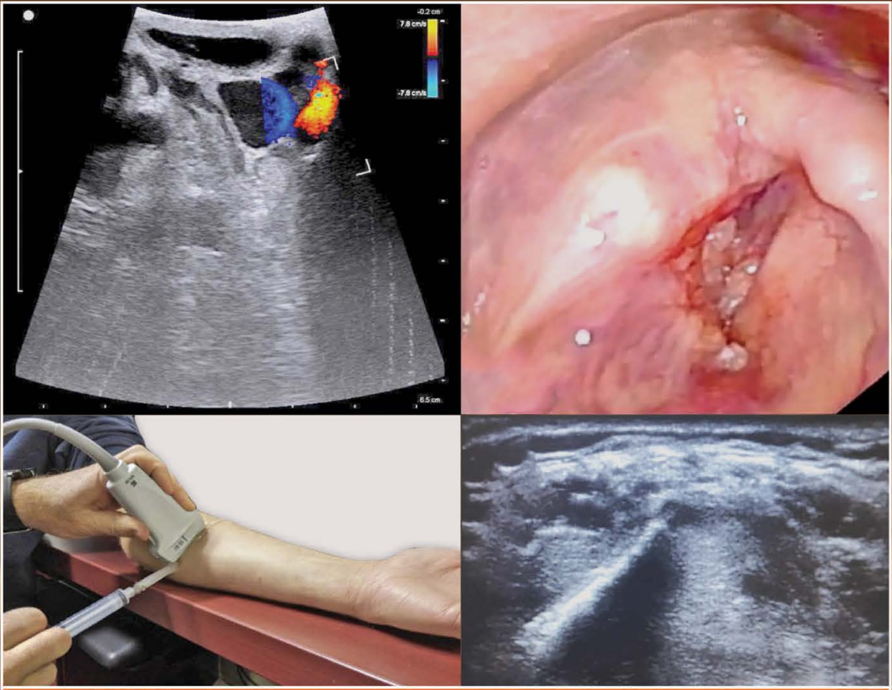


Practical Guide to Point-of-Care Ultrasound

A Simplified Approach

Puneet Khanna
Bhavana K

JAYPEE

Contents

CHAPTER

4 Point-of-Care Ultrasound in ENT

Smile Kajal, Smita Manchanda, Hitesh Verma

INTRODUCTION

Ultrasound (USG) is a commonly used radiological investigation, both for diagnostic and for therapeutic purposes, in almost all specialties. It was first used for medical purposes to examine human skulls in 1947. Over the next two decades, its use increased in specialties such as cardiology, obstetrics, and general radiology but the development of USG in otolaryngology and head and neck surgery lagged behind. USG was first applied in otolaryngology for examining the maxillary sinus in 1974.[1] Since then, its use has expanded to various areas of interest in ENT (ear, nose, throat) such as thyroid, parathyroid, salivary glands, neck space infections, and lesions of the aerodigestive tract. During the last two decades, USG technology has become more compact, improved in quality, and reduced in cost, thus making it more accessible to both patient and doctor. This has given rise to the concept of point-of-care ultrasound (POCUS) which is defined as ultrasonography performed and interpreted by the clinician at the bedside.[2] A systematic review assessing the role of POCUS, in general, practice concluded that POCUS could lower healthcare expenditures.[3] Although the experience in POCUS is variable among various centers, there is a strong interest in increasing resident skill acquisition in USG training among otolaryngology residents and POCUS can be of great use in camps organized in low- and middle-income group countries.[4] In this chapter, we will outline the role of POCUS in various areas of otolaryngology and head–neck surgery.

RELEVANT ANATOMY

Comprehension of the ultrasonographic appearance of the head and neck requires a full understanding of its intricate anatomy. Surgeons are already familiar with surgical anatomy, and it becomes easier for them to acclimatize to radiographic or USG images with practice. It is important to appreciate the normal sonographic appearance of head and neck structures before recognizing abnormal pathology. An USG examination should follow a systematic and thorough course to ensure that all structures of the neck from the clavicle and mandible are evaluated.[5] In this section, we will discuss the relevant anatomy of various regions of the head and neck.

Neck

In line with clinical and surgical anatomy, the neck during POCUS can be divided into an anterior and posterior triangle. The triangular-shaped area anterior to the sternocleidomastoid muscle is the anterior triangle, whereas the region posterior to the muscle is termed the posterior triangle. The anterior triangle is further divided into infrahyoid and suprahyoid sections. The anterior belly of the digastric muscle subdivides the suprahyoid portion into the submandibular triangle posteriorly and the submental triangle anteriorly. Below the posterior belly of the digastric muscle, the infrahyoid triangle is divided into the muscular and carotid triangles by the superior belly of the omohyoid muscle. The borders of the posterior triangle include the sternocleidomastoid muscle anteriorly, the occiput superiorly, the clavicle inferiorly, and the trapezius muscle posteriorly. The inferior belly of the omohyoid muscle subdivides the region into the occipital triangle superiorly and the supraclavicular triangle inferiorly. Various structures can be appreciated during POCUS in these triangles.[5]

Structures in Submental and Submandibular Triangles

- *Muscles:*
  - Mylohyoid, a sling like muscle that forms the floor of the mouth, remains immobile during tongue movement. A lesion deep to the mylohyoid, arises from the sublingual space; whereas any lesion superficial to the muscle lies in the submandibular space.
  - Hyoglossus—contracts with side to side tongue movement
  - Genioglossus
  - Geniohyoid
- *Lingual artery:* Medial to the hyoglossus muscle
- *Submandibular gland:* Runs alongside the sublingual gland between the hyoglossus and the more superficial mylohyoid muscle (normal duct is less evident; dilated duct can be easily seen).
- *Submandibular gland:* Homogenous and hyperechoic. Unlike the parotid gland, there are no lymph nodes within the submandibular gland parenchyma. Any sonographic abnormalities in the gland should be considered pathologic.
- *Sublingual gland:* Elongated in longitudinal section and hyperechoic
- *Facial artery:* Key feature of the submandibular space and can be followed on its tortuous course from the external carotid artery to the point where it crosses the body of the mandible
- *Retromandibular vein:* Landmark for distinguishing parotid space pathology posteriorly from submandibular gland pathology anteriorly.

Structures in Carotid and Muscular Triangles

- *Carotid vessels* **(Fig. 1)**: They are seen deep and anterior to the hypoechoic sternocleidomastoid muscle, pulsating and relatively noncompressible with bifurcation at the level of hyoid. Commonly seen is the posterior enhancement effect which is an artifact due to distal reflected echoes behind an area of low attenuation (in this case, anechoic blood in the lumen of the carotid artery) giving the enhanced appearance as compared with the adjacent tissue.
- *Internal jugular vein* **(Fig. 1)**: It is compressible with pressure and dilates with the Valsalva maneuver.
- *Vagus nerve:* It is occasionally seen as a dot on axial imaging or as a hypoechoic line medial to the carotid artery on longitudinal imaging.
- *Anterior scalene muscle:* It is seen originating from the transverse process of cervical vertebrae.
- *Thyroid gland:* Hyperechoic and homogenous compared with the relatively hypoechoic strap muscles.

Structures in Posterior Triangle

- *Muscles*—sternocleidomastoid, trapezius, levator scapulae, splenius capitis

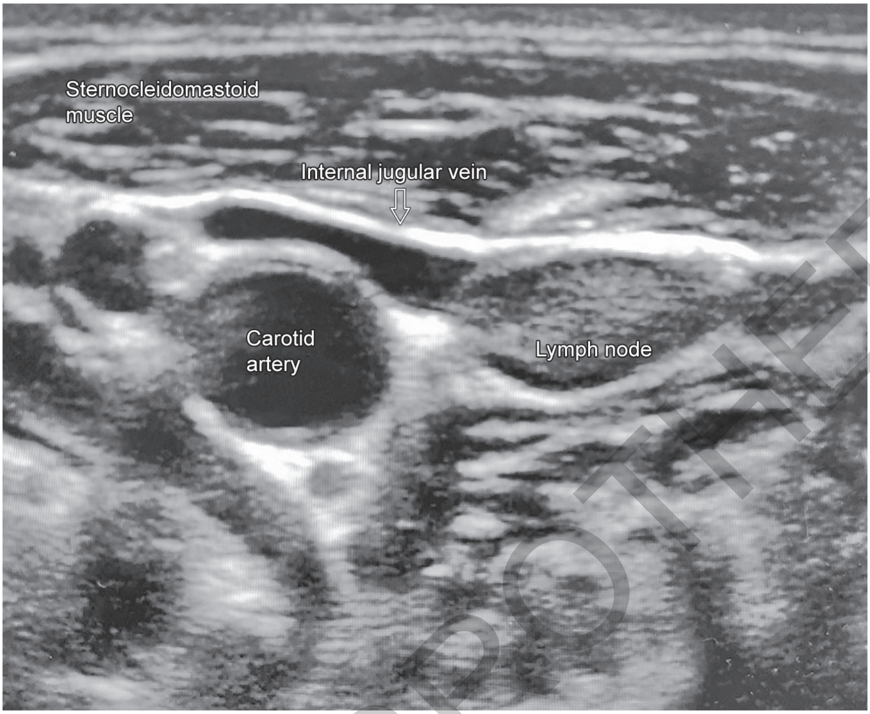


Fig. 1: Sternocleidomastoid muscle, carotid artery, internal jugular vein, and a suspicious lymph node.

- Subclavian vein—seen posterior to clavicle
- *Brachial plexus*—seen as rounded hypoechoic structures on axial imaging.

Thyroid: POCUS for thyroid lesions is of great interest not only to otolaryngologists but also to other specialties such as internal medicine and endocrinologists. The advantage of using POCUS in the thyroid is that it reduces the need for multiple visits. It has been seen that USG-guided fine needle aspiration cytology (FNAC) conducted by a surgeon minimizes the time to make a definitive plan and reduces the frequency of patient visits and cost, thus resulting in more efficient care.[6] But it may hamper diagnostic accuracy initially in inexperienced hands and may require supervision by radiologists.[7] Lack of experience, improper technique, difficult patient anatomy, or intrinsic qualities of the nodules can all cause unsatisfactory results.[8] Nevertheless, POCUS can be very useful in case of emergency like diagnosing and draining hematoma/collection compromising airway post thyroidectomy. The following features can be appreciated during POCUS in thyroid:[5]

- Normal thyroid parenchyma is hyperechoic and homogenous **(Fig. 2)** as compared to hypoechoic strap muscles (sternothyroid and sternohyoid) which border the gland anteriorly.
- The cervical fascia investing the muscles and the thyroid gland appears as a thin, white line. An examiner should be alerted to the possibility of extrathyroidal expansion by a malignancy if the fascia enclosing the gland is disrupted.
- Both the superior and the inferior thyroid arteries can be traced from their origins at the external carotid artery and

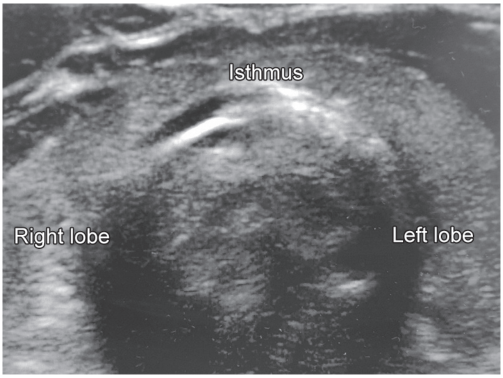


Fig. 2: Normal thyroid gland.

thyrocervical trunk, respectively, to the gland. The inferior thyroid artery is an excellent marker for the depth of the recurrent laryngeal nerve. Color flow Doppler is essential to differentiate blood vessels from cystic thyroid pathology.

- Thyroid nodules appear as hypoechoic foci.

Parathyroids: Normal parathyroid glands may not be visible on USG.[9] Scanning should be performed from high in the neck to as low as feasible in the neck. Enlarged parathyroids are visible as hypoechoic lesions and may have cystic contents. They can be difficult to distinguish from posteriorly located thyroid nodules or lymph nodes. The superior parathyroids can be found near the cricothyroid joint, but inferior parathyroids are more variable in location.[5]

Parotid Space: The following features can be appreciated while using POCUS to evaluate the parotid region:

- *Normal parotid gland:* Homogenous and hyperechoic. When scanning, areas in the gland that are hypoechoic suggest abnormal pathology.
- *Retromandibular vein:* Can be used as a landmark to assess the depth of facial artery. Delineates superficial and deep lobes.
- *Masseter muscle:* Seen anterior to the parotid gland
- *Stenson's duct:* Normal duct may not be visible but dilated duct can be seen anterior to masseter.

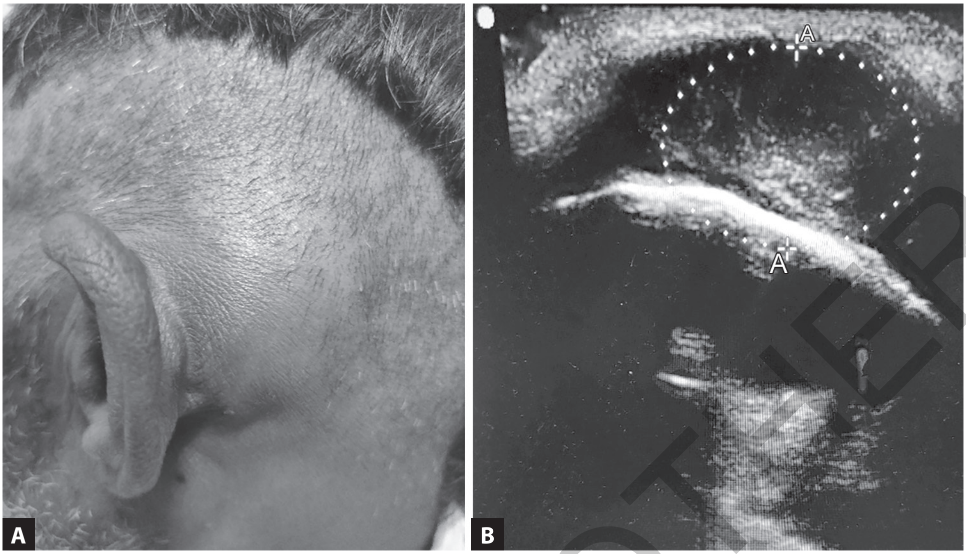
Airway and esophagus: POCUS can be very useful in emergency airway assessment and intervention (discussed later). The following structures can be assessed during USG of airway and esophagus:

- *Larynx:* The thyroid, cricoid, and arytenoid cartilages are all echogenic, whereas the intrinsic muscles of the larynx appear hypoechoic. The laryngeal mucosa is hyperechoic, in contrast to the anechoic intraluminal air column. Fat in the pre-epiglottic space is echogenic, whereas the cartilage of the epiglottis is hypoechoic. This region is best visualized via the thyrohyoid membrane.
- *Trachea:* In the midline of the neck, deep to the thyroid gland, the cartilaginous tracheal rings and cricoid are useful landmarks in both the axial and the longitudinal planes. The cricoid cartilage forms a complete ring and is the most cephalad portion of the trachea. Below the cricoid, the first five to six tracheal rings can be seen with gentle neck extension.
- *Esophagus:* This is seen to the left of the trachea. It has a characteristic echogenic center of air and saliva with a hypoechoic muscular rim which is described as a bull's eye or target. When a patient swallows, the hyperechoic esophageal center dilates actively and then returns to the resting state.

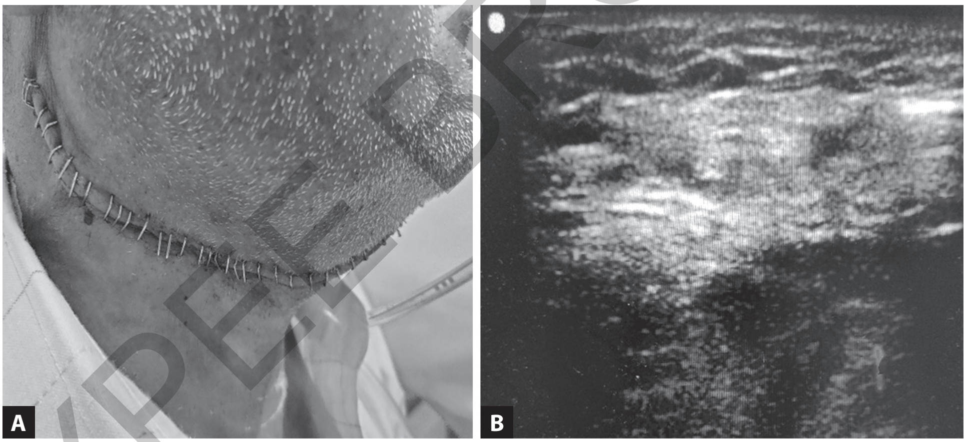
APPLICATION OF POINT-OF-CARE ULTRASOUND IN VARIOUS PATHOLOGIES

Abscess, Hematoma/Seroma

Identification and drainage of collection in any region can be done using POCUS keeping in mind the relevant anatomy and



Figs. 3A and B: (A) Postaural abscess; (B) Ultrasound of the same swelling suggestive of a hypoechoic collection.



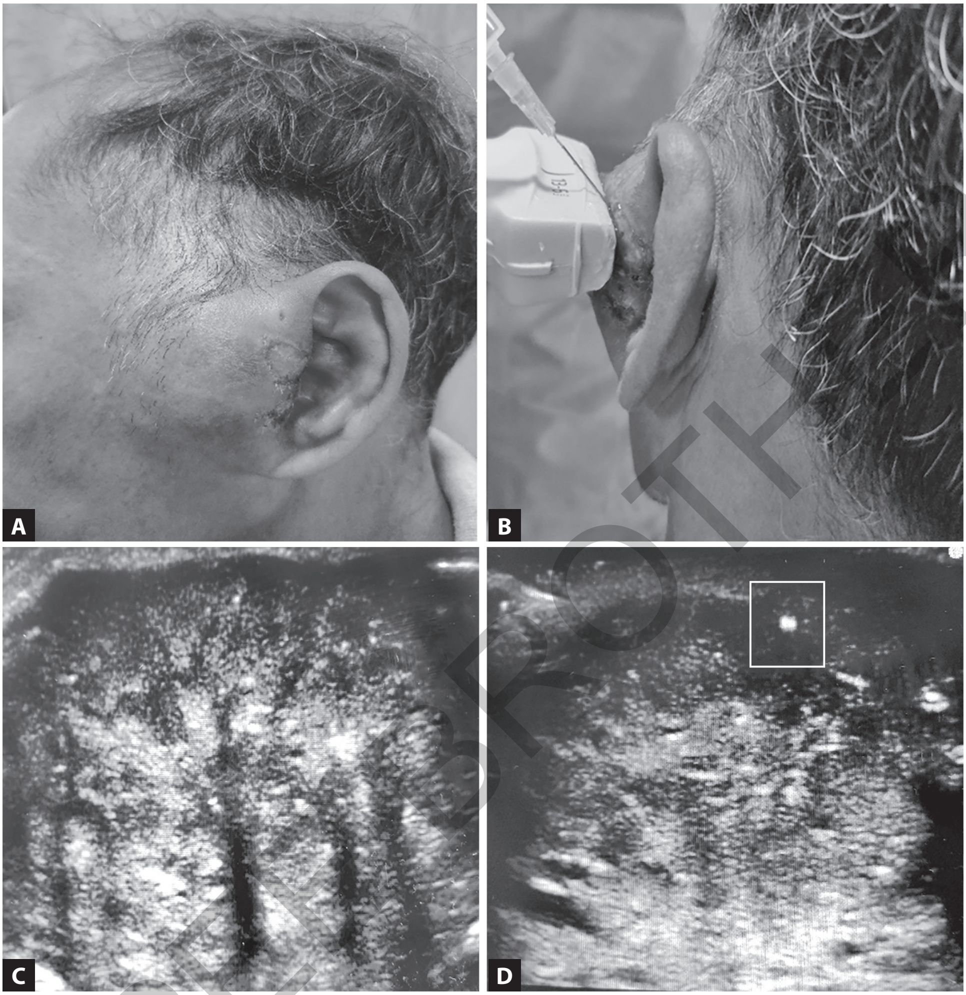
Figs. 4A and B: (A) A clinically suspicious collection in the right submandibular area postoperatively; (B) Ultrasound of the same region suggestive of only tissue edema (small hypoechoic pockets).

surrounding vital structures. POCUS is also useful to differentiate between collection and edema/cellulitis **(Figs. 3 and 4)**. USG guided greater auricular nerve block for drainage of ear abscess have also been reported.[10]

Thyroid Nodule

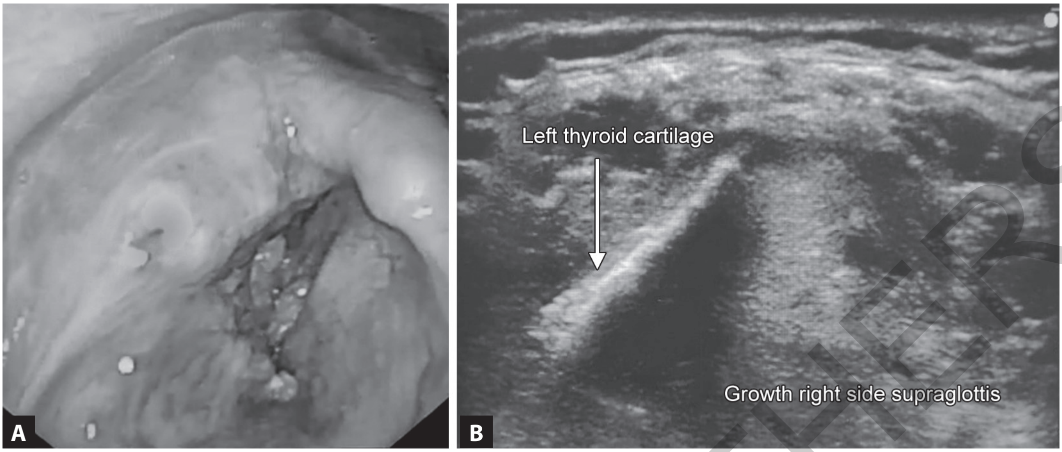
- Thyroid imaging reporting and data system (TI-RADS) is commonly followed by radiologists for risk stratification and making decisions whether to aspirate/biopsy the nodule or not.[11] POCUS performed by an otolaryngologist may not be helpful in detailed evaluation of nodules, but one can decide whether to perform FNA or not. Nodules with suspicious features (like taller than wide, ill-defined, or irregular borders, microcalcifications) and solid hypoechoic nodules 1 cm or larger require aspiration.[12] FNA can be avoided in cystic nodules as they are a strong independent predictor of non-diagnostic yield.[8] Thyroid FNA performed by a surgeon may be especially beneficial for noncystic nodules because of the high diagnosis rate and potential for earlier decisive therapy.[13]

- Vocal cord mobility assessment is an important aspect of preoperative workup. It can be done to differentiate between a benign and malignant thyroid swelling. Accidental or planned injury to the laryngeal nerve in previous thyroid or airway surgeries can modify the voice by compromising the movement of vocal cords. In rare conditions, vocal cord mobility is restricted temporarily under the influence of local anesthetic used for cervical nerve block. Immediate postoperative assessment of vocal cord mobility is usually done by an anesthetist immediately after extubating the patient. Translaryngeal USG can be used in difficult situations (obese patients, trismus, stridor, etc.) where standard methods are not possible to assess the vocal cords' mobility.
- *Parathyroids:* POCUS maybe used to localize parathyroid lesions such as parathyroid adenoma, especially in an intraoperative setting, but the patient's body mass index, concomitant thyroid pathology, parathyroid gland weight, and its anatomical location may limit the use of USG in parathyroid lesions.[14] Although advanced modalities such as sestamibi scan and 4D computed tomography are commonly used for the detection of parathyroid abnormalities, USG may provide more refined information regarding the anatomic location of the adenoma than nuclear medicine study alone.[15]
- *Neck lymph nodes:* POCUS can be very useful in the detection of pathological lymph nodes and making surgical decisions on this basis. FNA can be performed on suspicious nodes as an office-based procedure. Neck lymph nodes with size >1 cm (>1.5 cm in jugulodigastric node), clustering of nodes, irregular margins, rounding of shape, peripheral vascularity, cystic (hyperechoic) change, microcalcification, and loss of a distinguishable fatty hilum on USG are all characteristics of malignancy within cervical nodes.[16]
- *Parotid region:* POCUS can be used to drain parotid abscess, FNA of cystic lesions, diagnosis of acute sialolithiasis, and diagnosis of infantile hemangiomas[17,18] **(Figs. 5A to D)**.
- *Sinonasal region:*
  - Bedside USG can be useful in the detection of acute maxillary sinusitis, especially in mechanically ventilated patients. Studies have shown that the use of bedside USG in such cases has high specificity which means that a positive USG finding (air-fluid level) can be regarded as evidence of maxillary sinusitis.[19-21] A positive postural change test (disappearance of echogenic foci in a posterior maxillary wall while changing from upright/semiupright position to supine position) increases the predictability of bedside USG in the detection of acute maxillary sinusitis.[21]
  - Carotid Doppler is the useful tool to locate the internal carotid artery in extended trans-sphenoid endoscopic approaches.



Figs. 5A to D: (A) Swelling in the left parotid region; (B) Local anesthesia being injected around the ulcerated area of swelling prior to biopsy; (C) Ultrasound of the same swelling suggestive of solid mass (hyperechoic) with cystic spaces (hypoechoic); (D) Tip of the needle (red box) used for injecting local anesthesia. *(For color version, see Plate 3).*

- *Airway:* Various uses of POCUS have been described in airway:[23-26]
  - Emergency assessment of airway and vocal cord mobility in case of difficult laryngoscopy.
  - Identification of cricothyroid membrane for potential cricothyroidotomy.
  - Used to localize the airway when a large mass obscures the location of airway.
  - Assessing tracheal diameter, especially in cases of upper airway stenosis, for deciding the size of the endotracheal tube. POCUS is also used to localize the site of tracheostomy, especially when the tumor extends in the upper trachea, and position of the tracheostomy tube.
  - Localizing vocal cord lesions such as a polyp or a suspected malignant lesion.



Figs. 6A and B: (A) Fiberoptic laryngoscopic view of an ulceroproliferative growth over right true vocal cord extending to the left side; (B) Same growth on ultrasound (right half).

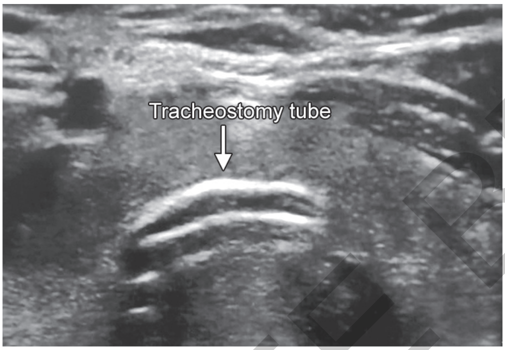


Fig. 7: Distal end of the tracheostomy tube in the upper airway.

- Biopsy of supraglottic mass or tonsillar mass **(Figs. 6A and B)** by the transcervical approach.
- Assisting in USG-guided percutaneous tracheostomy **(Fig. 7)**.
- *Injection laryngoplasty:* USG is used to localize the target muscle for injection therapy (medialization, botulinum toxin). Constrictor muscle spasm in postlaryngectomy patients is managed by botulinum toxin injection. The site of injection can be confirmed by POCUS.

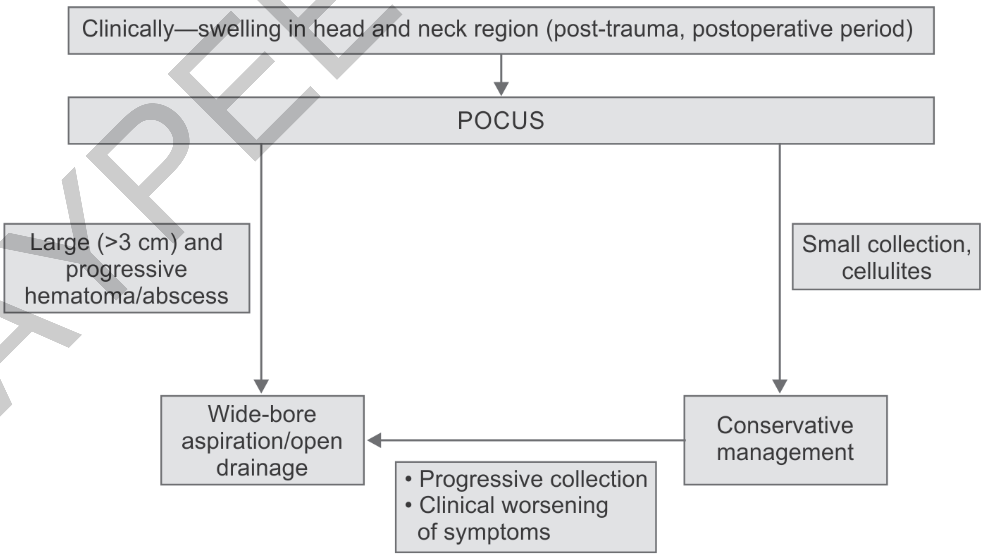
- *Other office-based procedures:* Bedside USG has been used recently for measuring the depth of invasion in suspicious malignant lesions of the tongue, for injecting sclerosing agents, botulinum toxin, radiofrequency ablation of benign thyroid nodules, and diagnosis and treatment of lymphatic malformations in pediatric population.[27-30]

TIPS ON IMAGE ACQUISITION AND INTERPRETATION

For head–neck pathologies, usually a linear transducer is used. The image contrast, magnification, and focal area are appropriately set before the procedure. The transducer must be prepared for the procedure to ensure that it is not exposed to body fluids or alcohol, which is used as asepsis for the skin. A generous amount of US gel should be placed on the end of the transducer. The indicator (a bump or groove on the probe) on the transducer probe usually corresponds to the left of the screen and is generally directed toward the patient's right side in a transverse plane. The examination is usually performed in both the axial and the longitudinal planes. The position of the patient should be tailored on an individual basis depending upon the anatomical region, suspected pathology, and hemodynamic stability of the patient. Specific positions such as Revonta's technique (in a sitting position, the patient's head is in slight flexion so that an imaginary line from the auditory canal to the lower margin of the orbit is horizontal) can be used for bedside USG in the maxillary sinus. The echogenicity of various structures is as follows:

- *Cervical fascia:* Very echogenic (seen clearly as a distinct white line that delineates structures)
- *Muscle:* Hypoechoic
- *Fat:* Hyperechoic relative to muscle
- *Mucosa:* Very echogenic and can be easily differentiated from the hypoechoic muscle that it typically overlies.
- *Vessels:* Seen round when the transducer is axial and as an anechoic linear structure when the transducer is longitudinal.
- *Arteries:* Anechoic but pulsations can often be seen.
- *Veins:* Anechoic and easily compressible with pressure from the USG probe.
- *Lymph nodes:* Benign lymph nodes appear as oblong, hypoechoic, and have a central fatty hilum that is echogenic.
- During any interventional procedure like FNA, drainage, or injection, either the long-axis technique or the short-axis technique can be used. In the long-axis technique, the transducer is placed in a longitudinal/sagittal plane relative to the structure. The advantage is that the whole length of the needle and any adjacent vessel can be visualized throughout the procedure. In the short-axis technique, the transducer is placed in the axial position and the tip of the needle can be visualized throughout the procedure.[30]

READY RECKONER FLOWCHARTS GUIDING DECISION-MAKING IN COMMON CLINICAL SCENARIOS



(POCUS: point-of-care ultrasound)

- Template for reporting

Name: Age/Sex: Hospital ID:
Address: Contact no.:

Indication for POCUS: Diagnostic/Therapeutic
Details:

Hospital setting: Outpatient/Inpatient(ward)/HDU/ICU/Others (please specify)
Pre-procedure vitals: BP Pulse Respiratory rate SpO_2

Diagnostic findings/Details of therapeutic procedure:

A. Cellulites abscess/hematoma:
   I. Site
   II. Dimensions
   III. Areas involved
   IV. Intervention done
   V. Amount aspirated
   VI. Type of fluid
   VII. Any investigation sent from aspirated fluid.

B. Vocal cord status: Unilateral/bilateral cord mobile partial or complete.

C. Airway status:
   I. Vertical length and subsides of airway involved by stenosis
   II. Cross-section area is compromised by stenosis—50%, 51–70%, 71–99%, and complete
   III. Unilateral/bilateral cord mobile partial or complete
   IV. Site of tracheostomy (ring of trachea)
   V. Injection given to muscle:
      1. Name of muscle injection given
      2. Type of injection—fat, any commercial drug ________
      3. Immediate postoperative effect
      4. Delayed effect.

Postprocedure vitals: BP Pulse Respiratory rate SpO_2

Any complication:

Signature of doctor

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Practical Guide to Point-of-Care

Ultrasound

A Simplified Approach

Salient Features

- Details on focused ultrasound examinations that can be of great advantage in a variety of patient-care settings
- Can be used at the bedside to answer-specific questions in real time
- Ready-reckoner flowcharts guiding decision making to common clinical scenarios
- Covered in detail are the broad applications of Point-of-Care Ultrasound (POCUS) that are most generalizable to healthcare providers from any discipline or practice setting.

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