THE NORTHERN HOSPITAL

SONOGRAPHY OF THE AIRWAY

Robin in the Snow, watercolour, Dawn Derman, (date unknown).

Of all the continua mapped by science, the most relevant to the humanities are the senses, which are extremely limited in our species. Vision is based in Homo sapiens on an almost infinitesimal sliver of energy, four hundred to seven hundred nanometers in the electromagnetic spectrum. The rest of the spectrum, saturating the Universe, ranges from gamma rays trillions of times shorter than the human visual segment to radio waves, trillions of times longer. Animals live within their own sliver of continua. Below 400 nanometers, for example butterflies find pollen and nectar in flowers by the patterns of ultraviolet light reflected off the petals - patterns and colours unseen by us. Where we see a yellow or red blossom, the insects see an array of spots and concentric circles in light and dark.

Healthy people believe intuitively that they can hear almost every sound. However, our species is programmed to detect only twenty thousand hertz (cycles of air compression per second). Above that range, flying bats broadcast ultrasonic pulses into the night air, and listen for the echoes to dodge obstacles and snatch moths and other insects on the wing. Below the human range, elephants rumble complex messages in exchanges back and forth with other members of the herd. We walk through nature like a deaf person on the streets of new York, sensing only a few vibrations, able to interpret almost nothing.

Human beings have one of the poorest senses of smell of all the organisms on Earth, so weak that we have only a tiny vocabulary to express it. We depend heavily on similes such as "lemony" or "acidic" of 'fetid". In contrast, the vast majority of other organisms, ranging in kind, from bacteria to snakes and wolves, rely on odor and taste for their very existence. We depend on the sophistication of trained dogs to lead us through the olfactory world, detecting even the slightest trace of explosives and other dangerous chemicals.

Our species is almost wholly unconscious of certain other kinds of stimuli without the use of instruments. We detect electricity solely by a tingle, a shock, or a flash of light. In contrast, there exists a variety of freshwater eels, catfish, and elephant-nose fish, confined to murky water, deprived of vision, they live instead in a galvanic world. They generate charged fields around their bodies with trunk muscle tissue that has been modified by evolution into organic batteries. With the aid of electric shadows in the pattern of charges, the fish avoid obstacles around them, locate prey and communicate with others of the same species. Yet another part of the environment beyond the reach of humans is Earth's magnetic field, used by some migratory birds to guide them during their long-distance journeys.

Edward O. Wilson, (Pulitzer Prize Winner),
"The Meaning of Human Existence", 2014.

In the spruce forests of northern Sweden, a tiny red robin, fluffs herself up against the first bitter snows. She has successfully reared her brood of young chicks over the recent summer, but now the winter is becoming so cold a primal instinct is telling her that it is time to fly south. The forest is alive with a cacophony of urgent, yet happy chirping, she is not the only robin who feels this instinct. Over the last few weeks she has been fattening herself up on insects and berries in preparation for the epic journey she must take. Suddenly she and the other robins take off into the night as one, flying over the frozen *moonlit landscape far below, the beginning of an astonishing journey for such a tiny, yet remarkable creature - a journey that will take her hundreds of miles to the warm North African coast, where she will spend the winter months.*

We witness in the European Robin (or Erithacus rubecula) a most miraculous phenomenon. For many years, it remained a complete mystery as to how precisely the robin managed to navigate the vast distances it travelled during its yearly winter migration, to escape the Nordic winter. Brilliant scientists and biologists have recently determined the astonishing fact that robins do not navigate by any sense, familiar to humans. The robin can in fact, sense magnetic fields - specifically the magnetic field of the Earth itself! And it does this by a miracle of evolutionary biology encoded into its very DNA, that appears to make use of the properties of quantum mechanics! Initial suspicions that the robin was navigating by use of the Earth's magnetic field, were met with extreme scepticism, as there was simply no biochemical mechanism known that could detect a magnetic field.

*No **conventional** biochemical mechanism, that is! It seems that the robin is able to respond at the quantum mechanical level, by generating free radicals with pairs of quantum entangled electrons generated by a reaction know as the "fast triplet reaction", which can act as an exquisitely sensitive detector of even the most minute of magnetic fields. Robins navigate north - south by detecting the inclination of the lines of Earth's magnetic field. These lines strike the Earth at varying angles depending on the latitude the bird happens to be in. At the (magnetic) poles the inclination of the magnetic field is exactly vertical, while at the equator they are exactly horizontal, i.e parallel to the Earth's surface. The robin navigates north-*south *by use of a biological magnetic inclination compass, that operates on the quantum level of its biochemistry! Furthermore this mechanism requires a small amount of light at the blue end of the visible electromagnetic spectrum to initiate the robins sense of the magnetic field. Enigmatic light receptors in the robin's eye, known as "cryptochromes" appear to have the ability to generate free radical pairs whose electrons are quantum entangled. We have no idea of how the robin perceives a magnetic field, other than to say that perhaps - in terms humans can understand - they can somehow "see" it, via a "sixth magnetic sense"!*

Homo sapiens, stride through the Earth, arrogantly confident in their sense of it - and yet as the magisterial Edward O. Wilson pointed out our sense of the Universe around us is like a blind, anosmic, deaf person who walks down the streets of New York city! In our quest to understand the "mind of God" we have much to learn from the extended senses of other species on Earth. We cannot possibly even hope to understand what we are incapable of seeing. Fortunately one evolutionary advantage we do have is our intellect, and so we rely on fabulous technologies to extend our sensory perceptions. Our astronomers now "see" almost to the origin of the universe itself and at the other end of the spectrum our physicists have "seen" quarks, the basic constituents of the universe, and to the greatest benefit of humankind, 21st century technologies, such as ultrasound allow to see into our very bodies!

SONOGRAPHY OF THE AIRWAY

Introduction

Ultrasonography of the airway can be used to:

1. Identify the cricothyroid membrane (CTM).
2. Confirm correct ETT placement.
3. Recognise endobronchial intubation.
4. Determining the correct cuffed and uncuffed ETT sizes in paediatric patients.

Sonographic Basics

The linear probe is used to assess the airway.

When the ultrasound beam reaches intraluminal air there are:

- Comet tails
- Reverberation artefacts
- A hyperechoic linear air-mucosal interface
- A series of parallel hyperechoic lines that occur at regularly spaced intervals deep to the initial one.

The ultrasound beam hitting bone results in:

- A hyperechoic line
- Acoustic shadowing.

Cartilaginous structures, such as the cricoid cartilage, appear hypoechoic (dark).

Calcification of these structures with age can limit the sonography.

Glandular structures such as the thyroid glands are homogeneously hyperechoic compared to nearby soft tissues.

Identifying the Cricothyroid Membrane (CTM)

Maintain the neck in **full extension.**

Apply the linear transducer in longitudinal plane along the midline of the anterior neck with the directional indicator oriented towards the patient's head.

If the neck cannot be palpated easily begin at the suprasternal notch.

The tracheal rings (T1, T2, T3) appear as a series of hypoechoic "string of beads" that terminate superiorly with the larger ovoid-shaped hypoechoic cricoid cartilage.
The hyperechoic line deep to the string of beads represents the air-mucosal (A-M) interface.

Move the transducer superiorly, in the longitudinal orientation.

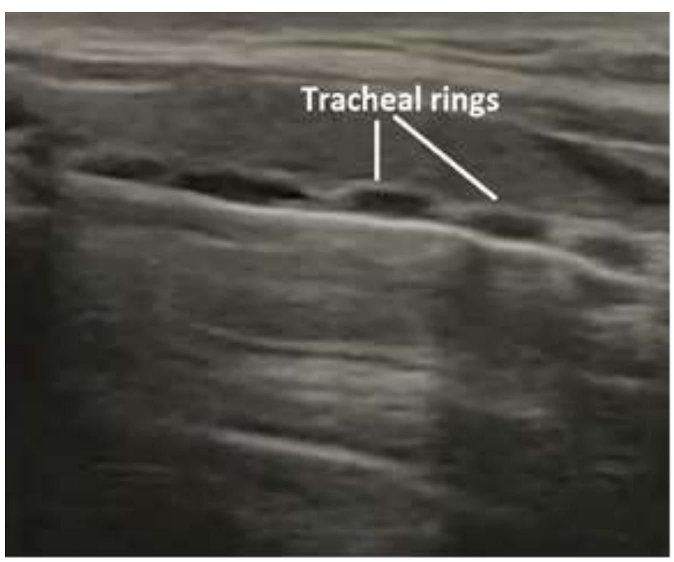
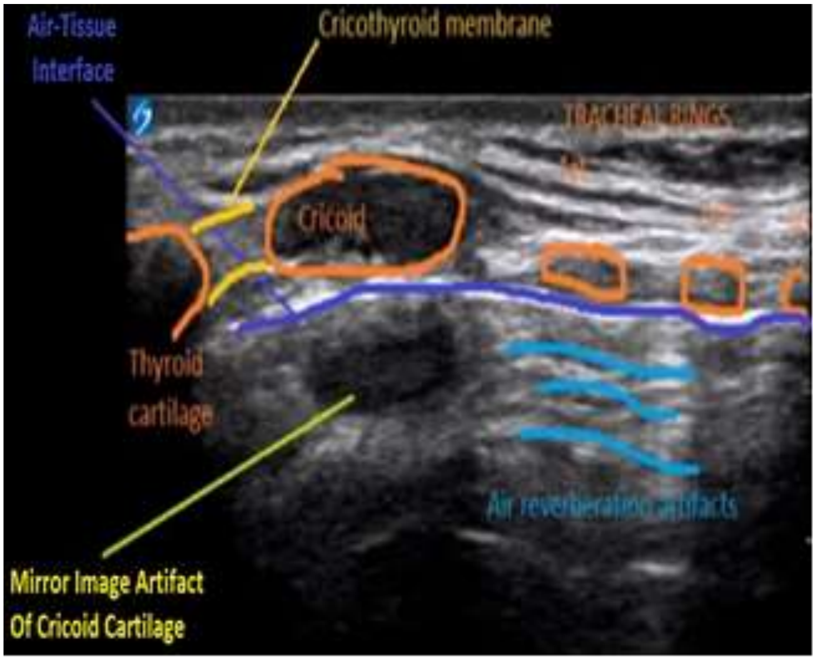


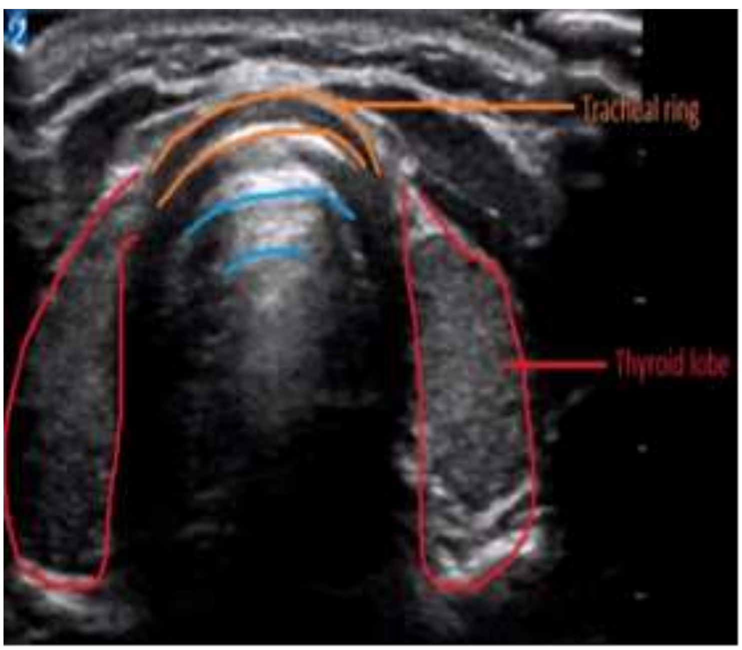
Image showing the tracheal rings.

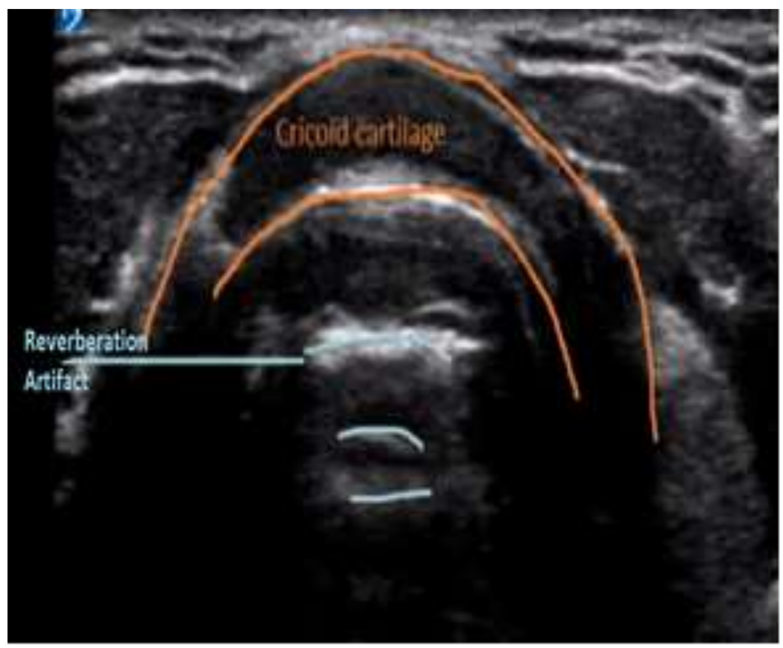


Longitudinal view depicting airway structures.

From left to right:

- Thyroid cartilage
- *Cricothyroid membrane*
- Cricoid cartilage
- Tracheal rings

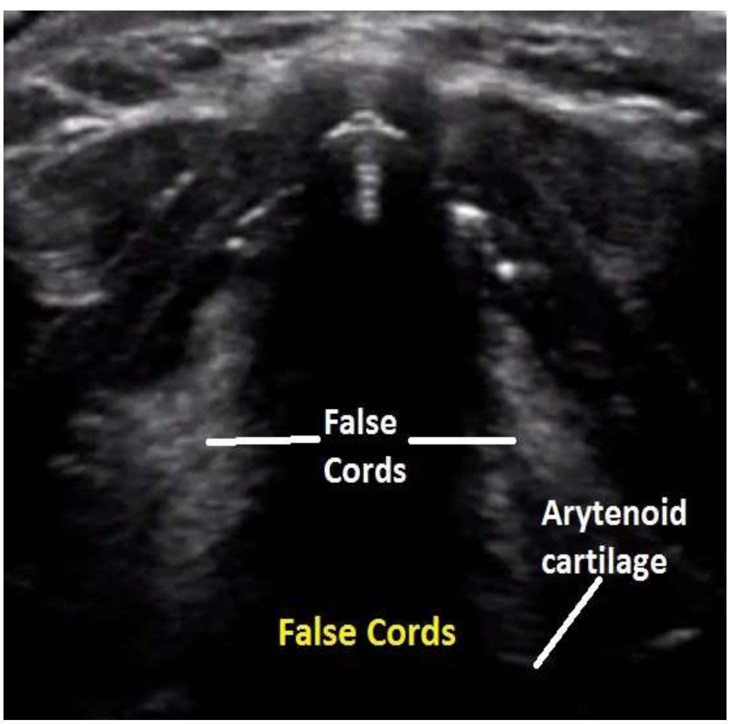


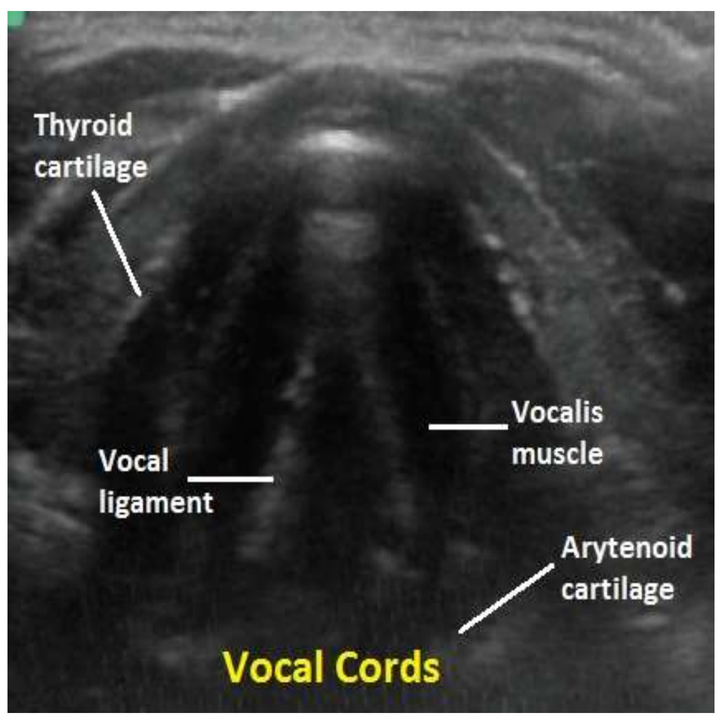


In the transverse plane the cricoid cartilage forms a hypoechoic inverted U highlighted by a linear hyperechoic A-M interface and reverberation artefact posteriorly.

The CTM is seen as a hyperechoic band linking the hypoechoic thyroid and cricoid cartilages

Anatomy of the Vocal Cords

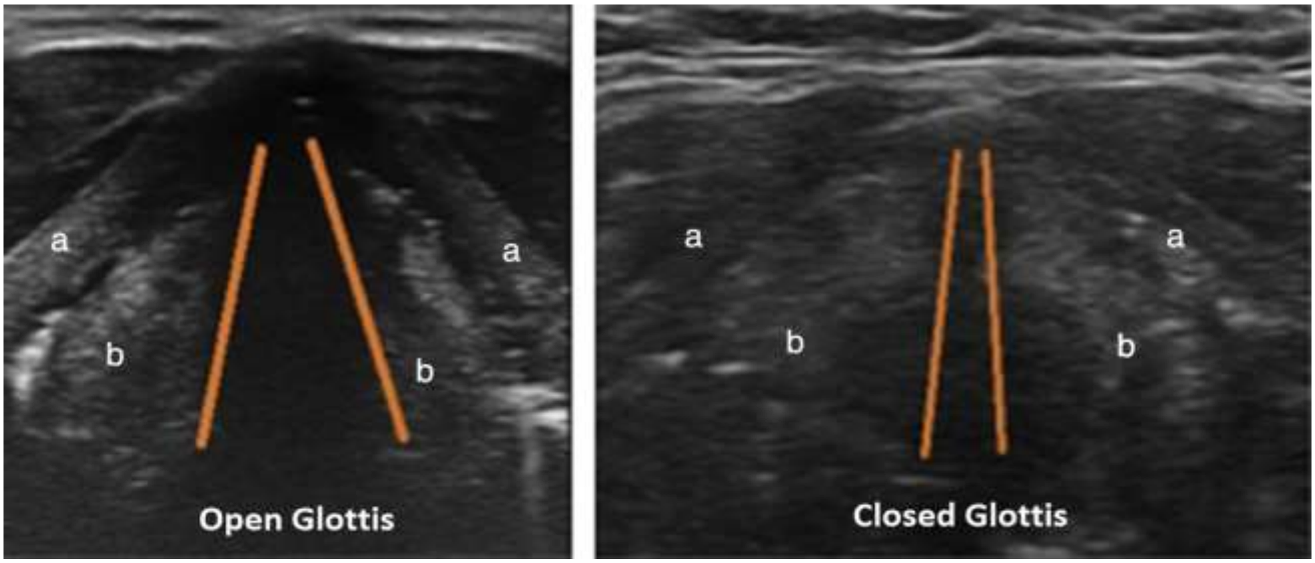


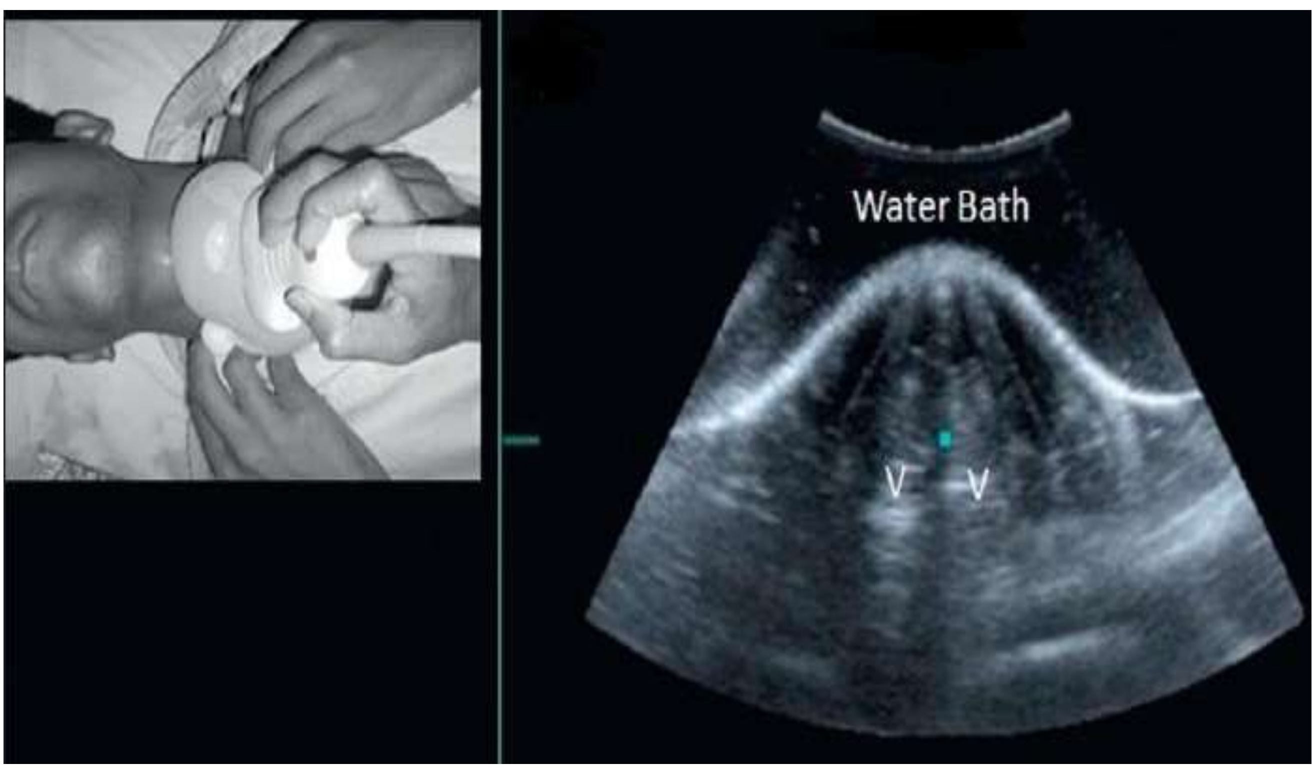


Apply the linear transducer in transverse plane over the thyroid cartilage to view the vocal cords, which are seen forming a triangle with a central tracheal shadow.

The false vocal cords lie parallel and cephalad to the true cords and are more hyperechoic in appearance.

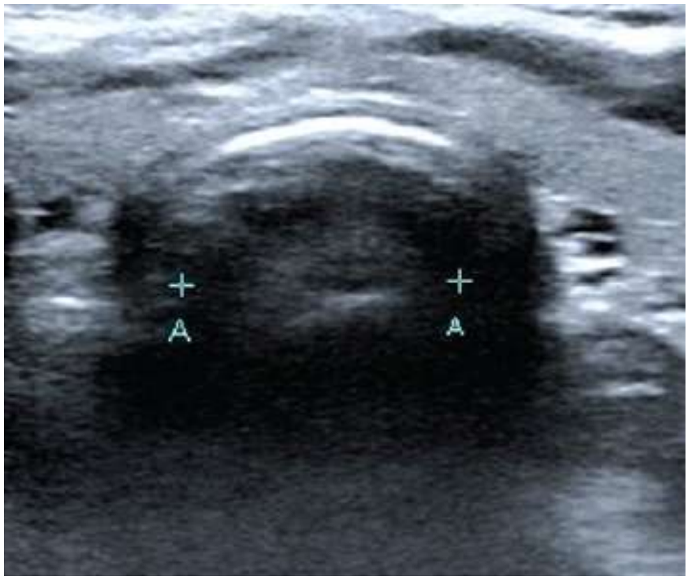
During phonation, the true cords oscillate and move towards the midline when compared to the false cords, which remain relatively immobile.





Vocal cord movement can be better visualised with water bath between probe and skin.

Estimating ETT Size

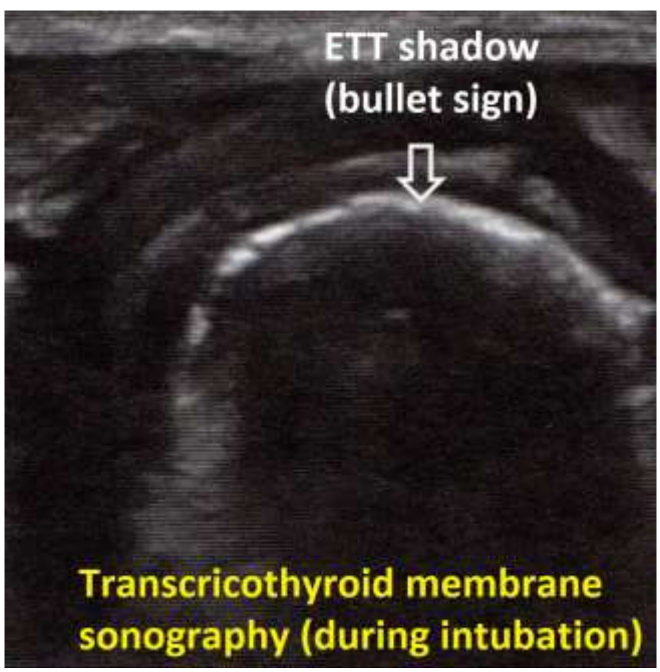


Measurement of the subglottic tracheal diameter correlates with the ETT size needed for intubation in paediatric patients greater than 12 months of age.

Begin with the patient in the sniffing position and the linear transducer placed transversely over the cricoid cartilage.

The transverse air column diameter should be measured.

Confirming Endotracheal Intubation



Several methods have been described which involve 2 operators and should be combined with lung ultrasound.

The transducer plane is always transverse.

Glottic ultrasound:

- Look for widening of the cords and enhanced posterior shadowing of the trachea as the styletted tube is placed between the cords.

Trans-cricothyroid membrane ultrasound:

- As the ETT passes the trachea, a 'snow storm' is seen, and the trans-cricothyroid membrane appears round, "bullet sign".

Trans-tracheal ultrasound:

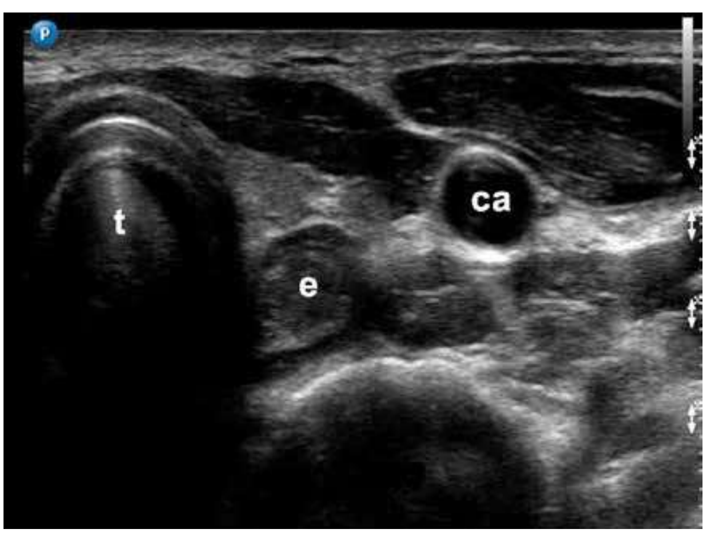
This is a more commonly described method.

- Apply the linear transducer to the trachea in a transverse plane just cephalad to the suprasternal notch and slide it to the patient's left.

- The trachea is recognized by its location and reverberations from the air-mucosa interface.

- The oesophagus is identified by its concentric layers and its position distally and to the right. In addition, asking the patient to swallow results in visible peristaltic movement of the oesophageal lumen.

- In situations where the oesophagus is not visible then rotate the probe toward the contralateral nipple. If still not visible then repeat the technique from the right side.



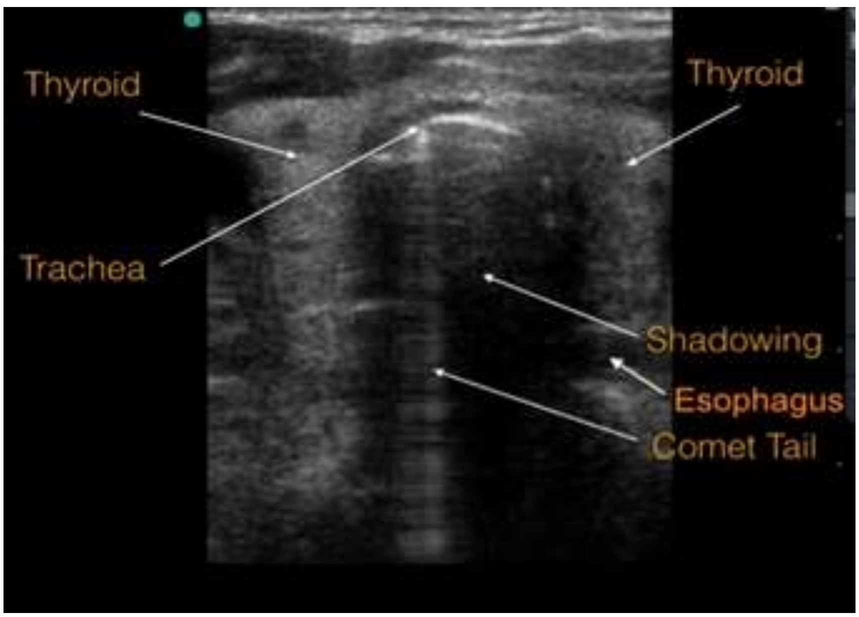
Transtracheal ultrasound showing the trachea and oesophagus.

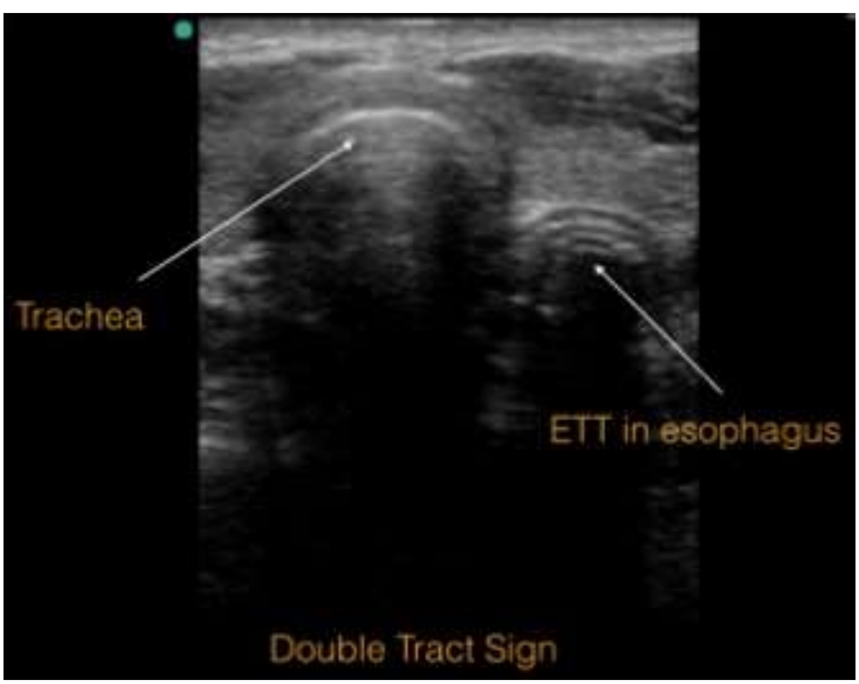
Rotating the transducer towards the opposite nipple may reveal the oesophagus

Transtracheal ultrasound from the opposite side, angling towards contralateral nipple, to reveal the oesophagus.

Features of tracheal intubation:

- Second hyperechoic curvilinear structure within the trachea.
- Posterior shadowing, bullet sign.
- Gently shake the ETT and visualize tracheal movements on the screen.
- Using Doppler, a colour ray will also appear within the trachea during movements.
- If a tube is not visualized in the oesophagus, correct endotracheal placement is thereby confirmed indirectly.
- Increased AP diameter of the trachea with balloon insufflation.





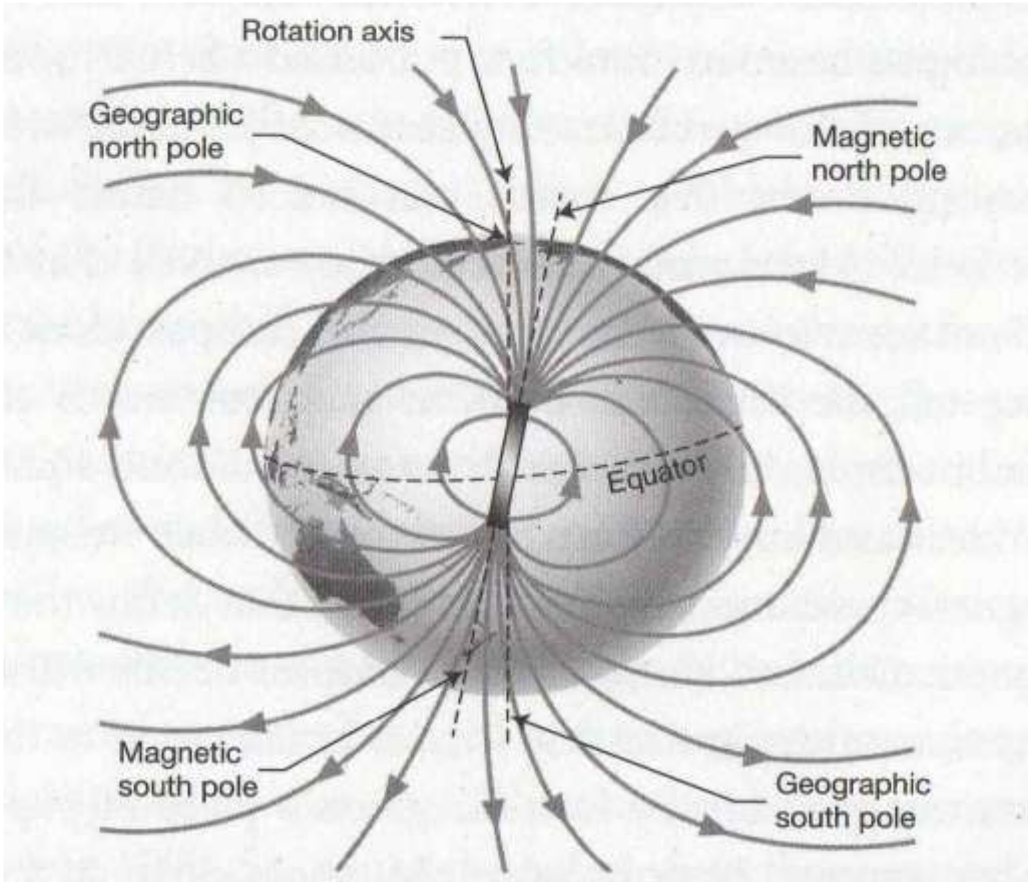
Features of oesophageal intubation:

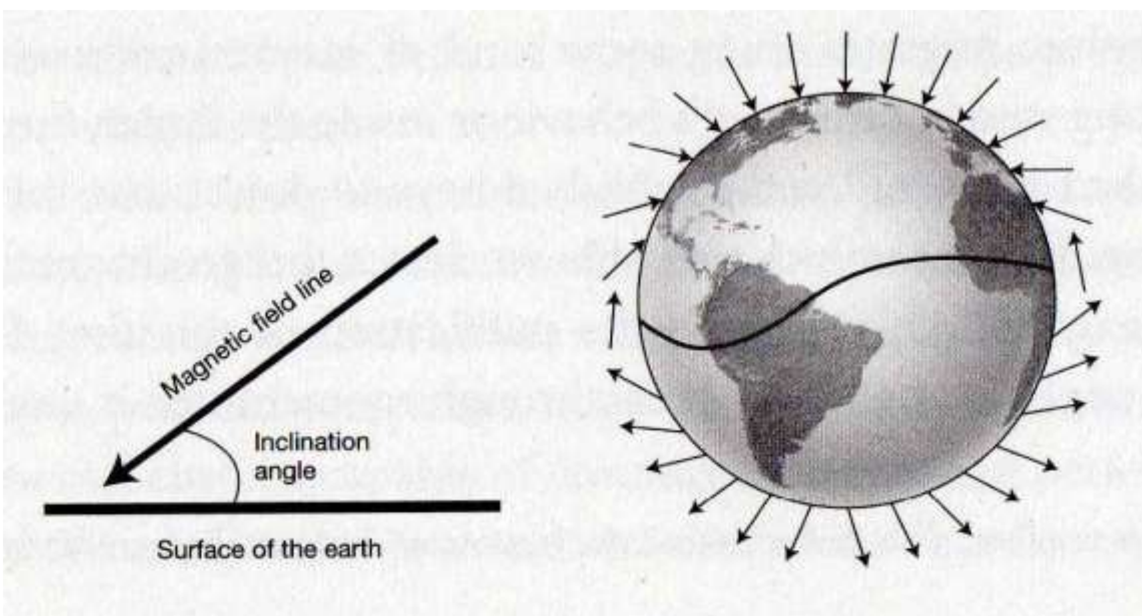
- "Double tract sign" whereby two air-mucosal interfaces are seen, tracheal and oesophageal.

- A curved hyperechoic structure being manipulated through the oesophageal lumen.

Endobronchial intubation:

- Diagnosed by movement of the diaphragm and presence of lung-sliding only on the ventilated lung (endobronchial) and absent or restricted movement of the diaphragm and absence of lung-sliding sign on the contralateral side (non-ventilated lung).





The magnetic field of the Earth

References

1. Ultrasound in Airway Management, Wendy H.L Teoh, July 7 2014

    - Airway eLearning Website: http://www.airwayelearning.com/

2. Stephen Alerhand; Ultrasound for confirmation of endotracheal tube placement during CPR, 18 February 2016.

    - emDocs Website: http://www.emdocs.net/

3. Assessment of the subglottic region by ultrasonography for estimation of appropriate size endotracheal tube: A clinical prospective study, Kumkum Gupta et al. Anesth Essays Res. 2012 Jul-Dec; 6 (2): 157-160.

    - doi:10.4103/0259-1162.108298

4. Focused Ultrasound for Airway Management, Philips tutorial, Michael B. Stone and Wilma Chan. July 2014.

5. Accuracy of a Novel Ultrasound Technique for Confirmation of Endotracheal Intubation by Expert and Novice Emergency Physicians. Michael Gottlieb at al. West J Emerg Med. 2014 Nov; 15(7): 834 - 839.

    - doi: 10.5811/westjem.22550.9.22550

6. Mark Favot, Ultrasound for Verification of Endotracheal Tube Location. ALIEM Website; 2 March 2015.

    - http://www.aliem.com

Further reading:

Edward O. Wilson, "The Meaning of Human Existence", 2014.

Jim Al-Khalili & Johnjoe McFadden, "Life on the Edge: The Coming of Age of Quantum Biology", 2014.

Dr Peter Papadopoulos
Dr J. Hayes.
July2016.