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Research Article

Predicting Neck Abscess with Contrast-Enhanced Computed Tomography

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Neck abscesses are difficult to diagnose and treat. Currently, contrast-enhanced computed tomography (CECT) is the imaging modality of choice. The study aims to determine the predictive value of CECT findings in diagnosing neck abscess, causes of neck abscess and the most common neck space involved in the local population. 84 consecutive patients clinically suspected to have neck abscess who underwent CECT and surgical confirmation of pus were included. Demographic and clinical data were recorded. 75 patients were diagnosed as having neck abscess on CECT; out of those 71 patients were found to have pus. Overall CECT findings were found to have a high sensitivity (98.6%) and positive predictive value (PPV) (94.7%) but lower specificity (67.2%) in diagnosing neck abscess. The CECT diagnostic criterion with the highest PPV is the presence of rim irregularity (96%). The most common deep neck space involved is the submandibular compartment, which correlates with the finding that odontogenic cause was the most common identifiable cause of abscess in the study population. Thus, in a patient clinically suspected of having neck abscess, CECT findings of a hypodense mass with rim irregularity are helpful in confirming the diagnosis and guiding clinical management.

1. Introduction

Neck abscesses are still commonly encountered in the era of widespread antibiotic usage. Neck abscesses are usually sequelae of upper respiratory tract infection, odontogenic infection, or even direct trauma [1–5]. These abscesses may spread into adjacent compartments of the neck or into the mediastinum via the retropharyngeal, parapharyngeal, carotid, or prevertebral spaces [1, 2]. The potentially life-threatening complications associated with neck abscess include respiratory embarrassment, mediastinitis, internal jugular vein thrombosis, pseudoaneurysm, fulminant sepsis, and even death. Therefore, neck abscess poses significant morbidity and mortality risks such that any patient suspected to have it should be assessed and treated immediately [1, 3, 6, 7]. However, it is recognized that neck abscesses are difficult to diagnose and treat. Currently, contrast-enhanced computed tomography (CECT) of the neck is the imaging modality of choice in determining the presence of neck abscess and the neck spaces involved. In clinical routine, the examination of the neck should be extended to include the evaluation of the mediastinum in order to exclude the presence of a descending necrotizing mediastinitis as one of the complications aforementioned.

The classical radiological description of an abscess is that of a hypodense mass with complete rim enhancement [8–14]. Often, difficulty arises in differentiating a neck abscess from a phlegmon. A phlegmon is usually described as an area of hypodensity with soft tissue oedema and loss of fat plane but without rim enhancement [1, 3]. However, evidence has suggested that a rim-enhancing fluid collection seen on CECT does not necessarily preclude the presence of an abscess. Fluid collection with partial or absent rim enhancement may be present in early abscess or cellulitis. Presence of air within

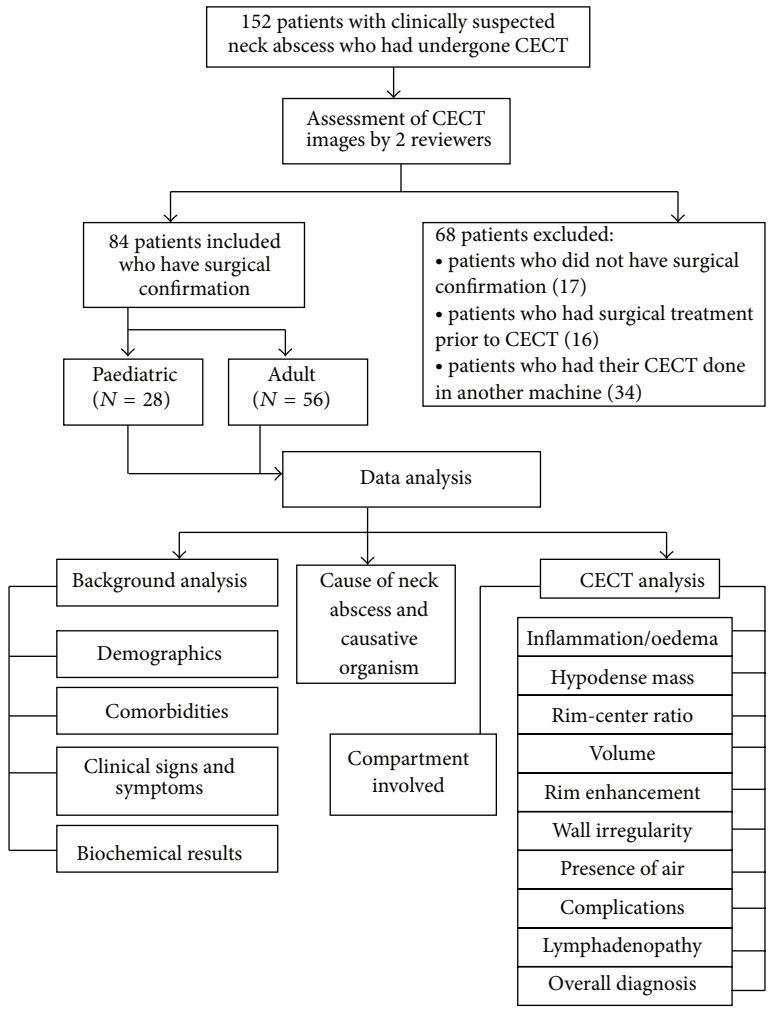

Figure 1: Study methodology.

the fluid collection and irregularity of abscess wall have been shown to be better predictors of abscess than just rim enhancement [9, 11].

The decision for surgical drainage is often guided by imaging studies in concurrence with patient's clinical status. Larger abscesses usually require incision and drainage. However, abscess in its early stage when it is still small, confined to a single compartment or non-fluctuant, may be treated conservatively with intravenous antibiotics, thus, reducing potential operating costs, hospital stay, and morbidity associated with surgery and anaesthesia [8, 14–16].

2. Methodology

2.1. Study Design. 152 patients referred for a CECT of the neck between September 2010 and August 2012 on clinical suspicion of an abscess were consecutively recruited. Out of these, 84 patients, 28 children (aged less than 18 years old) and 56 adults who were followed by surgical confirmation of whether pus was present or absent, were included. 68 patients were excluded for reasons as depicted in the flow chart (Figure 1). Patients were divided into 2 groups based on whether pus was present (abscess) or absent (non-abscess group) by open neck exploration or fine needle aspiration. Demographics including age, sex and ethnicity, and clinical data including signs and symptoms, such as pain, swelling and fever, presence of comorbidities, white blood cell (WBC) count prior to surgery, and culture of pus and swab specimens, were collected from the Hospital Information System (HIS). Ethical clearance for the study was obtained from the Malaysian Ministry of Health Research and Ethics Committee.

2.2. CECT Image Acquisition and Analysis. Patients were examined using a 4-slice CT scanner (Toshiba Aquilion Model TSX-101A 2002). Patients were scanned supine in a plane parallel to the hard palate from the base of skull to manubrium using full helical rotation without gantry tilt. 50 mL of low osmolar contrast media (LOCM) followed by 30 mL of normal saline was used at a rate of 2 mL/second. In children, the amount of LOCM used was 1.5–2 mL/kg. Image reconstruction was done using Multiview program in coronal and sagittal plane. The acquired axial slice thickness was 5.0 mm for adult and 3.0 mm for children. Thinner slices

were reconstructed at 2.0 mm with reconstruction intervals of 1.8 mm for all patients. Two reviewers, a radiologist and a radiology registrar, blinded to the clinical and surgical findings reviewed the CECT neck images electronically via Picture Archiving and Communications System (PACS). Review of images was done on the same computer and viewer using the same software (Centricity Radiology RA1000 Workstation, GE Healthcare, Barrington, United States of America) for all patients. Criteria for the presence of abscess included the following:

(i) presence of signs of inflammation, induration, or cellulitis,

(ii) presence of a hypodense mass,

(iii) rim-center ratio,

(iv) estimation of abscess volume,

(v) rim enhancement,

(vi) irregularity of abscess wall,

(vii) presence of air,

(viii) presence of complications,

(ix) presence of lymphadenopathy,

(x) final overall CECT diagnosis.

2.3. Statistical Analysis. Statistical analysis was performed using SPSS software (SPSS Inc., Chicago, IL; version 20). Continuous variables were expressed as mean ± SD/range and categorical variables as percentages (%). Comparisons of variables between the abscess and non-abscess group were done using the independent sample t-test for continuous and χ^2-test for categorical variables. The tests were 2-tailed; P value < 0.05 was considered statistically significant. CECT diagnostic criteria of abscess were compared with surgical confirmation of whether pus was present or absent to calculate the percentages of true positives, false positives, true negatives, false negatives, positive predictive value (PPV), and negative predictive value (NPV).

3. Results

3.1. Patient Characteristics. Out of the 84 patients included in the study, 72 patients (85.7%) were placed in the abscess group and 12 patients (14.3%) in the non-abscess group. In the abscess group, there were 25 children (34.7%) and 47 (65.3%) adults. Meanwhile in the non-abscess group, there were 3 children (25%) and 9 adults (75%). The youngest patient in the abscess group was a neonate at day 18 of life while the oldest patient was 98 years old. Mean age was 28.3 years old. In the non-abscess group, the youngest patient was 3 years old and the oldest was 48 years old with mean age of 27.6 years old. Most patients were male in both abscess and non-abscess groups. In the abscess group, 51 patients (70.8%) were male while in the non-abscess group, 7 patients (58.3%) were male. Malay was the majority ethnicity in the abscess group (69.4%), followed by Chinese (12.5%) and Indian (4.2%). Similarly, in the non-abscess group, Malay was the majority (58.3%), followed by Indian (16.7%) and Chinese (8.3%). These statistics grossly reflect the ethnicity background of Malaysia. The majority of the patients in the abscess group had no associated comorbidities (56.9%). Of the 31 patients (43.1%) with concurrent comorbidities, 14 (45.1%) had multiple associated comorbidities while 17 (54.8%) had single comorbidity. Diabetes mellitus was the most common associated comorbidity in the abscess group, being present in 22 out of 72 patients (30.6%). Presence of hypertension, hypercholesterolemia, hyperlipidemia, end-stage renal disease, ischemic heart disease, stroke, and morbid obesity was seen only in the abscess group. 50% of the patients in the non-abscess group had associated comorbidities. Of these, 4 patients (66.7%) had single comorbidity and only 2 patients (33.3%) had multiple comorbidities. In the non-abscess group, only one patient (8.3%) had diabetes mellitus. Frequency of each type of comorbid is shown in Table 1.

Table 1: Frequency of comorbidities in abscess versus non-abscess groups.

Comorbidities	Number of patients	
	Abscess group ($N = 72$)	Non-abscess group ($N = 12$)
Diabetes mellitus	22	1
Hypertension	14	
Hypercholesterolemia	2	
Hyperlipidemia	2	
End-stage renal disease	2	
Ischemic heart disease	2	
Thalassemia trait	1	
Stroke	2	
Morbid obesity	1	
Recent chicken pox infection	1	
Peptic ulcer disease	2	
Asthma		1
Hepatitis B	1	
Down's syndrome	1	
Pleomorphic adenoma of parotid		1
Carcinoma of larynx	1	
Nasopharyngeal carcinoma		1
Hypothyroidism	1	
Old pulmonary tuberculosis	1	
Knee osteoarthritis	1	
Branchial cyst		1
Nasal polyps		1
Slipped intervertebral disc		1

The most common presenting symptoms in the abscess group are swelling (95.8%) and pain (73%). Documented temperature of more than 37.5° was present in 32.7%. Trismus is seen in only 24 patients (33.3%) in the abscess group. It is most commonly seen in patients with submandibular (14 out of 21) and masticator space (8 out of 10) involvement. 26.4% of patients had dysphagia and 16.7% had odynophagia. In the non-abscess group, swelling and pain were also the most common presenting symptoms, comprising 11 patients

Table 2: Frequency of isolated organism.

Organism	Number of patients ($N = 35$) (%)
Klebsiella pneumoniae	15 (42.9)
Staphylococcus aureus	6 (17.1%)
BSA *Streptococcus* beta haemolytic Group A	2 (5.7%)
Enterococcus sp.	2 (5.7%)
Pseudomonas aeruginosa	1 (2.8%)
Burkholderia (*pseudo*) *pseudomallei*	1 (2.8%)
Achromobacter	1 (2.8%)
Klebsiella ozaenae	1 (2.8%)
Proteus mirabilis	1 (2.8%)
Candida sp.	1 (2.8%)
Streptococcus, beta haemolytic Group B	1 (2.8%)
Enterobacter cloacae	1 (2.8%)
Escherichia coli	1 (2.8%)
Staphylococcus aureus + *Pseudomonas aeruginosa*	1 (2.8%)

(91.7%) each. Only one patient had a documented temperature of more than 37.5°. Two patients (16.7%) had symptoms of dysphagia and/or odynophagia. Of these, one had an acute-on-chronic sialadenitis of the submandibular gland who also had trismus on presentation. All patients except for one patient in the abscess group had signs of swelling. The patient with no visible swelling was morbidly obese and later was found to have retropharyngeal abscess on CECT. 58.3% of patients had tenderness on palpation and 38.9% had erythema. Fluctuance was only noted in 13 patients (18.1%). In 24 patients (33.3%), the lesions were still firm/tense/hard on palpation. 45 patients (62.5%) had at least two symptoms associated with abscess, that is, swelling, tenderness, inflammation, and/or fluctuance. Direct observation of pus discharge was noted in 5 patients (6.9%). In the non-abscess group, all patients had swelling on clinical examination. Half of them had tenderness on palpation. Fluctuance was noted on palpation in one patient whose lesion was a branchial cyst. In 4 patients, there was associated warmth on palpation. These patients were subsequently diagnosed with Ludwig's angina, carcinoma of tonsil, branchial cyst, and cellulitis, respectively. Two patients (16.7%) had associated erythema.

In the abscess group, the cause was not identified in 45 patients (62.5%). In 8 patients, the abscess was preceded by an upper respiratory tract infection. 16 patients (22.2%) had odontogenic cause of the abscess. Other causes include mastoiditis, infected mandibular plate and screws, and tuberculosis. Table 2 lists the most common causative organism isolated from cultures of pus and wound swab specimens from the abscess group. In 31 patients (43.1%), there was no growth from the pus/wound swab specimens. Overall, *Klebsiella pneumoniae* was the most common organism isolated, seen in 42.9% of patients, followed by *Staphylococcus aureus* (17.1%) despite only 30.6% of patients having diabetes mellitus. *Staphylococcus aureus* was the most common organism isolated in children, seen in 6 patients (46.2%). There were 2 patients (15.4%) who had *Klebsiella pneumoniae* and another 2 patients (15.4%) with BSA *Streptococcus* beta haemolytic Group A. Both *Staphylococcus aureus* and BSA *Streptococcus* beta haemolytic Group A were only seen in children. *Klebsiella pneumoniae* accounted for 13 out of 19 (68.4%) adult patients. All patients had WBC count performed on admission. Mean WBC in the abscess group was 16.6×10^9/L with minimum of 5.8×10^9/L and maximum of 53.0×10^9/L. In the non-abscess group, mean WBC was 10.3×10^9/L with minimum of 4.0×10^9/L and maximum of 20.8×10^9/L. There was significant difference in the mean WBC between the abscess group and non-abscess group ($P < 0.05$).

Table 3: Overall CECT diagnosis versus surgical findings.

Overall CECT diagnosis	Surgical findings	
	Abscess	Non-abscess
Abscess ($N = 75$)	71 (true positive)	4 (false positive)
Non-abscess ($N = 9$)	1 (false negative)	8 (true negative)

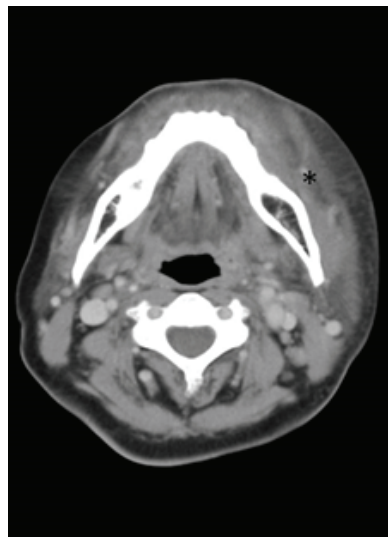

Figure 2: Axial CECT of the neck of a patient diagnosed with cellulitis on CECT but confirmed to have pus during surgery. Diffuse oedema of the superficial space and buccinator muscles at the left submandibular region noted (asterisk) (false negative case).

3.2. CECT Findings. Table 3 shows comparison of result between overall CECT diagnosis with surgical findings.

There was one case diagnosed as cellulitis (Figure 2) on CECT, which had pus on surgery (false negative) and subsequently was treated as left submandibular abscess. There were 4 cases diagnosed as abscess on CECT which turned out to have other diagnoses (false positives): acute-on-chronic submandibular sialadenitis (Figure 3), Ludwig's angina, pleomorphic adenoma of parotid gland, and cellulitis (Figure 4). There were 8 cases correctly diagnosed as not abscess (true negatives): B-cell lymphoma (2 cases), carcinoma of tonsil (1 case), branchial cyst (1 case), nasopharyngeal carcinoma (3 cases) (Figure 5), and lymphadenitis (1 case) (Figure 6).

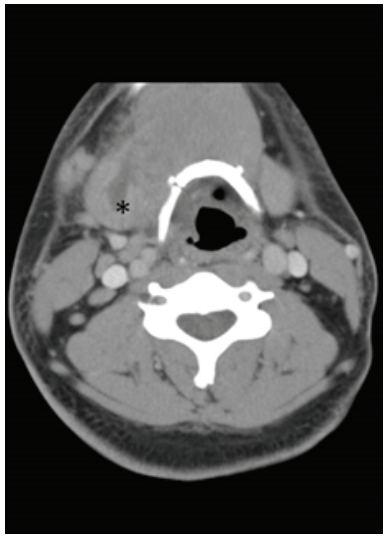

Figure 3: Axial CECT of the neck of a patient diagnosed as having abscess on CECT but confirmed surgically to be acute-on-chronic submandibular sialadenitis. A hypodense area was seen in the right submandibular gland (asterisk) (false positive case).

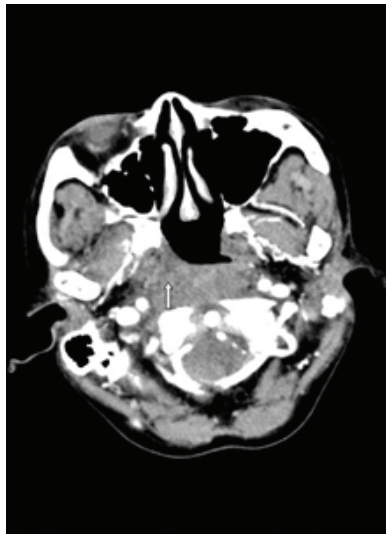

Figure 5: Axial CECT of the neck at the level of nasopharynx showing asymmetry of the fossa of Rosenmuller (thick white arrow) in a 37-year-old Indonesian lady. There was no hypodense mass noted in this patient (true negative case).

Figure 4: Axial CECT of the neck at the level of hypopharynx in a 40-year-old male patient who was diagnosed as abscess in the left paraspinal space (asterisk) on CECT but no pus was found on surgery (false positive case).

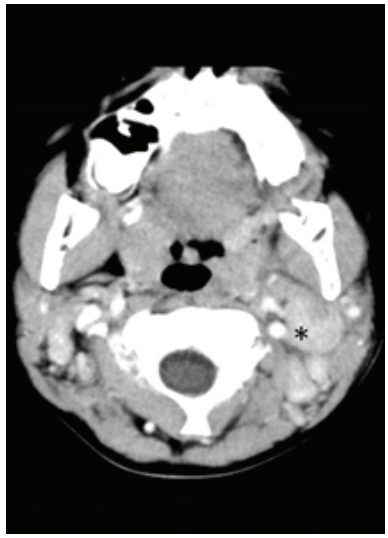

Figure 6: Axial CECT of the neck of a 9-year-old male with lymphadenitis showing enlarged lymph nodes in left level II (asterisk) (true negative case).

Table 4 shows the frequency of patients for each CECT diagnostic criterion. The sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) of the CECT criteria were calculated and presented in Table 5.

From Table 5, the PPV of CECT diagnostic criteria for abscess in descending order of percentage is presence of rim irregularity (96.9%), presence of rim enhancement (96.2%), presence of air (90.9%), presence of hypodense mass (89.8%), presence of signs of inflammation/oedema (87.5%), and presence of lymph node enlargement (84.4%). The NPV of CECT diagnostic criteria for abscess in descending order of percentage is absence of air (88.9%), absence of hypodense mass (80%), absence of rim enhancement (80%), absence of inflammation/oedema (75%), and absence of lymph node enlargement (10%). If the degree of enhancement was not taken into account, the PPV for presence of rim enhancement is reduced to 89.8%. If at least 50% or more enhancement was taken into account, the PPV increased slightly to 91.1% but still less than if only 100% rim enhancement criterion was used. For overall CECT findings, the sensitivity, specificity, PPV, and NPV are 98.6%, 67.2%, 94.7%, and 86.9%, respectively.

Table 4: Frequency of patients for each CECT diagnostic criterion.

CECT criteria	Number of patients			
	True positive ($N = 71$)	False positive ($N = 4$)	True negative ($N = 8$)	False negative ($N = 1$)
Presence of inflammation				
Yes	70	4	5	1
No	1		3	
Presence of hypodense mass				
Yes	71	4	4	
No			4	1
Presence of rim enhancement				
100%	50	0	2	0
≥50% but <100%	12	3	1	0
<50%	9	1	1	0
Not rim enhancement	0	0	4	1
Irregularity of rim enhancement				
Yes	63	2		
No	8	2	4	
Not applicable			4	
Presence of air				
Total number of cases	10	1		
Within collection only	8	1		
Tracking within fascia only	1			
Within collection, fascia and in bone	1			
Lymph node enlargement				
Total number of cases	54	4	6	0
Normal hilum	29	4	0	0
Abnormal hilum	25	0	6	0

In the 79 patients with hypodense mass, 71 patients (89.9%) were proven to have abscess on surgery. The mean central HU, rim-center ratio, and volume were compared between the abscess and non-abscess groups in Table 6. Mean HU, rim-center ratio, and volume in the abscess group are 33.4, 2.58, and 103.8 mL, respectively.

From the 71 true positive cases, 30 patients (42.3%) had single compartment involvement and 41 patients (57.7%) had more than one compartment involved. The most common location involved in a single compartment involvement is the sternocleidomastoid muscle (26.7%). In multiple compartment involvement, the superficial space (36.6%) is the most commonly involved space. The most common deep neck space involved is the submandibular space (31.7%). Odontogenic cause was seen in 11 of the cases involving the submandibular space, which was statistically significant ($P < 0.005$).

4. Discussion

In this series, we found that neck abscess occurs in a wide range of age group with 1/3 of the abscess group consisting of children. The patient population was predominantly male as in other studies [4, 5, 7, 9, 17]. The presenting signs and symptoms of the abscess group were consistent with other studies as well, with the majority of patients having at least symptoms of swelling, pain, and/or fever. This study showed significant statistical difference in the WBC count between the abscess and non-abscess groups. This could be due to the fact that in the non-abscess group there were 8 cases that were due to malignancy and only 4 were related to infectious/inflammatory cause, thus contributing to the significant discrepancy in the mean WBC count between both groups. Diabetes mellitus is one of the recognized risk factors for neck abscess. As Malaysia has the highest diabetic population in the region [18], it is not surprising to find that diabetes mellitus is the most common comorbidity found in the abscess group. *Klebsiella pneumoniae* was the most commonly isolated organism not only in patients with diabetes mellitus but also in the overall patient population. This was also observed in two other studies done in Malaysia and neighbouring Singapore [19, 20]. Interestingly, this study found that *Staphylococcus aureus* was almost exclusively seen in children. Most studies in children also reported *Staphylococcus aureus* as the most commonly cultured organism [3, 5, 6, 10, 11, 17]. In this study, the youngest patient with *Staphylococcus aureus* infection was an 18-day-old neonate with left parotid abscess.

Odontogenic-related cause is the most common cause of abscess in this series with patients having either dental caries or recent dental-related procedures. Second most common cause is due to preceding upper respiratory tract infection, coinciding with the findings in other series [3, 19]. In patients with preceding upper respiratory tract infection, the cause

Table 5: Sensitivity, specificity, PPV, and NPV of the CECT criteria.

	Sensitivity (%)	Specificity (%)	Positive predictive value (PPV) (%)	Negative predictive value (NPV) (%)
Presence of inflammation	97.2	25.0	87.5	75.0
Presence of hypodense mass	98.1	33.3	89.8	80.0
Presence of rim enhancement				
Irrespective of degree of enhancement	98.6	33.3	89.8	80.0
100%			96.2	
≥50%–100%			91.1	
Presence of air	13.9	66.7	90.9	88.9
Presence of rim irregularity	87.5	66.7	96.9	42.1
Lymph node enlargement	75	16.7	84.4	10.0

Table 6: Mean HU, rim-center ratio, and volume of hypodense lesion between abscess versus non-abscess group.

	Number of patients	Mean	SD	*P* value
HU				
Abscess	71	33.4507	11.49825	0.036
Non-abscess	8	24.6000	5.82041	
Ratio				
Abscess	71	2.5826	2.20206	0.642
Non-abscess	8	2.2161	0.51954	
Volume				
Abscess	71	103.7524	371.82237	0.636
Non-abscess	8	40.8552	56.23393	

is likely due to suppurative cervical adenitis [1]. A probable cause of abscess was not identified in more than half of the study population. This finding was similar to other studies [1, 19, 20].

This study showed that overall, CECT findings have a high sensitivity and PPV in diagnosing neck abscess. The figures obtained in this study are higher than those reported in the literature [5, 9, 10, 21]. Presence of rim irregularity was found to have the highest PPV (96.9%). This is comparable with the study done by Kirse and Roberson [11]. However, Kirse and Roberson found a lower sensitivity of 64% compared with 87.5% in this study. In this study, patients presented later to medical attention. Kirse and Roberson postulated that scalloping of the rim is a late sign in neck abscess. Thus, with later presentation, there is time for the abscess to liquefy and subsequently the abscess is more likely to have scalloping of the rim on CECT in this study, explaining the higher sensitivity value.

Presence of air has a PPV of 90.9% for neck abscess in this series. Freling et al. reported that air has a PPV of 100% in their study [9]. Air may be due to anaerobic organisms, prior surgical drainage, or fistula formation following tooth extraction. Air was seen in one patient on CECT in this series but proven not to have abscess on surgery. It is postulated that in this patient, the cause is possibly due to the adjacent dental caries, which have caused the formation of fistula. Presence of inflammation/oedema changes and hypodense mass has high sensitivity and PPV for neck abscess but low specificity and may be seen in other non-abscess etiologies. This study found significant differences in the mean average HU between abscess group and non-abscess group in patients who have a hypodense mass on CECT. This could be due to the larger study population in this series compared to that by Smith et al. who found no significant differences in both groups (32 patients) [22].

The most common compartment involved in the deep neck space is the submandibular compartment in both single and multiple compartments. This correlates with the finding that odontogenic cause was the most common identifiable cause of abscess in this study population. There were other series that reported submandibular space [4, 6, 21] as the most commonly involved space as well as parapharyngeal space [7, 14, 17, 19].

Limitation of this study is that patients who were medically treated were not included, which may explain some of the discrepancies in the results obtained with other studies. It may indeed be interesting to compare the medically and non-medically treated groups to see if there are any significant differences in terms of CECT diagnostic criteria between the groups.

5. Conclusion

In conclusion, the management of neck abscess is a challenging process in view of the complex anatomy in this region. Overall, CECT has high sensitivity and PPV in diagnosing neck abscess but relatively low specificity. In this series of 84 patients, the CECT diagnostic criterion with the highest PPV is presence of rim irregularity. Thus, in a patient who is clinically suspected to have a neck abscess, the presence of a hypodense mass on CECT with rim irregularity suggests that a drainable abscess is likely to be present.

Conflict of Interests

The authors declare that there is no conflict of interests regarding the publication of this paper.

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