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Characterization of color doppler ultrasonography and magnetic resonance imaging-based diagnosis of neck swellings in children and young adults: An observational study

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Abstract

Aims & Objectives: To Characterize and co-relate the clinical, Colour Doppler Ultrasonography (USG) and Magnetic Resonance imaging (MRI) based diagnosis of neck swellings in children and young adults.

Method: An observational cross sectional study was performed for a duration of 6 months with a conveniently recruited sample size of 35 subjects. A brief history, clinical examination, Imaging (USG and MRI-mandatorily; other modalities/histology as needed for diagnosis) was performed as per standard protocol for all the patients. The characterization was done was done by reporting and co-relating clinical, final and imaging based diagnosis.

Results: The maximum number of cases were of developmental origin (37.1%), followed by the masses of vascular origin (17.1%), masses of mesenchymal origin (17.1%), thyroid masses (11.4%), salivary gland masses (8.6%), malignant lymph nodal masses (5.8%) and inflammatory masses (2.8%). The benign lesion accounted for 85.7% (n=30) while 14.3% (n=5) were malignant. Clinical diagnosis was in agreement with final diagnosis in 25 (71.4%) out of 35 cases. USG based diagnosis matched with final diagnosis in 29 out of 35 cases and MRI based diagnosis in 32 out of 35 cases, having a diagnostic accuracy of 82.8 % and 94.2% respectively.

Conclusion: The study showed, MRI has higher diagnostic ability than USG, but final diagnosis need correlations for other modalities. Ultrasonography with Doppler settings should be considered as the first-line screening investigation while, MRI to be used for accurate anatomical localization and characterization of neck swellings.

Keywords: Colour doppler ultrasonography, imaging, magnetic resonance imaging diagnosis, neck swellings

1. Introduction

Soft-tissue swellings of the neck are basically benign cystic or neoplastic masses or malignant tumour. The soft tissue tumours are defined as mesenchymal proliferations that occur in extraskeletal nonepithelial tissues of the body [1]. It must be noted that neck masses in children, are less neoplastic and more non-neoplastic (infective/ congenital or inflammatory) [2]. The neck region, given its less anatomical barriers and clinically superficial presenting swellings the Ultrasonography (USG) is widely implemented as imaging modality. It is initial used for extracranial head and neck masses in children considering its ease of availability and non-ionizing nature [3]. Computed tomography (CT) [4] and Magnetic resonance Imaging (MRI) [5] has become the diagnostic technique of choice because of its excellent soft-tissue contrast for this large and heterogeneous group of tumours with many overlapping features. The multidetector computed tomography (MDCT) technology allows rapid and detailed examination of the neck, however, attempts of minimizing radiation dose and adhering to the ALARA (As Low as Reasonably Achievable) principle are essential. The children or younger age group may not be cooperative or contraindicated for high doses [3].

The USG and MRI are relatively safer options and combination with other modalities is essential to establish diagnosis and formulate needed treatment plan. The advancement of USG, Doppler features with a higher frequency (7-12 MHz) linear probe is useful in more detailed views of superficial structures of neck [3]. Likewise, for MRI a Standard examination should include a T2-weighted fast spin echo (FSE) sequence in axial and coronal planes, a T2-weighted fat suppression or inversion recovery sequence and a plain T1-weighted FSE or spin echo (SE) sequence [6].

The neck swellings manifest as inflammatory, infectious, developmental or neoplastic lesions, given their anatomical complexity, proximity of different tissue and possibility of easy of infection from face. They must be clearly characterized based on safe imaging modalities and correlated if needed with other modalities like CT, PET, Nuclear Imaging or histology. This attempt was made in children reporting to tertiary care facility in northern India. The current study was aimed at characterization of neck swellings of children by describing the clinical, Doppler USG and MRI. Also, we attempted to report on incidence and correlate on diagnostic accuracy of USG and MRI in terms of these swellings.

2. Materials and methods

2.1 Study settings

An observational cross-sectional study was performed for duration of 6 months (November 2013 to May 2015) at Department of Radio-diagnosis in collaboration with the Department of Burns and Plastic Surgery, P.G.I.M.E.R. & Dr. Ram Manohar Lohia Hospital, New Delhi, India. A sample size of 35 was considered by convenient sampling. The cases that reported to the institute were consecutively recruited on grounds of the inclusion and exclusion criteria before recruitment and consideration for imaging.

Inclusion criteria for the study

i) Clinical cases suspected for and provisionally diagnosed for "soft tissue swelling of neck" in children and young adults below age of 18 years.
ii) Cases indicated for radiography for the same diagnostic workup.

Exclusion criteria were those

i) Patients on pharmacological or surgical interventions.
ii) Patients who have contraindication to MR Imaging namely-claustrophobia, metallic implants or cardiac devices/pacemakers.
iii) Patients who are allergic to contrast material.
iv) A radiographic diagnosis deemed.
v) Patients who are unwilling/uncooperative or not given consent for participation.

A detailed history, complete general physical and systemic examination was done of all the subjects who were recruited based on above criteria. The imaging studies were performed namely Colour Doppler Ultrasonography (CDUSG) and Magnetic Resonance Imaging (MRI) as per study protocol, after getting written informed consent form the participants. Doppler evaluation (Model: DC8, Mindray medical Manufacturers, India) was performed using linear transducer with 5-12MHz frequency, with colour, pulsed Doppler and power Doppler capabilities. Colour flow imaging and spectral waveform analysis was done for all suspected vascular malformations. The colour and pulsed Doppler parameters including wall filter, gate width, gain and velocity scale were optimized for each case.

MRI was performed with a 1.5-Tesla MR system (Magnetom Symphony, Siemens India) was done in a non-emergent setting. Sedation (oral or intravenous) as required was administered as per standardized guidelines. The subjects were given 0.1mmol/kg body weight of intravenous contrast (Gd-DTPA) after performing pre-testing. Pre contrast T1 FSE axial, sagittal and coronal with STIR and GRE sequences, followed by post contrast T1 fat suppressed axial, sagittal and coronal images were taken. The sequences were modified as per the requirements of the cases. MR angiography/MDCT/CT angiography/nuclear imaging/his to-pathological examination were performed for cases that deemed necessary to comment on final diagnosis and as per the indication of the radiologists. The triple blinding strategy was employed i.e. USG and MRI were reported by different radiologists who were blinded each other and form statistical expert who had the clinical /final diagnosis data for correlations.

2.2 Statistical analysis

Data were pooled and coded in the Microsoft Excel spreadsheet. Descriptive statistics was employed for depicting the results. The continuous data were represented in the form of cumulative percentages.

3. Results and observations

3.1 Socio-demographic data

Age of the patients included in the study ranged from 0-18 years. The study sample was subdivided based on age, into three groups namely 0-2yrs, 3-9yrs and 10-18 years. The maximum sample belonged to the age group 10-18 years (51.4%) see Figure 1. The sex distribution followed slight male predominance i.e. 20 (57.2%) were males and 15 (42.8%) were females. The overall male to female ratio was 1.3:1.

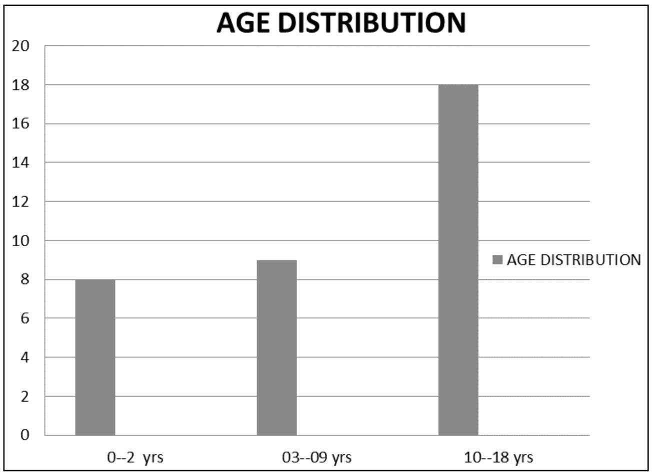

Fig 1: Age distribution of study participants

3.2 Chief complaints

The presenting complaint was swelling, discoloration of skin. The commonly associated symptoms were Fever, pain and dysphagia in the same word. The maximum number of cases were of developmental origin (37.1%), followed by the masses of vascular origin (17.1%), masses of mesenchymal origin (17.1%), thyroid masses (11.4%), salivary gland masses (8.6%), malignant lymph nodal masses (5.8%) and inflammatory masses (2.8%). The presenting complaint and final diagnosis arrived for the sample is depicted in Table 1.

Table 1: Presenting complaint and final diagnosis of study participants

Variable	Frequency	Percentage (%)
Presenting complaint		
1. Swelling	34	97.1
2. Pain	2	5.9%
3. Torticollis	3	8.6%
4. Discoloration Of Skin	4	11.4%
5. Dysphagia	1	2.8%
6. Fever	2	5.9%
7. Weight Loss	3	8.6%
Provisionally diagnosed clinical masses		
1. Masses of Developmental origin	13	37.1%
2. Masses of vascular origin	6	17.1%
3. Masses of mesenchymal origin	6	17.1%
4. Thyroid gland masses	4	11.4%
5. Salivary gland masses	3	8.6%
6. Malignant lymph nodes	2	5.9%
7. Inflammatory masses	1	2.8%

3.3 Radiographic examinations

Plain radiograph soft tissue neck revealed soft tissue swelling in 6 cases (lymphangioma, multinodular goiter, mucoepidermoid carcinoma, infantile hemangioma, rhabdomyosarcoma). Increased prevertebral soft tissue density was noted in 1 case (Retropharyngeal TB abscess). Calcific foci were noted in one case of multinodular goiter on plain radiograph soft tissue neck. USG neck was done in all the cases. Ultrasound abdomen revealed abnormality in two cases with lymphoma. Splenomegaly with mesenteric lymph nodes were seen in both the cases. MRI with contrast was done in all the cases. Out of 35 patients 17 required sedation. Multi detector computed tomography (MDCT) was done in 4 cases (2 cases of venous malformation & 1 case each of Papillary carcinoma & Rhabdomyosarcoma) to see the phleboliths, calcifications & bony destruction respectively.

3.4 Final diagnosis

The final diagnosis was arrived after FNAC in 22cases; histopathological examination in 10 cases, nuclear imaging/scintigraphy was done in 2 the cases of (ectopic thyroid). The benign lesion accounted for 85.7% (n=30) while 14.3% (n=5) were malignant. The various lesions detected in the study after final diagnoses are presented in Table 2. Clinical diagnosis was in agreement with final diagnosis in 25 (71.4%) out of 35 cases. Table 3.

Table 2: Final diagnosis of clinical masses with categorization based on benign and malignant nature

Final diagnosis (n=35)	Benign lesion (n=22)	No of cases	Malignant Lesion (n=13)	No of cases
Masses of developmental origin (n=13)	Thyroglossal duct cyst	4	Nil	
	Epidermoid cyst	3		
	Dermoid cyst	2		
	Lymphangioma	1		
	Ranula	1		
	Myelomeningocele	1		
	Branchial cleft cyst	1		
Masses of vascular origin (n=6)	Infantile Hemangioma	4	Nil	
	Venous Malformation	2		
Masses of mesenchymal origin (n=6)	Fibromatosis Colli	4	Rhabdomyosarcoma	1
	Myofibroma	1		
Thyroid masses (n=4)	Ectopic thyroid	2	Papillary carcinoma of thyroid	1
	Multinodular goitre	1		
Salivary gland masses (n=3)	Pleomorphic adenoma	2	Mucoepidermoid carcinoma	1
Inflammatory mass (n=1)	Tubercular abscess	1		
Malignant nodal mass (n=2)			Lymphoma	2

Table 3: Agreement between clinical and final diagnosis

Final diagnosis(n=35)	No. of cases	Clinical Diagnosis(n=35)		
		Same	Different	Indeterminate
Masses of developmental origin (n=13)				
Thyroglossal duct cyst	4	3	1 (goitre)	-
Epidermoid cyst	3	2	1 (TGDC)	-
Dermoid cyst	2	1	1 (epidermoid)	-
Lymphangioma	1	1	-	-
Ranula	1	1	-	-
Myelomeningocele	1	1	-	-
Branchial cleft cyst	1	1	-	-
Masses of vascular origin (n=6)				
Infantile hemangioma	4	3	1 (Cystic hygroma	-
Venous malformation	2	2	-	-
Masses of mesenchymal origin (n=6)				
Fibromatosis colli	4	4	-	-
Myofibroma	1	-	-	-
Rhabdomyosarcoma	1	-	1 (Fibromatosis colli)	1 (Solid mass lesion)
Thyroid masses (n=4)				
Ectopic thyroid	2	-	2 (Thyroglossal duct cyst)	-

Multinodular goiter	1	1		-
Papillary carcinoma of thyroid	1	1		-
Salivary gland masses (n=3)				
Pleomorphic adenoma	2	2	-	-
Mucoepidermoid Carcinoma	1	-	1 (Pleomorphic adenoma)	-
Inflammatory mass (n=1)				
Tubercular abscess	1	1	-	-
Malignant nodal mass (n=2)				
Lymphoma	2	2	-	-
Total	35	25	9	1

3.5 UGG and MRI vs. Final diagnosis

USG based diagnosis matched with final diagnosis in 29 out of 35 cases and MRI based diagnosis in 32 out of 35 cases, having a diagnostic accuracy of 82.8% and 94.2% respectively. Table 4.

Table 4: Agreement between USG, MRI and final diagnosis

Final Diagnosis (n=35)	**No. of cases**	**USG Diagnosis**		**MRI Diagnosis**	
		Same	**Different**	**Same**	**Different**
Masses of developmental origin (n=13)					
Thyroglossal duct cyst	4	4	-	4	-
Epidermoid	3	2	1 (TGDC)	3	-
Dermoid	2	2	-	2	-
Lymphangioma	1	1	-	1	-
Ranula	1	1	-	1	-
Myelomeningocele	1	1	-	1	-
Branchial cleft cyst	1	1	-	1	-
Masses of vascular origin (n=6)					
Infantile hemangioma	4	3	1 (Cystic hygroma)	4	-
Venous malformation	2	2	-	1	-
Masses of mesenchymal origin (n=6)					
Fibromatosis colli	4	4	-	4	-
Myofibroma	1	-	1 (Fibromatosis colli)	-	1 (Fibromatosis colli)
Rhabdomyosarcoma	1	-	1 (soft tissue mass lesion)	1	-
Thyroid masses (n=4)					
Ectopic thyroid	2	1	1 (Thyroglossal cyst)	2	-
Multinodular goiter	1	1	-	1	-
Papillary carcinoma of thyroid	1	1	-	1	-
Salivary gland masses (n=3)					
Pleomorphic adenoma	2	2	-	2	-
Mucoepidermoid Carcinoma	1	-	1 (Pleomorphic adenoma)	-	1 (Pleomorphic adenoma)
Inflammatory mass (n=1)					
Tubercular abscess	1	-	-	1	-
Malignant nodal mass (n=2)					
Lymphoma	2	2	-	2	-
Total	35	29	6	33	2

4. Discussion

Imaging plays a major role in diagnosis and planning the treatment in patients with neck masses. The radiologist must have a complete knowledge of all the modalities and techniques available to select the most efficient imaging protocol to solve the diagnostic problem. In the current study, the overall male to female sex ratio was 1.3:1. However, female preponderance was noted in masses of thyroid gland origin where all the four patients were females. This collaborated with the findings found in a study described by Patel *et al.*, who reported female predilection with 82% females and 18% males in thyroid diseases [7]. The distribution of diagnosed lesions were 85.7% benign and 14.3% malignant, consistent with spectrum of neck masses in children as described by Meuwly *et al*. [8].

4.1 Masses of developmental origin

1. Thyroglossal duct cyst

According to Richter *et al.* [8], thyroglossal duct cysts are the most common cause of congenital cyst. They are seen in the infrahyoid neck in 20%-65%. No gender predilection has been reported. They are seen in the infrahyoid neck in 20%-65% [8] in line with findings of cases in our study. On USG, they appear as a well-defined, thin-walled, anechoic mass with through enhancement. In our study also three cases showed similar findings but one case had thicker wall and internal echoes suggesting signs of infection.

On MR imaging, the T1-weighted signal intensity can vary from low to high, while the T2-weighted signal intensity remains high. These findings are seen till the lesion is not infected. In an infected Thyroglossal cyst heterogeneous signal intensity with thick cyst wall enhancement is seen.

2. Epidermoid cysts

On USG, epidermal cysts may appear as hypoechoic to hyperechoic masses or complex lesions depending on the composition of the cyst. On MRI, epidermoid cysts tend to follow fluid signal intensity and are generally hypointense on T1-weighted sequences and hyperintense on T2-

weighted sequences. Clemens *et al.* [9] also found that epidermoid cysts have fluid attenuation on CT scans and are hypointense on T1-weighted images and hyperintense on T2-weighted images, following the signal intensity of fluid.

3. Dermoid cysts

According to Nguyen *et al.* [10] globules of fat are seen within lesion. 'Sack of marble' appearance is virtually pathognomonic for dermoid. In our cases also, on USG, internal echoes were seen in both the lesions within the cystic component. Lesions had hyperechoic content within the cyst suggesting of internal macroscopic fat content. Clemens *et al.* [9] showed that, MR imaging depicts the topographic relationship of these cysts to the mylohyoid muscle in the floor of the mouth and helps determine the surgical approach. Dermoid cysts have variable signal intensity on T1-weighted images. They may be hyperintense (because of the presence of sebaceous lipid) or isointense relative to muscle on T1-weighted images. They are usually hyperintense on T2-weighted images. The mass has a clearly demarcated rim but frequently has a heterogeneous internal appearance. This was seen in both the cases of dermoid cyst in current study on MR imaging.

4. Lymphangioma

Mittal MK *et al.* [11] have reported that these lesions are usually discovered in infants or children younger than two years of age and occurrence in adults is uncommon. On USG, the lesion was characteristically compressible, multiseptated with thin septae. The lymphangiomas are cystic septated swelling that has to be differentiated from branchial cleft cysts. Both have similar soft tissue characteristics on CT and MRI, however, unlike brachial cleft cysts, cystic hygroma does not cause any displacement of structures in the neck [12].

5. Branchial cleft cyst

It was seen as a cystic lesion posterior and lateral to the submandibular gland, anterior to the sternocleidomastoid muscle and lateral to the carotid space. The wall of the cyst showed enhancement and was thickened which was suggestive of infection [11].

6. Ranula

According to Mittal *et al.* [11] the simple ranula is more common and is located in the sublingual space. The plunging ranula descends beyond the mylohyoid muscle and into the lower neck. On MRI, ranulas tend to have a low signal on T1- weighted images and high signal intensity on T2-weighted images. In our patient also the ranula was seen in sublingual space with similar imaging findings.

7. Posterior cervical myelomeningocele

One case of posterior cervical myelomeningocele was diagnosed who presented with large compressible occipital swelling since birth. The child had no neurological abnormality. On imaging evaluation, the sac contained neural elements. These findings are in line with reports by Chandra *et al.* [13].

4.2 Masses of vascular origin

According to Madani H *et al.* [14], classification of vascular malformations into high flow and low flow, had a significant impact on management (transarterial embolization and the later percutaneous sclerotherapy). Magnetic Resonance Imaging (MRI) is a non-invasive effective tool for imaging and classification of vascular malformations based on the presence of lobulated masses, signal voids, and hemodynamic flow characteristics. Hemangioma appears as a distinct intensely enhancing soft tissue mass with enlarged feeding arteries and draining veins as seen in current study.

Two cases of venous malformation were found which on USG, showed hypoechoic echotexture with few calcific foci & on Doppler showed low velocity flow consistent with findings reported by Mittal MK *et al.* [11]. On MRI, phleboliths and delayed progressive enhancement of the malformations helped in making the diagnosis. On the MRI, venous malformations are either isointense or hyperintense on T1-weighted images and hyperintense on T2-weighted images [11].

4.3 Masses of mesenchymal origin

1. Fibromatosis colli

USG could identify this entity in almost all the cases though CT scan and MRI features are also important. MRI features included decreased signal intensity of the mass on T2W images as compared to gradient-recalled T1W images, because of the presence of fibrous tissue. The extent of involved muscle was better delineated with MRI than with USG. The cytological features included bland-appearing fibroblasts and atrophic skeletal muscle as reported by Ablin *et al*. [15].

2. Myofibroma

One case which was diagnosed as fibromatosis colli on imaging evaluation was proved as myofibroma on histological examination. Infantile myofibroma is a rare entity in children. Although the cervical region is one of the frequent sites of location for this tumor, the diagnosis may be delayed if it occurs in a usual location for a well-known entity, such as muscular torticollis or fibromatosis colli [16].

3. Rhabdomyosarcoma

Freling *et al.* [17], reported that this tumour has bimodal distribution with one peak occurring during the first decade of life and the second occurring during adolescence. It aggressive tumor enriching bone, occurs in common the masseteric space and orbit commonly. The case in current study has shown a mass typically demonstrates high signal intensity on T2-weighted sequences and is isointense or minimally hyperintense to skeletal muscle on T1-weighted sequences. A fat-suppressed sequence is particularly helpful in evaluating orbital disease.

4.4 Thyroid masses

1. Ectopic thyroid

According to CP J *et al*., thyroid gland is not found in its usual location in 70% of patients with ectopic thyroid. Ectopic thyroid is rare and is often mistaken for thyroglossal duct cyst [18]. One case in our study also was mistaken as thyroglossal duct cyst on USG. Scintigraphy, using Tc-99m, I-131, or I-123, is the most important diagnostic tool to detect ectopic thyroid tissue and shows the absence or presence of thyroid in its normal location.

2. Thyroid goitre

Degenerative changes in goitrous nodules on ultrasound appeared as anechoic areas with echogenic contents within and intracystic septations. On the MRI, multinodular goitre is typically heterogeneous; signal intensity is isointense to normal thyroid or increased on T1-weighted images and mixed on T2-weighted images [19].

3. Papillary carcinoma of thyroid

The main role of cross-sectional imaging in thyroid neoplasms is not in the characterization of an intrathyroid lesion, as there are no imaging findings that are histologically specific [19]. The role of the radiologist is to assess the findings related to a thyroid mass which will influence treatment decisions, including invasion through thyroid capsule and infiltration of adjacent tissues and structures of neck and to identify presence of cervical lymph node metastasis. The one case in our study was diagnosed with same approach.

4.5 Salivary gland lesions

Thoeny *et al*. [20] observed that nearly 80% of benign unilateral parotid neoplasms are pleomorphic adenoma, consistent with our study findings. The cases appeared as heterogeneously enhancing, well defined lobulated lesions with isointense signal on T1 and hyperintensity on T2 weighted images. A single MR finding cannot distinguished pleomorphic adenomas from other parotid tumours and that the MR findings of a complete capsule, lobulated contour, or high T2 signal intensity have a predictive value of 74% for the diagnosis of pleomorphic adenoma. One case involving the parotid gland was misdiagnosed as pleomorphic adenoma which came out to be low grade mucoepidermoid carcinoma on histopathology. These cancers need both CT and MRI showed a considerable tendency of misdiagnosis [20].

4.6 Inflammatory masses

Infection of the neck is a common clinical problem in all age groups, especially children and young adults. Ultrasound has also been used in the evaluation of superficial neck infections, especially to determine fluid accumulation [21]. In our study one case of abscess in the perivertebral space was diagnosed in a patient presenting with dysphagia with fever, leucocytosis and neutrophilia.

4.7 Lymphoma

The lymphoma is the most common head and neck malignancy in children. The lymph nodes in lymphomas are reported to be hypoechoic, round, with sharp borders and absent echogenic hilum (74%). Aiken AH *et al.* [22] described in lymphoma with an involvement of multiple deep chain lymph nodes multiple which can be unilateral or bilateral and of varying sizes, found to be less with Hodgkin’s disease and comparatively higher with non-Hodgkin’s lymphoma. In our study also, the patients had multiple discrete non necrotic lymph nodes at various levels of lymph node station. This was in concordance to the findings described above in various studies.

Summary of observations

The diagnostic accuracy of USG in detection of lesions was 82.8% and for MRI it was 94.2%. USG appears to be the best initial modality irrespective of the clinical presentation for the initial investigation of paediatric neck masses. It is widely available, low in cost and does not expose the patient to radiation. USG guided aspiration can be done for cytological study, which can diagnose most conditions. However, it is operator dependent and can be time consuming. Still, the benefits outweigh the shortcomings. For most mass lesions, USG would be sufficient for detection. However, for better analysis, MRI with contrast study should be advised, which would provide good soft tissue resolution and multiplanar images, thus giving better information about margins, intensity, extent and enhancement pattern. CT is required for bony destruction or to delineate calcifications. Particularly, in neoplastic masses, MRI helped in describing the accurate extent of the lesion and narrowing the differential diagnosis. It provided a road map to surgeons pre-operatively.

Limitations

This study did not include dedicated diffusion weighted MRI and dynamic contrast studies of tumours, which could have provided more discriminatory features among benign and malignant tumours. Future studies should assess the role of dynamic enhancement and DWI in a detailed fashion.

5. Conclusion

The combined use of the Doppler USG and MRI was helpful in making the correct diagnosis in diagnosis of neck swellings. The study showed, MRI has higher diagnostic ability than USG, but final diagnosis need correlations for other modalities. Ultrasonography with Doppler settings should be considered as the first-line screening investigation while, MRI to be used for accurate anatomical localization and characterization of neck swellings.

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