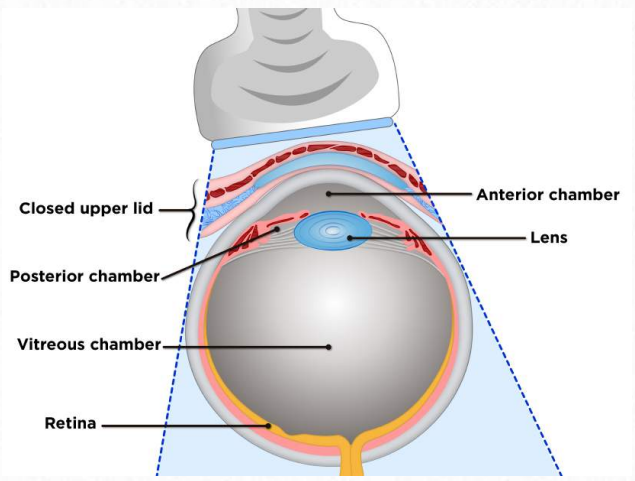
B. OPTIC NERVE SHEATH DIAMETER CORRELATION TO INTRACRANIAL PRESSURE

Elevated intracranial pressure (ICP) is a challenging and potentially fatal complication of acute head trauma. Early intervention in the form of either surgical evacuation of the space-occupying hematoma or medical management of the raised ICP is vital to improve outcome. Unfortunately, the ability to detect elevated intracranial pressure by physical examination alone is difficult. Diagnosis is often made by cranial CT. However, CT has some disadvantages: 1) it involves transporting the critically ill patient, 2) the scanner is often situated away from the resuscitation room, and 3) transport to CT is not feasible during acute hemodynamic instability.

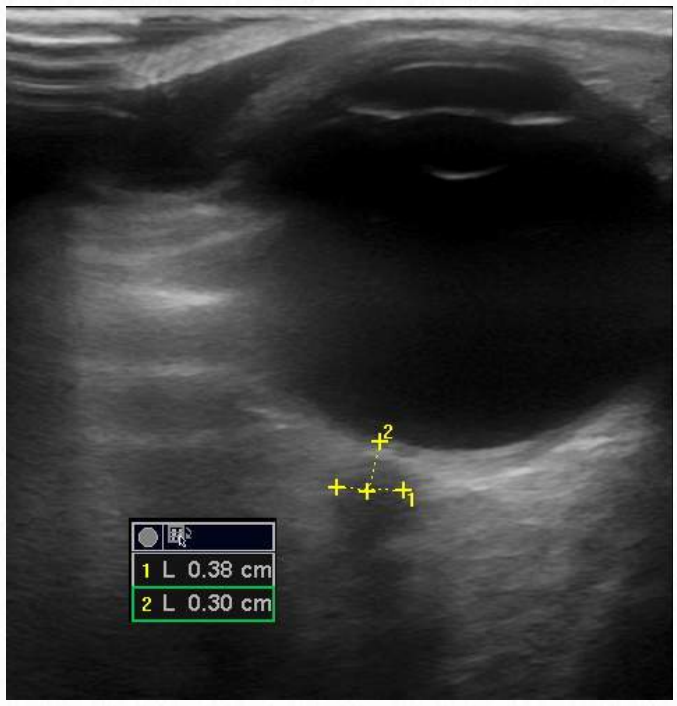
Recently, point of care ultrasound (POCUS) of the optic nerve sheath diameter (ONSD) has been suggested as a possible indicator of elevated ICP. Studies have shown that the measurement of the optic nerve sheath diameter has a sensitivity of 98.6% and specificity of 92.8%. The following CT findings in clinically significant elevated ICP normally include (used traditionally to identify elevated ICP): significant edema, midline shift, mass effect, effacement of sulci, collapse of ventricles, or compression of cisterns. The ability to correlate the ONSD with ICP is possible because the optic nerve sheath includes the subarachnoid space around the optic nerve, which enlarges in situations of elevated ICP (see picture below). Therefore, POCUS of ONSD provides a reliable, rapid, bedside, non-invasive test for raised ICP. *The upper limit of normal ONSD is 5 mm for adults, 4.5 mm for children aged 1—15 years, and 4.0 mm for infants up to 1 year of age.*



Probe Type: High frequency linear probe only

Image Acquisition: Place the high frequency probe transversely (indicator at the 9 o'clock position) to the patient's eyelid. Keep the probe over the top part of the eyelid and aim the probe in a slightly caudad direction, such that the probe makes a 60 to 70 degree angle with the eyelid. Remember, the optic nerve exits the eye posteriorly approximately at the middle of the eyeball. One should keep increasing and decreasing the axis angel of the probe to the eyelid to maximize the diameter of the optic nerve sheath (=ONSD). Measurements of the ONSD should be done approximately 3 mm behind the optic disc (see below).

Place high frequency probe transversely over upper part of eyelid. Measure the optic nerve 3 mm behind the optic disc.



C. IDENTIFICATION OF CORRECT ENDOTRACHEAL TUBE PLACEMENT AND POSITION

Ultrasound for Identification of Successful ET Placement: Esophageal intubation is one of the main causes of accidents leading to death or neurologic damage. Direct visualization of the tracheal tube passing through the glottis is often applied in practice, but it is not always possible to see the glottis, especially if intubation is difficult. Recently, POCUS has been proven to reliably detect successful trachea intubation as well as identify unwanted esophageal intubation with 100% sensitivity and specificity.

Probe Type: High frequency linear probe only.

Image Acquisition: Place the ultrasound probe transversely on the anterior neck, just superior to the suprasternal notch, before tracheal intubation (see picture below). When the tracheal tube passes through the trachea, a hyperechoic shadow, or comet sign, is shown in the trachea. Esophageal intubation is much more striking because one sees it being opened by the tracheal tube.

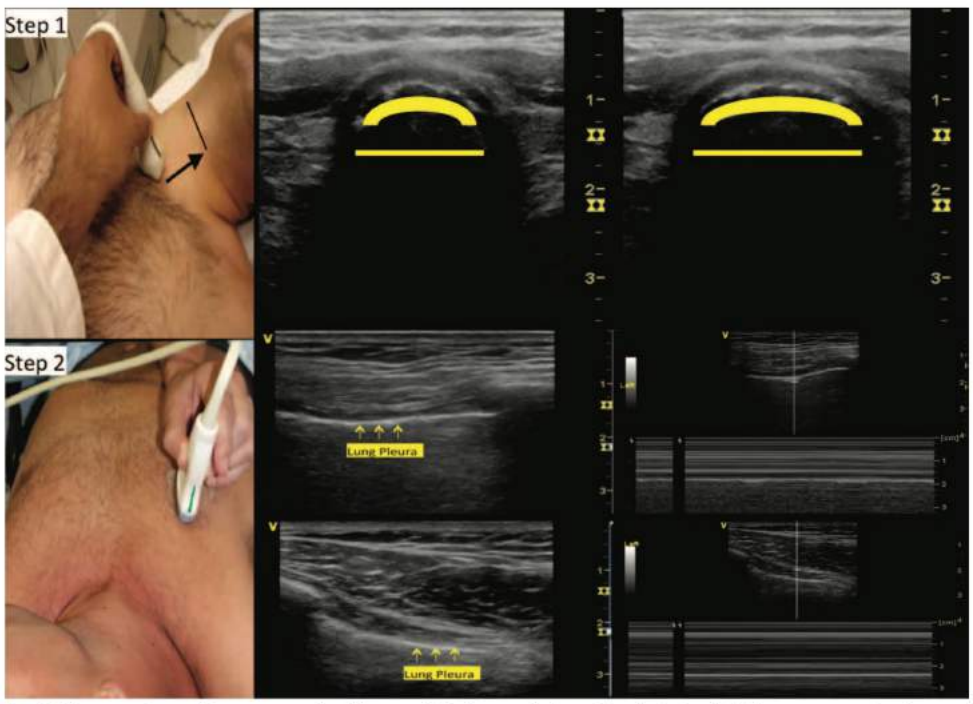


Fig. 1. Pulmonary tree and Lung expansion Ultrasound Study examination. Step 1: tracheal dilation assessment—ultrasound probe placed transversely on the anterior neck approximately 2 cm superior to the suprasternal notch and scanned cranially to the cricothyroid membrane. The marker for endotracheal cuff is tracheal dilation with balloon inflation. The image on the *left* in step 1 shows a nondilated trachea, and the one on the *right* shows a dilated trachea secondary to balloon inflation. Absence of tracheal dilation suggests that the endotracheal cuff is not in the area examined. Step 2: pleural sliding assessment—ultrasound placed vertically on the anterior chest at the third rib space midclavicular line bilaterally. Assessment of lung expansion evaluated by the detection of the horizontal movement of the two pleural linings with respiration. Use of M-mode facilitates pleural sliding assessment. The *top* image for step 2 examination shows normal pleural sliding verified with M-mode identification of pleural motion. The *bottom* image for step 2 examination shows absence of pleural sliding verified with no motion identified with M-mode.

ETT Location Within the Trachea: One can identify the location of the ETT by placing the ultrasound probe transversely on the anterior neck approximately 2 cm superior to the suprasternal notch and scanning (cranially / caudally) to the cricothyroid membrane. During this exam one will deflate and inflate ETT to examine for tracheal dilation. Then, one can examine the lung pleura to also assess for bilateral equal pleural lung sliding. In this examination, it is the absence of tracheal dilation with cuff inflation that is concerning for deep ETT position (at risk for main stem intubation), and one can examine for pleural sliding to see if the ETT is likely mainstemed (lack of lung sliding would indicate main-stem on the opposite side).