Imaging of the head and neck

Ivan Zammit-Maempel

Abstract
Imaging is increasingly being used in the evaluation of patients presenting with a neck mass or with a 'hot' neck and has an established role in the staging of head and neck cancer. Plain radiographs have a very limited role and the workhorses of neck imaging are ultrasound, CT and MRI with an increased demand for positron emission tomography-CT. Contrast studies, videofluoroscopy, angiography, cone beam CT and nuclear medicine have a limited but important role in selected cases. This article will discuss the role of some of these imaging modalities in evaluating the soft tissues of the neck.

Keywords Computed tomography; head and neck; magnetic resonance imaging; positron emission tomography; radiology; ultrasound

Introduction

Radiology is a prerequisite in the evaluation of masses in the neck, staging of head and neck tumours and their post-treatment follow-up. Radiologists are increasingly being involved in image-guided biopsies and aspirations of masses and collections in the neck, injection of botulinum toxin in selected post-surgical patients to improve speech or reduce salivary flow and treating patients by vascular stenting or embolization.

The surgical trainee may be baffled by the various imaging modalities available and be unsure as to which investigation to request. This review will aim to clarify this. It should be emphasized that meticulous clinical history and examination may suggest the clinical diagnosis and imaging should be performed to confirm or refute this and not used as a blanket screening examination.

Plain radiographs

Plain radiographs have a limited role in detecting ingested radio-opaque foreign bodies and evaluating the dentition in patients presenting with any abscess around the floor of mouth and bony hard masses (Figure 1). Air and calcium may prove difficult to identify on ultrasound and MRI respectively and a plain radiograph may very quickly solve the problem.

Ultrasound

Ultrasound is cheap, quick, non-invasive, readily available and does not use ionizing radiation but is operator dependent. It is widely used in evaluating the thyroid gland, neck lumps, lymph nodes and the salivary glands, extremely useful in the paediatric population and can be used to guide fine needle aspirations/biopsies (Box 1). The verbal interaction with patients while placing the probe directly over a mass, is a huge advantage compared to other cross-sectional imaging.

Ultrasound works by creating an image from tissues using the reflection of sound waves from different density tissues. The ultrasound probe both transmits high frequency sound energy and receives it after it has been reflected by the tissues. As the neck structures are relatively superficial, high-frequency probes (7.5−12 MHz) are used, resulting in excellent near field resolution but there is a trade off in lack of penetration. Colour Doppler is used to assess the vascularity of masses.

As ultrasound is particularly helpful in the evaluation of nodes, some detail will be provided in this regard.

Nodal masses: ultrasound confirms the location, size, number, shape, echogenicity and vascularity of the node and whether this is a simple reactive node or a more complex node that requires further investigation/treatment.[1]

Number and distribution: cervical lymph nodes are detectable in normal patients, especially children and adolescents, and commonly found in the submandibular, parotid, posterior triangle and upper deep cervical chain. Metastatic lymph nodes in the neck are site specific (e.g. the internal jugular chain involved by oropharyngeal tumours and the supraclavicular fossa by lung, breast and oesophageal tumours).

Size: the size of normal lymph nodes varies with age and location, for example a normal jugulodigastric node can measure up to 15 mm. Although a maximum short axis axial diameter of 10 mm is used as a cut off by most radiologists, 8 mm is preferred by some.

Shape: a round shape suggests a malignant node while an oval shape indicates normality.

Echogenic hilus: an echogenic hilus is a good sign of a benign node (Figure 2a), but should not be used as the sole criterion in assessment of cervical nodes.

Echogenicity: metastatic nodes are usually hypoechoic (Figure 2b) compared to the adjacent muscles, although metastatic nodes from papillary thyroid cancer may be hyperechoic.

Vascularity: normal and reactive nodes tend to show hilar vascularity or appear avascular. Metastatic nodes tend to have a disorganized, peripheral pattern with subcapsular vessels while lymphoma shows exaggerated hilar flow (Figure 2c).

Ultrasound guided fine needle aspiration (FNA) cytology: once a node has been identified as pathological, FNA can be performed (Figure 2d).

Computed tomography (CT)

CT is effectively the workhorse in head and neck cancer imaging and useful in detecting masses or abscesses in the deep structures of the neck inaccessible to ultrasound such as the retropharyngeal and parapharyngeal spaces. The entire neck can be scanned in a few seconds on modern multi-slice scanners with exquisite coronal and sagittal reconstructions. Disadvantages

***Ivan Zammit-Maempel** MB ChB (Hons) MRCP FRCR is a Consultant Radiologist at Freeman Hospital, Newcastle upon Tyne, UK. Conflicts of interest: none.*

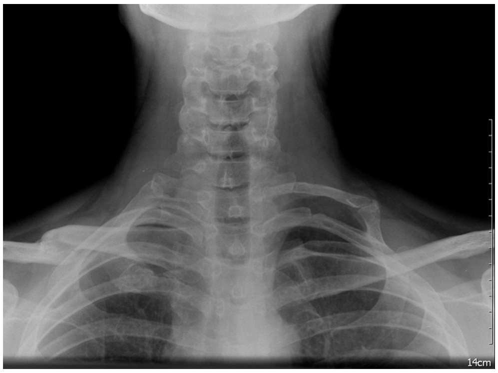

Figure 1 Plain radiograph showing anomalous left first and second rib articulation in a patient presenting with a hard supraclavicular mass.

include the use of ionizing radiation and artefact from dental amalgam and swallowing. The patient is asked to lie still, not to swallow and to breathe quietly. Intravenous iodinated contrast agents allow discrimination between normal tissues and tumours or inflammatory masses. Dual source scanning is the latest breakthrough in CT technology and early results are promising in imaging the neck.[2] Cone beam CT has an evolving role in head and neck imaging.[3]

Magnetic resonance imaging (MRI)

The strengths of MRI are that it produces images with very good soft tissue contrast and does not use ionizing radiation but is lengthy, contraindicated in *most* patients with pacemakers, ferromagnetic intraocular foreign bodies, cochlear implants, cerebral artery aneurysm clips and valve prostheses and potentially claustrophobic. The long acquisition times can result in images being degraded by swallowing and movement artefact. It plays a role in assessing salivary gland tumours especially deep lobe parotid gland involvement, oral cavity tumours where CT has resulted in considerable dental artefact and intracranial extension of skull base tumours.

Positron emission tomography (PET)

PET is a functional imaging technique that depicts tissue metabolic activity and uses short-lived radioisotopes that contain protons that decay emitting positrons. These positrons travel a short distance in tissue before combining with electrons resulting in annihilation with the emission of two 511 keV photons roughly at 180 degrees to each other. These exit the body and are detected by detectors forming part of the PET scanner. The commonest tracer used is fluorine-18-labelled 2-fluoro-2-deoxy-D-glucose (FDG), which is cyclotron produced and has a half life of 110 minutes. It is injected intravenously and accumulates intracellularly depending on the rate of glucose utilization. All hypermetabolic cells, not just malignant cells, accumulate the tracer resulting in increased activity as measured by standard uptake value (SUV). A major advance of PET has been the combination with CT into a single scanner, allowing more accurate anatomical localization. PET-CT is useful in assessing patients presenting with a metastatic neck node and no overt primary and in the post-treatment patient, where differentiation between post-treatment fibrosis and residual/recurrent tumour can be difficult. It is important to point out that various structures such as the lymphoid tissue in Waldeyer's ring, the salivary glands, nasal turbinates and cervical muscles normally show FDG uptake in the head and neck. The use of PET-MRI in the staging of head and neck cancer is currently being evaluated.[4]

Summary of the uses of ultrasound in the neck

Ultrasound is useful in the evaluation of:

- Salivary glands
- Nodes
- Thyroid gland
- Any palpable cervical mass
- Any mass in children

Ultrasound is not useful in the evaluation of:

- Deep lobe of parotid gland
- Parapharyngeal, prevertebral or retropharyngeal space masses
- Any mass containing a large amount of air

Box 1

Lump in the neck

The imaging of patients presenting with a neck lump depends on the age of the patient, clinical history and location of the mass.

Children

Most neck lumps are due to reactive lymph nodes and if small, soft and mobile and associated with an upper respiratory tract infection, imaging is not necessary. If nodes are larger than 3 cm, present in the supraclavicular region or the child has fever, hepatosplenomegaly, weight loss or night sweats, then a chest radiograph besides a full blood count and serology especially for Epstein–Barr virus, should be performed and the neck imaged initially by ultrasound.[5] Ultrasound will generally differentiate reactive lymphoid hyperplasia from lymphoma and excision biopsy necessary in only a very small proportion of cases.

Should the neck lump not be a lymph node, then ultrasound can differentiate between a cystic or solid mass. CT and MRI serve as supplementary examinations in defining the exact anatomy prior to surgery. The differential diagnosis of cystic masses in children depends on location. A cystic mass in the submental region is likely to be an epidermoid (Figure 3a) or ranula, a second branchial cyst in the submandibular space (Figure 3b), a thyroglossal duct cyst (Figure 3c) if closely related to the strap muscles and a venous (Figure 3d) or lymphatic malformation if it straddles the neck.[6] Atypical mycobacterial cervical adenitis is a cause of a unilateral persistent neck lump in a child under 5 years of age, often associated with an overlying violaceous skin appearance. Ultrasound reveals a marked decrease of echogenicity in the early stages and intranodal liquefaction in the advanced stages.

Adults

Adult lymphadenopathy is more unusual than in children and any adult presenting with a suspicious neck lump should be