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ANATOMY AND TECHNIQUE

RM Evans

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Introduction

Over the past two decades, rapid strides in ultrasound (US) technology and in particular the development of high resolution US have led to a greater role for ultrasound in the assessment of the extracranial head and neck. The increased spatial resolution achieved by the latest generation of machines and transducers allows excellent near field resolution. When one considers that the majority of structures and associated pathology in the neck lie only between one and five centimetres below the skin surface, and given the superior resolution that high resolution US can attain, it is not surprising that US is gaining in popularity in the field of head and neck imaging. As it is relatively inexpensive (in Radiology terms) and is readily available, the use of US will continue to increase.

One criticism of US is that it is 'operator dependent'. While there can be no argument with that statement, it is not a criticism that is made of other imaging techniques, which are equally operator dependent. We accept that cytology is operator dependent, we know that surgery is operator dependent, so why is 'operator dependent' a criticism that is continually heard when US is discussed? Most medicine is operator dependent in one form or other; the myth that US is more 'operator dependent' than other techniques should be laid to rest. If one is enthusiastic and willing to learn, the learning curve in US is no steeper than that in magnetic resonance imaging (MRI), computed tomography (CT), or any other branch of radiology.

The key to an understanding of the neck, as in all other areas of radiology, is a sound knowledge of anatomy. The aim of this chapter is to provide that knowledge as a basis for understanding ultrasound of the neck.

Equipment and technique

A state-of-the-art high resolution US machine is desirable but not essential. A dedicated high resolution US machine is a luxury for most of those who work in busy US departments; however, most reputable multifunction machines now have sufficient high resolution hardware, software and probes to allow adequate examination of the head and neck. A linear 7.5–10 MHz probe with a relatively small 'footprint', i.e. a small contact surface area, is optimal. Higher frequency probes, i.e. 10 MHz and above, allow superior resolution for superficial structures but there is a trade-off in lack of depth penetration. Be aware that a probe of too high a frequency, i.e. 10–13 MHz, can definitely be counterproductive when learning; for the beginner, an appreciation of the overall anatomy is much more easily obtained using lower frequency probes. There is a role for 5 MHz probes in assessing deep lesions such as those in the deep lobe of the parotid. Colour flow facilities are now standard on most machines; and while preferable they are not necessarily essential. The beginner will find it easier to pick out the vascular anatomy of the neck using colour flow, but there will be less dependence once familiarity with the anatomy has been attained. Power flow applications are desirable for assessing flow patterns, for example in lymph nodes and thyroid nodules. The beginner may be deterred from carrying out a biopsy in the head and neck if colour imaging is regularly used. Many head and neck tumours and lymph nodes have spectacular colour flow features but core biopsy and fine-needle aspiration biopsy (FNAB) can still be safely carried out!

One essential piece of equipment is a high quality, adjustable and mobile table. It is important that for US and US guided procedures in the neck, the examiner is comfortable. A mobile table that can be easily positioned so that the patient's neck is level with the US monitor and within the operators scanning range is essential. Most operators find the most comfortable position to be, one in which the patient's neck is level with the examiner's thigh or knees. When carrying out biopsy techniques the operator must be positioned so that the monitor can be viewed comfortably without undue stretching or twisting. A monitor on a manoeuvrable arm is ideal. The patient's neck should be sufficiently close so that both the hand holding the probe and the hand holding the needle or biopsy gun are in a relaxed position, again without undue stretching or twisting. The probe, needle, monitor and patient should be in a tight or acute field of view for optimal positioning. Comfort of operator and patient will reduce problems when free-hand biopsies are performed under real-time US control. While this appears to be no more common sense, most of the problems encountered by the author when teaching free-hand biopsy techniques are due to poor positioning of both radiologist and patient.

The patient should be positioned with the neck extended, a pillow behind the shoulders and lower neck allowing the patient to adopt a comfortable position that can be maintained throughout the study. There may be difficulties in elderly patients with arthritic necks or respiratory problems; in these patients the table should be adjusted to 45 degrees and a pillow placed behind the shoulders, if possible, to enable some extension of the neck. The patient may be scanned in a sitting position if necessary, although assessment of the lower neck may be compromised.

The use of a gel block is sometimes required, particularly if one is not blessed with a probe with a small footprint. Integrated stand-off blocks are not necessary. In certain 'angular' positions, such as the angle of the mandible and supraclavicular fossa in thin individuals, a better image will be obtained using a stand off block. The author finds a small (9 cm), round gel disc (Aqua flex gel pad, Parker laboratories, USA) to be the most satisfactory. It is washable and usually lasts for 4–6 weeks in a busy department. If one has a high frequency probe with a small footprint, the application of a good covering of gel is usually sufficient for the assessment of the most superficial structures.

EQUIPMENT AND TECHNIQUE
High frequency (7.5–10 MHz), small footprint probe
Colour flow imaging
Manoeuvrable monitor
Mobile adjustable table
Pillow under patient's shoulders
Comfort is vital, for operator and patient alike

Anatomy: introduction

As in any field of radiology, an understanding of the anatomy of the region is the key to the radiological approach. Unfortunately the complex anatomy of the

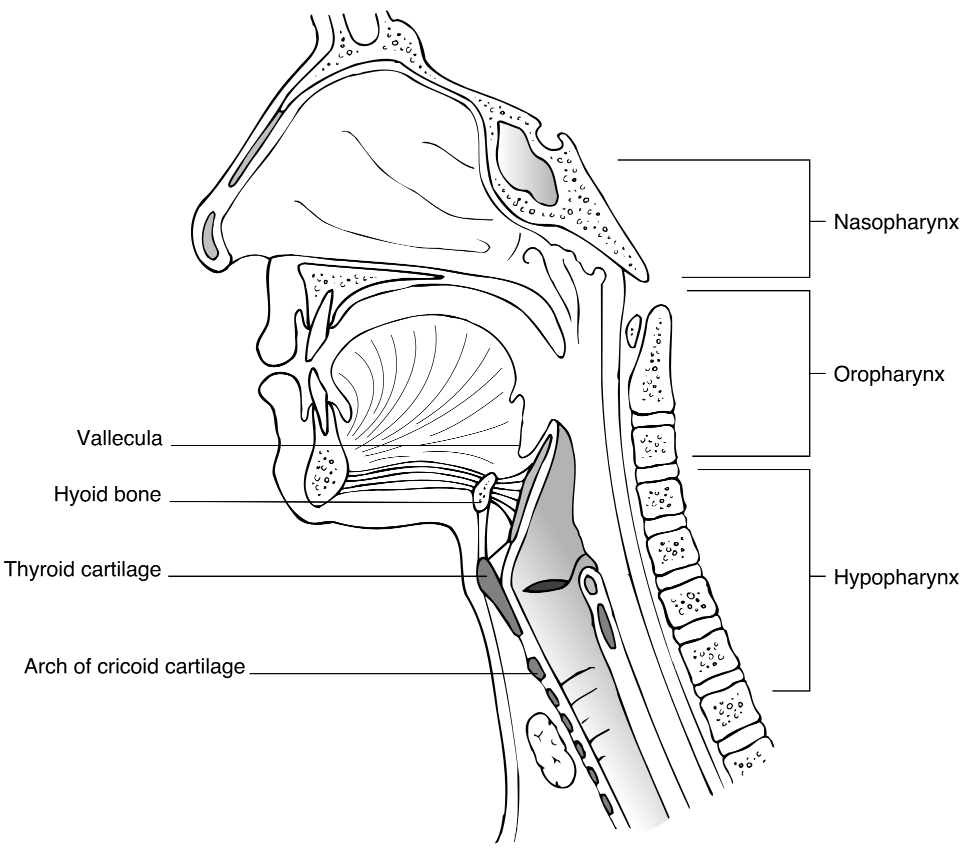


Figure 1.1 – Sagittal section showing the divisions of the upper aerodigestive tract.

head and neck can prove a daunting prospect for the radiologist who only infrequently carries out scanning in this area. The situation is not helped by the many and varied methods and concepts employed in describing the anatomy of the extracranial head and neck.

Traditionally, the upper aerodigestive tract is divided into four areas: nasopharynx, oropharynx, hypopharynx and oral cavity. These subdivisions are important in CT and MRI but of less significance in ultrasound. All radiologists should be aware of these traditional divisions (Figure 1.1). They are relevant in the diagnosis and staging of squamous cell carcinoma (SCC), the most prevalent tumour of the upper aerodigestive tract.[1]

Surgeons and anatomists[2] have traditionally divided the neck into triangles based on muscular landmarks and boundaries. This division of the neck into triangles does not sit easily with the cross-sectional anatomy techniques practised by radiologists, however radiologists must be aware of the surgical system in order to comprehend referrals for imaging (Figure 1.2).

Knowledge of the anatomy of just three muscles – the sternocleidomastoid, digastric and omohyoid – is the key to understanding the triangles of the neck. The sternocleidomastoid, which runs from the mastoid process to the clavicle and sternum, divides the neck into two large triangles: anterior and posterior.

The anterior triangle is subdivided into supra- and infra-hyoid portions. The suprahyoid portion is further divided by the anterior belly of digastric muscle into the submental and submandibular triangles. The infrahyoid portion is divided by the superior belly of the omohyoid muscle into muscular and carotid triangles. The posterior belly of digastric marks the superior border of the carotid triangle.

The posterior triangle is demarcated by the posterior border of sternomastoid anteriorly and the anterior border of trapezius posteriorly. The apex is formed by the occiput while the base of the triangle is formed by the clavicle. The triangle is further subdivided by the posterior belly of the omohyoid muscle, forming an occipital triangle superiorly and a supraclavicular triangle inferiorly. The division of the neck by the sternomastoid often poses a dilemma in that a mass deep to the sternomastoid is not strictly in the anterior or the posterior triangle, the posterior border of sternomas-

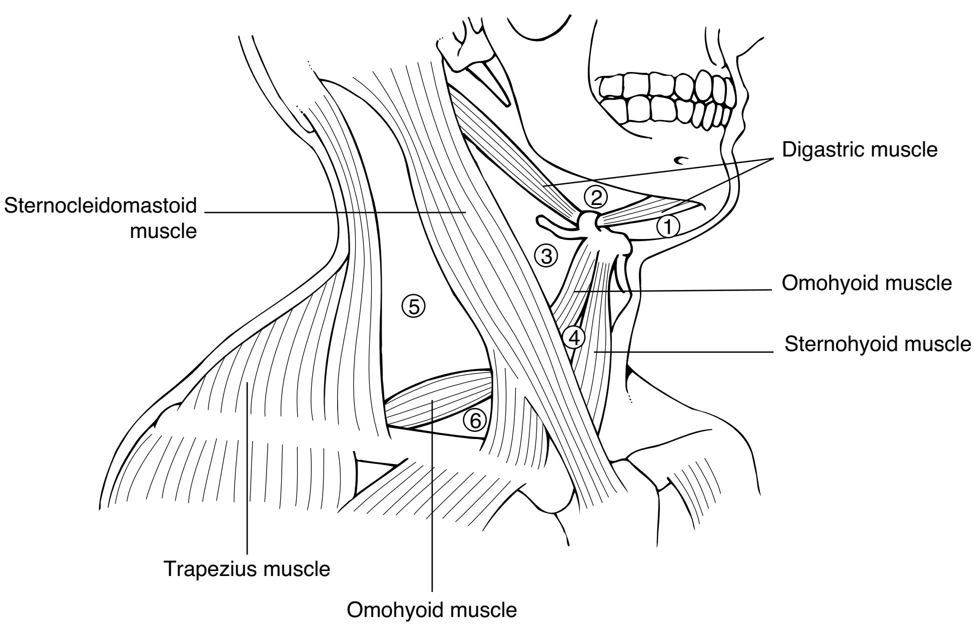


Figure 1.2 – Division of the neck into 'triangles'. The anterior triangle is divided into ① submental ② submandibular, ③ carotid and ④ muscular triangles. The posterior triangle is divided into a ⑤ occipital triangle and an ⑥ supraclavicular.

toid demarcating the anterior boundary of the posterior triangle.

The advent of CT and MRI has brought about a reappraisal by radiologists of the anatomy of the extracranial head and neck. The multiplanar capabilities of MRI in particular have enabled a far better appreciation of the complex anatomy of this region. The 'spaces' concept has been heralded as the key to a better understanding of the anatomy and pathology of the head and neck. Radiologists, in particular Harnsberger,[3–6] have developed a clear and practical method of using the spaces concept to analyse head and neck pathology (Figures 1.3, 1.4). Above the hyoid bone the spaces concept works well and knowledge of the suprahyoid spaces aids assessment with ultrasound, however the same is not true when assessing the infrahyoid neck.

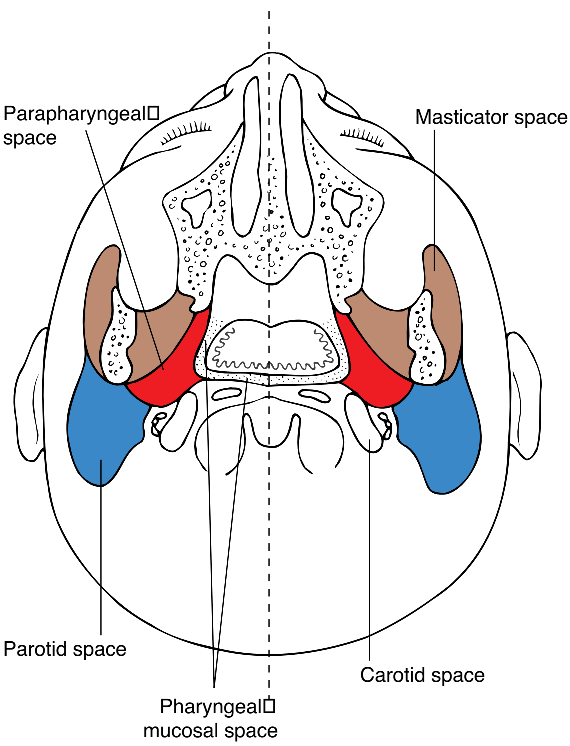


Figure 1.3 – Axial section depicting the 'big five' spaces of the neck, i.e. parapharyngeal space (red), parotid space (blue), carotid space, masticator space (brown), and pharyngeal mucosal space.

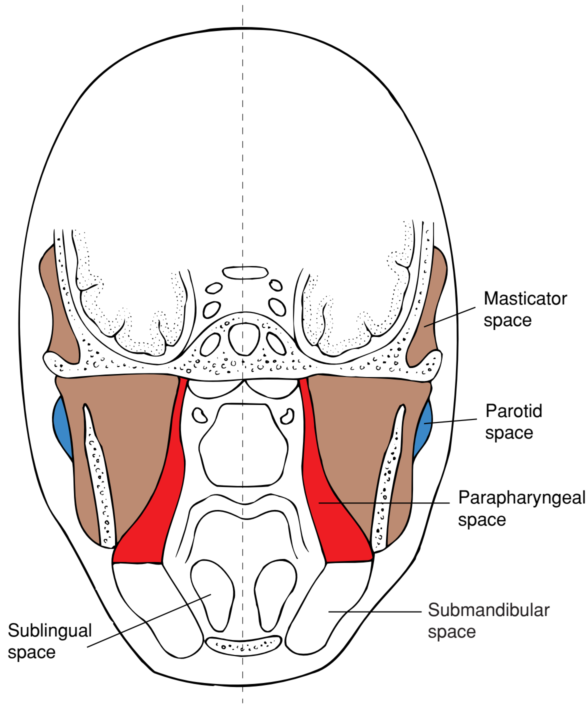


Figure 1.4 – Coronal section showing the major spaces. Note the cranial/caudal extension of the parapharyngeal and masticator spaces. Note also the communication between the parapharyngeal and submandibular spaces.

Ultrasound anatomy

'Where do I start?' is a familiar plea when attempting ultrasound of the head and neck. It is essential to have an easily replicated systematic strategy for the examination of the extracranial head and neck. This allows key structures to be identified and enables assessment of the whole neck. The aim of this chapter is to present a strategy that allows the sonographer or radiologist to quickly and systematically examine the neck.

The ensuing method follows a logical progression from mandible to clavicle in direction. For each region the key structures that can be, and need to be, identified will be highlighted.

Submental region (Figure 1.5)

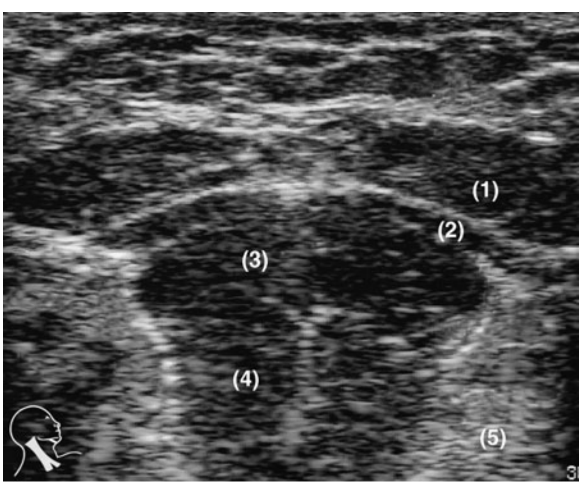
The borders of the submental triangle are easily defined on ultrasound. The floor is formed by the mylohyoid muscle, and the apex of the triangle by the symphysis mentis, the base of the triangle being formed by the hyoid bone. The anterior belly of the digastric muscles represent the sides of the triangle. These can be followed down in transverse section to the hyoid. The only contents of note are the submental lymph node group.

The genioglossus and geniohyoid muscles form the root of the tongue. Together with the hyoglossus muscle they make up the major extrinsic muscles of the tongue. The mylohyoid muscle is synonymous with the floor of mouth, forming a muscular sling between the medial aspect of the mandibular bodies. Posteriorly the mylohyoid has a free thick border and is thinner anteriorly where it is attached to the anterior mandible inferior to the origins of the genial muscles (genioglossus and geniohyoid). The anterior portion of the mylohyoid can be difficult to demonstrate, and in some instances it is deficient anteriorly.

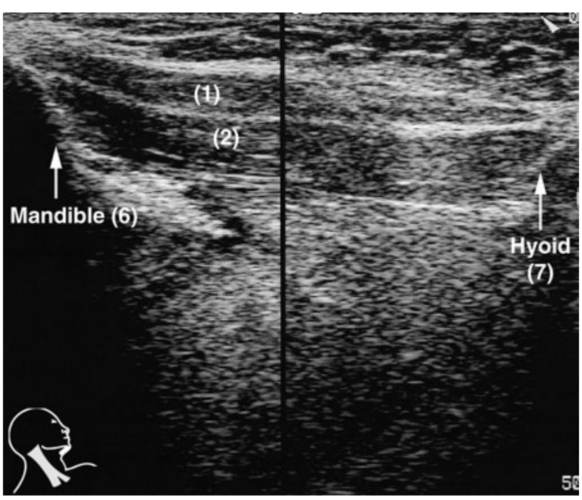
The lingual artery can be easily picked up using colour flow imaging, and is a readily recognised landmark. It is just medial to the hyoglossus muscle. Differentiation between the mylohyoid and hyoglossus muscles can be aided by scanning in the coronal plane, while asking the patient to move the tongue from side to side. The mylohyoid is relatively immobile while the hyoglossus is identified actively contracting (see Figure 1.6b, c). Contraction of the hyoglossus muscle depresses the tongue. Lateral to the hyoglossus, the submandibular duct can be identified[7], particularly if it is dilated (see Figure 1.6d). Take care not to confuse the duct with the lingual vein which sits alongside the proximal submandibular duct; colour flow imaging usually identifies the vein. The submandibular duct is sandwiched with the sublingual gland between the hyoglossus and mylohyoid muscles. It lies just superior and lateral to the lingual artery, which can be identified medial to the hyoglossus muscle (Fig 1.6b).

The sublingual gland is identified on transverse or axial sections as an elongated hyperechoic structure, lateral to hyoglossus. It is much larger than is generally appreciated: anteriorly it almost touches the symphysis mentis and posteriorly it abuts the deep surface of the submandibular gland. The submandibular duct often receives a large accessory duct from the anterior part of the sublingual gland (Bartholin's duct). The sublingual gland may be joined to the submandibular gland to form a large, single sublingual–submandibular complex.

The mylohyoid muscle is the key to differentiating whether or not a lesion is in the sublingual or submandibular space. Lesions deep to mylohyoid are within the sublingual space; if a lesion is superficial to mylohyoid it lies within the submandibular space (see Figure 1.4). Around the posterior border of the mylo-



(a)



(b)

Figure 1.5 – (a) Coronal and (b) sagittal images of the submental region. (1) Anterior belly of digastric muscle. (2) Mylohyoid. (3) Geniohyoid. (4) Genioglossus. (5) Sublingual gland. (6) Mandible. (7) Hyoid.

hyoid muscle free communication is possible between the posterior sublingual space and the adjacent submandibular and inferior parapharyngeal space (as in a diving ranula – a retention cyst of the sublingual gland that extends posteriorly into the submandibular space and inferiorly into the parapharyngeal space).

The submandibular duct extends anteriorly from the gland within the submandibular space into the sublingual space, swerving around the free posterior border of mylohyoid.

Submandibular region (Figure 1.6)

The submandibular gland sits like a saddle astride the digastric and mylohyoid muscles when viewed in a transverse plane. The anterior belly of the digastric may be seen emerging anteriorly. The anterior belly of the digastric is more muscular and easier to define than the tendinous portion of the posterior belly which is identified immediately posterior to the body of the submandibular gland. The tendon of the posterior belly can be followed down towards the hyoid. Immediately

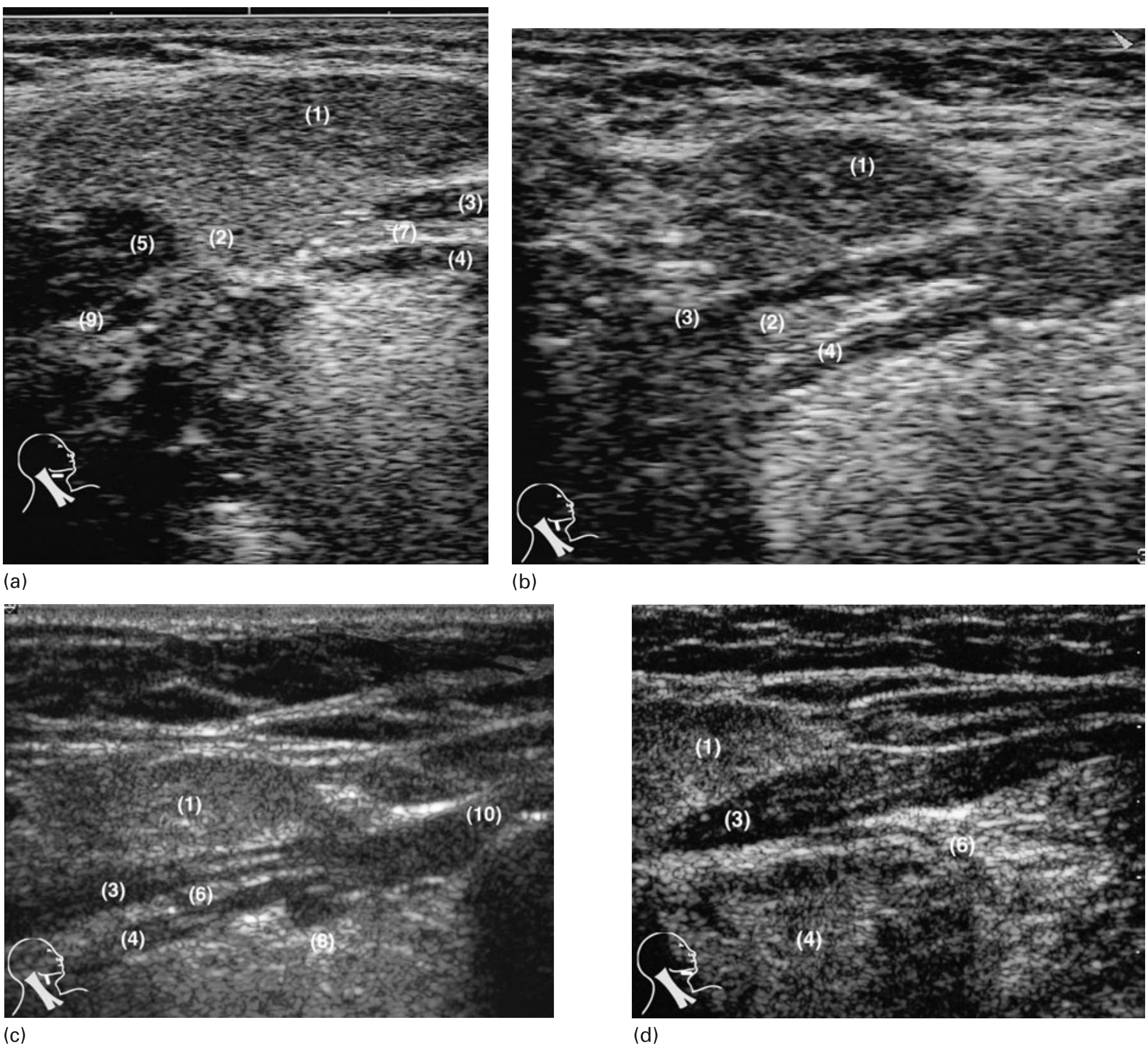


Figure 1.6 – (a) Transverse, (b) coronal, (c) coronal oblique, (d) transverse views of the submandibular region. (1) Superficial submandibular gland. (2) Deep submandibular gland. (3) Mylohyoid. (4) Hyoglossus. (5) Posterior belly of digastric. (6) Submandibular duct. (7) Lingual vein. (8) Lingual artery. (9) Facial artery. (10) Hyoid.

inferior to the submandibular gland it cannot usually be seen as it splits the stylohyoid muscle and then enters its fascial tunnel. The submandibular gland lies in the plane of the anterior belly of digastric, hence more of the anterior belly is identified in parasagittal sections of the submandibular gland than the posterior belly which runs in a more cranial–caudal orientation, i.e. more vertically. More posteriorly the mylohyoid is visible, its posterior free border indenting the submandibular gland.

Anterior to the submandibular gland is a small, fat-filled triangular space. Lymph nodes can be identified in this region. Two constant venous landmarks outline the submandibular gland; anteriorly and superiorly the facial vein can be seen coursing superficially, and posteriorly the anterior division of the retromandibular vein can be identified. This joins with the facial vein to drain into the internal jugular vein. Displacement of this venous structure is the key to differentiating whether a mass is arising from the submandibular gland anteriorly or the parotid gland posteriorly. The superficial venous anatomy of the neck, while variable, provides many recognisable landmarks (Figure 1.7). The serpiginous course of the facial artery can be identified with colour flow imaging as it passes deep to the anterior portion of the submandibular gland. It emerges from behind the mid/anterior portion of the gland to pass up and over the body of mandible.

Parotid region (Figure 1.8)

The parotid space extends from the external auditory meatus superiorly to the angle of the mandible inferiorly. Within the gland lies the retromandibular vein (RMV) and, just medial to it, the external carotid artery (ECA). The RMV is a landmark for the facial nerve which courses just laterally. The RMV can be taken as a marker for the division of the parotid into superficial and deep lobes. Alternatively, an imaginary line drawn along the axis of the ramus of the mandible through the parotid acts to divide the superficial and deep lobes. The main parotid duct is identified as an echogenic line within the superficial lobe. The masseter muscle lies just deep to the anterior aspect of the superficial lobe, and accessory lobes of the parotid are identified in this region. The parotid duct runs approximately one finger breadth below the zygomatic arch, coursing anteriorly through the buccal space before

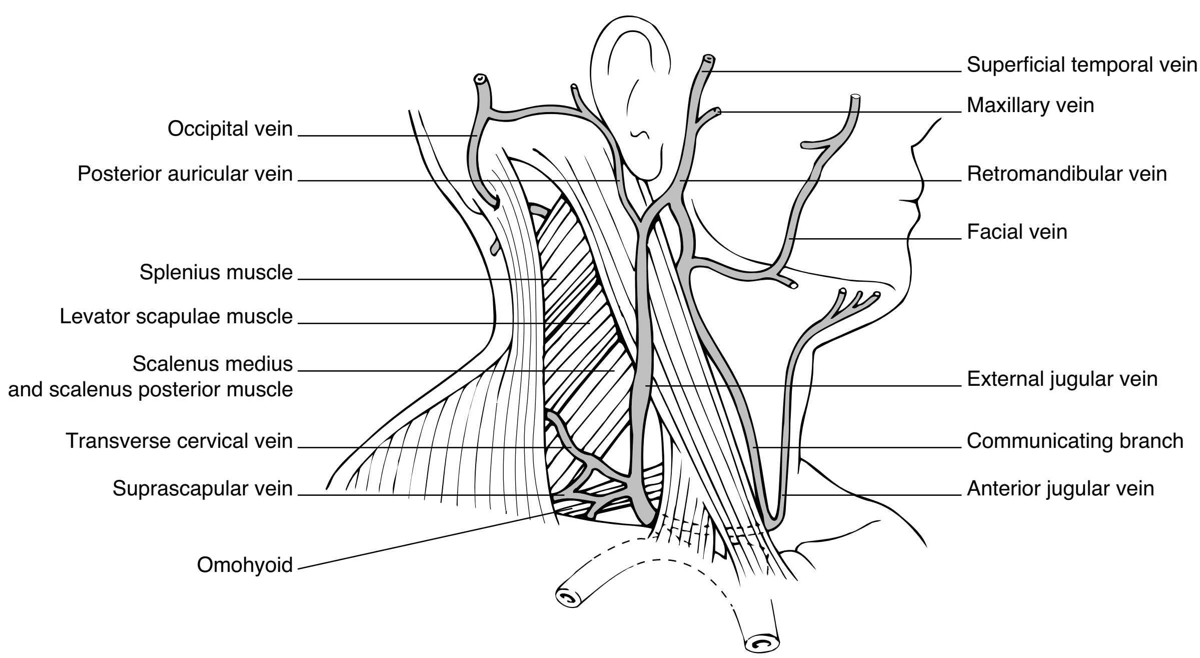


Figure 1.7 – Superficial venous anatomy of the neck.

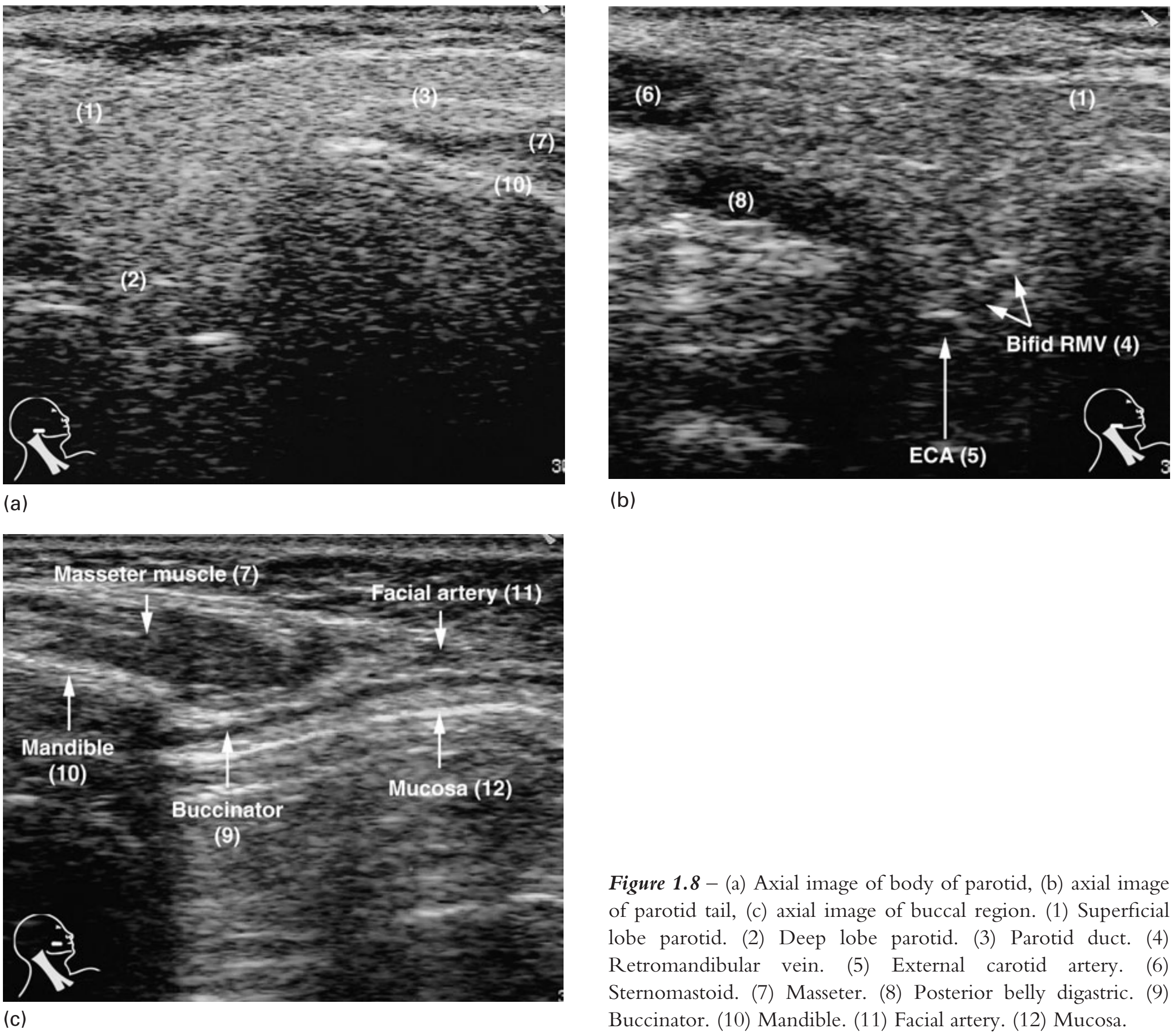


Figure 1.8 – (a) Axial image of body of parotid, (b) axial image of parotid tail, (c) axial image of buccal region. (1) Superficial lobe parotid. (2) Deep lobe parotid. (3) Parotid duct. (4) Retromandibular vein. (5) External carotid artery. (6) Sternomastoid. (7) Masseter. (8) Posterior belly digastric. (9) Buccinator. (10) Mandible. (11) Facial artery. (12) Mucosa.

piercing the buccinator muscle. The thin buccinator muscle extends anteriorly and just medially to the anterior margin of the masseter (Figure 1.8c). Asking the patient to blow out the cheek or clench the teeth aids its identification. The buccal space, which lies lateral to the buccinator muscle, contains fat, the facial nerve, vein, artery and parotid duct.

Upper cervical region (Figure 1.9)

As the probe passes down from the tail of the parotid gland the operator is confronted by a minefield of vascular structures. Colour flow imaging is of great assistance in this area.

The two structures to pick out are the internal jugular vein (IJV), which acts as the landmark for the deep cervical lymph node chain, and the posterior belly of digastric muscle. The posterior belly of the digastric muscle is a key structure in separating the parotid region from the upper cervical region inferiorly. Clinically, the posterior belly of the digastric muscle marks the division between the submandibular triangle anteriorly and the carotid triangle more posteriorly. To identify it, align the probe just anterior to the mastoid process, directing down towards the hyoid. The posterior belly of digastric will be identified emerging deep to sternomastoid muscle to abut the tail of the parotid. It is a superficial structure and courses at approximately