

**Question:**

In patients presenting to the ED (and other settings) with concerning S/Sx of elevated ICP, does ultrasonographic measurements of optic nerve sheath diameter (ONSD) compared to standard diagnostic methods provide an accurate surrogate method for detecting elevated ICP?

**Scenario 1:**

0230hrs, small hospital in a rural community, 30 year old male presents to your department via EMS for altered mental status, fever. The sole CT scanner just went down.

**Scenario 2:**

You get a report from downrange. Medics are bringing a soldier to your Forward Surgical Team (FST) facility. The soldier was blown from the blast of an IUD. Aside from superficial appearing injuries, the patient remains AMS with a posterior head injury. No CT scanner available.

**Scenario 3:**

23 year old female presents to your E.D. with continued N/V over the last 12 hours with headache and history of pseudotumor cerebri s/p shunt two years ago. No obvious problems with the shunt. Is the ICP elevated? Do I have to put this patient through yet another head CT scan?

Author / Title	Objective / Study Design	Results	Limitations	Comments
Kimberly, et al "Correlation of Optic Nerve Sheath Diameter with Direct Measurement of Intracranial Pressure," Acad. Emer. Med., 15: 201-204, 2008.	-Eval U/S ONSD cut-off 5mm for intracranial HTN via ICP measurement <b>-15 pts, 38 scans</b> -2 EM docs -EVD placed -Test pop: suspected elevated ICP -Vent, sedated <b>-No control</b> <b>-Concurrent ONSD &amp; ICP</b> -Blinded to ICP	30 scans @ <20cmH2O: 4.4 ± 0.49mm ONSD 8 scans @ >20cmH2O: 5.4 ± 0.49mm ONSD  <b>ONSD 5.0mm, Sn 88%, Sp 93%</b>  CI: 95% interval for Sn & SP	Small population No control Measured axial only	Authors agree that ONSD of 5mm should be used as cut-off for intracranial HTN.  Sedation protocol? Interobserver difference?  <b>Define intracranial HTN as 20cmH2O, don't discuss 20mmHg (BTF, TBI)</b>  Probe type: linear 10-5MHz
Moretti, et al "Optic Nerve Ultrasound for Detection of Intracranial Hypertension in Intracranial Hemorrhage Patients," J of Neurosurg and Anesthes, Vol 21, No 1, Jan 2009.	-Eval U/S ONSD cut-off 5mm for intracranial HTN via ICP comparison -106 pts, 53 controls -Test pop: ICH/SAH -Control pop: vent, sedated <b>-ONSD w/in 1hr prior to ICP</b>	34, ICH/SAH, <20mmHg: 5.0 ± 0.5mm ONSD 19, ICH/SAH, >20mmHg: 6.2 ± 0.6 mm ONSD 53, control 4.9 ± 0.4mm  <b>ONSD 5.2mm, Sn 94%, Sp 76%</b>  ONSD 5.0mm, Sn ~94%, Sp 59%	<b>ONSD and ICP measurements were NOT taken at the same time, allowed for 1 hr window.</b>	Authors believe ONSD 5.2mm is more appropriate cut-off for intracranial HTN, but <b>study is flawed (measurements not concurrent)</b> .  Axial v sagittal difference? Interobserver difference?  Probe type: linear 7.5MHz

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Moretti, et al "Reliability of Optic Nerve Ultrasound for the Evaluation of Patients with Spontaneous Intracranial Hemorrhage," Neurocrit Care, 11: 406-410, 2009.	-Eval U/S ONSD reliability with dynamic ICP -63pts, 94 scans, no controls -Test pop: ICH/SAH <b>-ONSD &amp; ICP concurrent</b> -Blinded to ICP -If ICP>20mmHg, then ONSD before & within 1min after CSF drain.	65 scans @ <20mmHg: 5.0 ± 0.49mm ONSD 29 scans @ >20mmHg: 6.16 ± 0.57mm ONSD  Interobserver difference: 0.25mm Axial > sagittal: 0.15mm  <b>ONSD 5.2mm, Sn 93%, Sp 73.8%</b>	No control	Authors re-affirm prior study's 5.2mm ONSD as cut-off for intracranial HTN.  Probe type: linear 7.5MHz
Geeraerts, et al "Ultrasonography of the optic nerve sheath may be useful for detecting raised intracranial pressure after severe brain injury," Intensive Care Med, 33: 1704-11, 2007.	-Eval U/S ONSD and ICP in first 48h after trauma -62pts, 31 controls -Test pop: TBI, GCS≤8 -Control pop: vent, sedated -Blinded to any CT <b>-ONSD w/in 1hr prior to ICP</b>	16, TBI, ICP<20mmHg: OD: 5.1 ± 0.7mm ONSD OS: 5.0 ± 0.7mm ONSD  15, TBI, ICP>20mmHg: OD: 6.2 ± 0.4mm ONSD OS: 6.3 ± 0.6mm ONSD  31, control: OD: 4.9 ± 0.3mm ONSD OS: 4.8 ± 0.5mm ONSD  Interobserver difference: 0.3mm  ONSD 5.9mm, Sn 87%, Sp 94%  <b>ONSD 5.7mm, Sn 100%, NPV 100%</b>	<b>ONSD and ICP measurements were NOT taken at the same time, allowed for 1 hr window.</b>	Authors argue for ONSD 5.7mm for cut-off of intracranial HTN given Sn 100%, but <b>study is flawed (no concurrent measurements)</b> .  Probe type: linear 7.5MHz
Geeraerts, et al "Non-invasive assessment of intracranial pressure using ocular sonography in neurocritical care patients," Intensive Care med, 34: 2062-67, 2008.	-Assess relationship b/w ONSD and ICP in neurocrit pts -37 pts, 78 scans, no controls -Test pop: TBI &/or ICH/SAH, GCS≤8 <b>-Concurrent ONSD &amp; ICP</b> -Not blinded to ICP	38 scans, <20mmHg  40 scans, >20mmHg  <b>ONSD 5.86mm, Sn 95%, Sp 79%</b>  <b>ONSD 5.80mm, NPV 100%</b>	No control.	Authors address prior study's flaw, argue for ONSD 5.8mm cut-off for intracranial HTN.  Probe type: linear 7.5MHz
<b>Utilization Studies</b>				
Fagenholz, et al "Optic Nerve Sheath diameter correlates with the presence and severity of acute mountain sickness," J Appl Physiol, 106: 1207-11, 2009.	-Association of ONSD (surrogate for ICP) association with acute mtn sickness. -287pts, 69 with acute mtn sickness -Acute Mtn Sickness: ha + LLS ≥3 -All pts <2w at or below 4240m / 13,911ft (Pheriche, Nepal), 461mmHg, 8.9 psi, 0.6 ATM	69 w/ acute mtn sickness ONSD 5.34mm, 5.18-5.51  218 w/o acute mtn sickness ONSD 4.46mm, 4.39-4.54	<b>No ICP measurement.</b>	Authors demonstrate an association b/w ONSD and acute mtn sickness.  No gold standard comparison.  Cerebral edema associated with disease process may affect ONSD.  Probe: 7 to 10MHz

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Beare, et al "Detection of raised intracranial pressure by ultrasound measurement of optic nerve sheath diameter in African children," Trop Med and Internation Hlth, Vol 13 No 11, 1400-04, Nov 2008.	-Eval ONSD in detecting intracranial HTN in African children with acute neuro pathology. -51pts, 21 neuro, 30 control - Neuro pt assessed for intracranial HTN via fundus exam, neuro exam, ± CT -Neuro malaria cases excluded d/t other study	14, neuro, increased ICP: ONSD 5.4mm (4.3 – 6.2)  7, neuro, increased ICP: ONSD 3.6mm (2.8 – 4.4)  30, control: ONSD 3.5mm (2.5 – 4.1)  ONSD 4.2mm, Sn 100%, Sp 86%  ONSD 4.5mm, Sn 93%, Sp 100%	<b>No ICP measurement.</b>  Confid interval?  Age discrep b/w control (33 m old, average) and neuro (69 m old, average)	Authors argue for ONSD 4.2mm cut-off for elevated ICP with 4.5mm clearly indicating elevated ICP.  No gold standard comparison.  Does not account for prior study recommendations of different ONSD cut-off values for <1yo versus ped >1yo.  Age discrepancy  Probe: curved 7MHz
Newman, et al "Measurement of optic nerve sheath diameter by ultrasound: a means of detecting acute raised intracranial pressure in hydrocephalus," Br J Ophthal, 86: 1109-13, 2002.	-Eval of utility of ONSD in peds with shunted hydrocephalus suspected of raised ICP. -125pts total, 102 control  Defined ONSD Upper NL for <1yo as 4.0mm, >1yo as 4.5mm (for purposes of comparison)	102 control: ONSD: 3.1mm (2.1 – 4.3)  6 hydro, shunted, NL: ONSD: 2.9mm (2.1 – 3.6)  5 hydro, shunted, Sx of elev ICP resolved: 3.1 (2.6 – 3.8)  12 hydro, shunted, elevated ICP: 5.9 (4.5 – 7.0)	Not all pts received ICP measurement	Authors agree with prior established ONSD Upper NL for cut-off of elevated ICP.  Incomplete comparison to gold standard.  Probe: 7MHz

**Bottom line:**

U/S measurement of optic nerve sheath diameter (ONSD) as a surrogate for detecting intracranial hypertension has utility in the emergency department along with the intensive care unit and austere environments. However, the cut-off values for adults (between 5mm and at most 5.8mm) and pediatrics (<1yo 4.0mm, >1yo 4.5mm) require further review and a study.

Physicians should avoid direct and/or linear correlation between ONSD and ICP, although this remains an area of study in some disease processes.