

regarding its use in trauma patients is limited, though studies in animal models have suggested benefit. This study aimed to determine if the use of AVP in trauma patients with hemorrhage decreased the need for blood product transfusion.

The primary outcome of this single-center randomized clinical trial was the volume of blood products transfused within 48 hours, including packed red blood cells (PRBC), fresh frozen plasma (FFP), and platelets. Secondary outcomes included total volume of crystalloid infused, estimated blood loss, overall fluid balance, and total vasopressor requirement in the first 48 hours. Trauma patients age 18-65 who received at least 6 units of blood product within 12 hours were enrolled and randomly assigned by a computer process in groups of six to the study group (AVP administration) or a placebo group. In the study group, a 4-unit bolus of AVP was given, followed by an infusion which was started at 0.04 U/min. In the placebo group, an identical volume of saline was bolused and infused. Once hemorrhage was controlled as determined by the operating surgeon, the infusion could be titrated to maintain a mean arterial pressure (MAP) of at least 65 mmHg for 48 hours. If additional vasopressors were needed, neosynephrine, norepinephrine, and/or epinephrine were used. Blood products were given at the discretion of the primary treating physician, as well as in the operating room or interventional suite. Blood products were ideally transfused in a 1:1:1 fashion. All investigators and study participants were blinded to the study group assignments. Exclusion criteria included prehospital cardiopulmonary resuscitation, emergency department thoracotomy, corticosteroid use, chronic renal insufficiency, coronary artery disease, traumatic brain injury requiring neurosurgical intervention, pregnancy, prisoner status, or administration of AVP prior to study enrollment. Investigators performed both intention-to-treat (ITT) and per-protocol analyses. The per-protocol analysis excluded 9 patients with non-survivable injuries who expired in the operating room.

Of 257 hypotensive trauma patients who presented during the study period, 157 were excluded mostly due to insufficient blood product transfusion. Seven patients who were treated with AVP prior to randomization and one whose family did not consent to enrollment were also excluded. There were no significant differences in patient demographics, injury characteristics, primary source of hemorrhage, hemorrhage control, initial trauma bay vitals, time to enrollment, pre-enrollment resuscitation requirements, or initial laboratory values. Forty-nine participants received AVP, and 51 received placebo. In the ITT analysis, AVP was associated with significantly less cumulative volume of all blood products with a median difference of -1.00 L (95% CI, -2.03 to 0.00 L; $p = .03$). When blood products were analyzed individually in the ITT analysis, AVP was associated with significantly lower volumes of FFP (median, 0.9 [IQR, 0.8-1.3] vs 1.0 [IQR, 0.5-1.8]L; $p = .03$), platelets (median, 200 [IQR, 0-300] vs 300 [IQR, 0-600] mL; $p = .02$), and cryoprecipitate (mean [SD], 12.6 [75.4] vs 34.7 [84.8] mL; $p = .04$). In the per-protocol analysis, there was a significant difference in the volume of all blood products used (median, 1.4 [IQR, 0.5-2.6] vs 2.9 [IQR, 1.1-4.8] L; $p = .01$). AVP had no effect on overall complications, including acute respiratory distress syndrome, length of mechanical ventilation, or acute kidney injury, in either analysis, but AVP was associated with

a decrease in rate of deep vein thrombosis in the ITT analysis (10 of 49 [20%] vs 20 of 51 [39%]; $p = .05$) and in the per-protocol analysis (5 of 44 [11%] vs 16 of 47 [34%]; $p = .02$). The ITT analysis showed no significant effect of AVP on overall mortality or risk of operative death. Both analyses showed no significant influence of AVP on length of stay in the intensive care unit or hospital.

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The authors concluded that use of AVP in the setting of traumatic hemorrhagic shock can significantly reduce the need for blood product resuscitation. Though it does not limit overall complications, AVP was associated with a significantly lower rate of DVTs. The authors note this study was underpowered to determine whether significant differences existed in clinically important outcomes such as acute kidney injury, acute respiratory distress syndrome, mechanical ventilation, length of stay, or mortality. Another limitation was the total dose of vasopressin administered varied between patients. Overall management of the patient was at the discretion of the clinical team, and though the goals of treatment were standardized, variation in treatment may have occurred. No standardized dosing schedule, such as one based on serum AVP level, was used. Overall, the authors felt that AVP can reduce the need for blood product administration in trauma, but a larger study is needed to confirm the generalizability of these findings.

□ TRACHEAL ULTRASOUND FOR THE ACCURATE CONFIRMATION OF THE ENDOTRACHEAL TUBE POSITION IN OBESE PATIENTS.



Xiao QM and Xi XY *Journal of Ultrasound Medicine*. April 24; 00:1-5

Endotracheal intubation is a commonly performed procedure within the healthcare system. Options for placement confirmation include direct visualization of the tube pass through the cords, fogging in the tube, carbon dioxide colorimetry, end tidal Co₂, breath sounds, radiography and bronchoscopy. Breath sounds are often used as the first confirmatory method but are unreliable especially in obese patients. The goal of this study was to evaluate an alternative bedside test that could be used to quickly confirm tube placement in this patient population.

The authors conducted a prospective and blinded study to determine utility of ultrasound in confirmation of endotracheal intubation in obese adults when compared to auscultation. Adults with a BMI defined as greater than 30kg/m² undergoing general anesthesia were recruited. During the study if patients became hemodynamically unstable or hypoxic (< 90% spo₂) they were removed from the study. Intubation was performed by two anesthetists who were not involved in data collection. Following induction with 2 µg/kg of Fentanyl and 2mg/kg of propofol, patients were preoxygenated for 3 minutes. Seven mm and 7.5mm tubes were used for females and males respectively. Correct ETT placement was defined as placement at the trachea while incorrect placement included right or left mainstem bronchus intubation or esophageal intubation.

Confirmation was first assessed via auscultation by the anesthetist performing the intubation and was then followed by ultrasound performed by a trained sonographer. Sonography of bilateral lung fields with a 5MHz curvilinear probe was performed looking for lung slide. Unilateral versus bilateral lung slide were used to differentiate between right mainstem bronchus intubation and tracheal intubation. Finally, a fiber optic bronchoscope was inserted to confirm appropriate tube placement. During the above process a researcher was present with ear plugs so as not to overhear the discussion in the room and the tube was covered to not reveal its depth to the researcher.

Sixty-eight adults were recruited. The average age was 60 years old and there was a slight male to female predominance 54% to 46% respectively. Rates of intubation success on first, second, and third attempts were as follows; 54 (79.4%), 10 (14.7%), and 3 (4.4%). There were 58 correct placements, 8 in the right main stem bronchus and 2 in the left mainstem bronchus. Of the 87 attempts there were 12 esophageal intubations (13.8%). Ultrasound was found to be more accurate in determining correct tube placement when compared to auscultation, 85.29% versus 67.6% ($P = .005$). Ultrasound was also more sensitive (84.48% versus 67.24%; $P = .005$) and specific (90.00% versus 70.00%; $P < .001$). They also found a 20% ($P = <.001$) absolute reduction in false positive and 17.24% ($P = .005$) absolute reduction in false negative rates.

The authors concluded that due to the above data, thoracic ultrasound could be incorporated into the repertoire for determining appropriate endotracheal tube placement. They note limitations, including the use of only one sonographer who was highly experienced, which may not always be available and limits generalizability.

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Comments: This study provides us with another potentially useful adjunct that may be utilized in emergency departments, especially as our obese population continues to grow. Tools such as end-tidal CO₂ and colorimetry help confirm placement in the airway as opposed to the esophagus; however, they do not provide indication as to whether or not the tube position within the airway is correct. The clinical applications for ultrasound are rapidly expanding and can be a good adjunct to airway management in scenarios where auscultation is difficult or there is a delay in portable radiography. Further research is needed to determine whether or not ultrasound is more useful than current methods used in determining correct endotracheal tube placement in obese ED patients.

□ DIAGNOSIS OF ELEVATED INTRACRANIAL PRESSURE IN CRITICALLY ILL ADULTS: SYSTEMATIC REVIEW AND META-ANALYSIS.

Fernando SM, Tran A, Cheng W, et al. *BMJ*. 2019; 366:14225 doi:10.1136/bmj.14225

Elevated intracranial pressure (ICP) is a commonly encountered condition due to brain injuries including traumatic brain injury (TBI), subarachnoid hemorrhage (SAH), and intracere-

bral hemorrhage and can result in cerebral ischemia, brain herniation and death if left untreated. Although guidelines recommend invasive ICP monitoring in suspected cases, the diagnostic reliability of physical examination, computed tomography (CT) findings and other non-invasive modalities for detecting increased ICP is unclear.

This systematic review and meta-analysis evaluated the reliability of physical examination, CT, optic nerve sheath diameter (ONSD) sonography, and transcranial Doppler (TCD) for the diagnosis of elevated ICP. Randomized controlled trials as well as retrospective and prospective observational studies of patients ≥ 16 years conducted in emergency departments or intensive care units evaluating the modalities of interest were included. With the assistance of a librarian, the authors searched for English language full text articles from six different databases. Invasive ICP monitoring pressure reading ≥ 20 mm Hg and craniotomy with operative diagnosis were used as reference standards for the diagnosis of elevated ICP. If there was a delay ≥ 1 hour between diagnostic testing and ICP measurement or if the non-invasive testing was completed after invasive ICP measurement, the studies were excluded. Studies underwent screening by two independent reviewers. The same independent reviewers extracted relevant data (true positives, false positives, true negatives and false negatives) which was verified by a third investigator. The quality assessment of diagnostic accuracy studies (QUADAS-2) tool (which evaluates patient selection, index test, reference standard and flow/timing) was used independently by the two reviewers to assess for risk of bias. The GRADE (grading of recommendations, assessments, development, and evaluation) approach was used to evaluate confidence in pooled diagnostic calculations.

After screening 2570 studies, a total of 40 studies were included in the meta-analysis, providing a total of 5123 patients. TBI and SAH accounted for the majority of the data, at 64.5% ($n=3304$) and 14.3% ($n=731$) of patients, respectively. Studies deemed at high risk of bias included those that used intraoperative diagnosis of elevated ICP (4 studies), epidural pressure monitoring (1 study), and lack of blinding to ICP monitor results (2 studies). Pupillary dilation, motor posturing (Glasgow coma scale (GCS) motor score ≤ 3), and decreased level of consciousness (LOC; GCS ≤ 8) were the only physical examination findings with sufficient data for meta-analysis. The sensitivity and specificity for diagnosis of elevated ICP was 28.2% (95% CI, 16% - 44.8%) and 85.9% (95% CI, 74.9% - 92.5%) respectively for pupillary dilation, 54.3% (95% CI, 36.6% - 71%) and 63.6% (95% CI, 46.5% - 77.8%) respectively for motor posturing, and 75.8% (95% CI, 62.4% - 85.5%) and 39.9% (95% CI, 26.9 - 54.5%) respectively for decreased LOC. CT findings included absence or compression of basal cisterns (sensitivity 85.9% (95% CI, 58 - 96.4%) and specificity 61.0% (95% CI, 29.1% - 85.6%)), any midline shift (sensitivity 80.9% (95% CI, 64.3% - 90.9%) and specificity 42.7% (95% CI, 24% - 63.7%)) and midline shift ≥ 10 mm (sensitivity 20.7% (95% CI, 13% - 31.3%) and specificity 89.2% (95% CI, 77.5% - 95.2%)). The Marshall classification system was also assessed with Marshall class ≥ 3 demonstrating a sensitivity of 80.6% (95% CI, 63.5% - 90.9%) and specificity 59.9% (95%

