumarasamy V, Jun TK, Periasamy C, Singh ASM. A 3 Years Retrospective Analysis of Outcome on the Patients Underwent Open and Closed Drains Following Incision and Drainage for Head and Neck Abscess. Presented on the Malaysian Society of Otorhinolaryngologists- Head & Neck Surgeons Annual Meeting, 2016. doi: 10.13140/RG.2.2.10250.39367
7. Hyun SY, Oh HK, Ryu JY, Kim JJ, Cho JY, Kim HM. Closed suction drainage for deep neck infections. J Craniomaxillofac Surg. 2014;42(6):751-56. doi:10.1016/j.jcms.2013.11.006
8. Karodpati N, Kuradagi V, Chavan P, Pawar R, Kakollu LS. A clinical study of deep neck space infection. 2021. Int J Otorhinolaryngol Head Neck Surg. 2021 Feb;7(2):349-353.
9. Abraham N, Doudle M, Carson P. Open versus closed surgical treatment of abscesses: a controlled clinical trial. Aust N Z J Surg. 1997;67:173-76.
10. Raj M, Arya S, Chejara RK, Chaudhary R, Mani V. Management of breast abscess by open drainage with primary closure versus standard incision and drainage: a randomized clinical trial. J Clin Diagn Res. 2021;15(5):PC05-PC08. doi: 10.7860/JCDR/2021/48187.14852
11. Freddo AL, Gomes FV, Martins CAM, Fristcher GG, Torriani MA. Odontogenic infections: severe complications associated with diabetes mellitus. 2013. Rev Odonto Cienc 2013;28(4):110-115.
12. Chevrollier GS, Rosato FE, Rosato EL. Fundamentals of drain management. In: Palazzo F, editor. Fundamentals of General Surgery. 1st ed. Cham: Springer; 2018. p. 143–59.
13. Thomas N, Tavvala A, Swarnapriya M, Nair RR, Famida PA. Deciphering deep neck space infections and its management: a case series. J Clin Diagn Res. 2023;17(4):MR01–MR05.
14. Lee HM, Park JW, Na YC. Influence of drain characteristics and other known risk factors on surgical site infection occurrence in plastic surgery patients. J Wound Manag Res. 2023;19(1):28–37. doi:10.22467/jwmr.2022.02341
15. Dower R, Turner ML. Pilot study of timing of biofilm formation on closed suction wound drains. Plast Reconstr Surg. 2012;130(5):1141-1146. doi:10.1097/PRS.0b013e318267d54e
16. Garbuio DC, Zamarioli CM, Silva NCM, Oliveira-Kumakura ARS, Carvalho EC. Assessment tools for the healing of wounds: an integrative review. Rev Eletr Enf. 2018;20(20).
17. Chi TH, Tsao YH, Yuan CH. Influences of patient age on deep neck infection: clinical etiology and treatment outcome. Otolaryngol Head Neck Surg. 2014;151(4):586-90. doi:10.1177/0194599814542589

18. Velhonoja J, Lääveri M, Soukka T, Irjala H, Kinnunen I. Deep neck space infections: an upward trend and changing characteristics. Eur Arch Otorhinolaryngol. 2020;277(3):863–72. doi:10.1007/s00405-019-05742-9