CI, 40.9% - 76.4%). Specificity increased to 83.5% (95% CI, 70.4% - 91.5%) for Marshall class of ≥ 5. ONSD sonography had a pooled AUROC of 0.94 (95% CI, 0.91% to 0.96%) in detection of elevated ICP based on ten studies, but there was heterogeneity of ONSD thresholds between studies. AUROC values for both Transcranial Doppler pulsatility index (TCD-PI) and arterial blood pressure (TCD-ABP) were calculated. However, AUROC values for TCD-PI indicated that pooling the data was inappropriate. The three studies examining TCD-ABP yielded a pooled AUROC of 0.85 (95% CI, 0.78 to 0.91).

Given current guidelines advocating for treatment of ICP > 20-25 mm Hg, and the potential complications of invasive monitoring, non-invasive diagnostic strategies for determining elevated ICP would be beneficial. The authors concluded that they were unable to identify any single modality capable of detecting elevated ICP with sufficient sensitivity. Although many studies have used CT findings as a reference standard, this study demonstrates that reliance on CT alone would result in a significant number of missed cases. Although ONSD sonography and TCD-ABP show promising results, further research is needed as sensitivity and specificity could not be calculated. The authors note several limitations of the study, such as a lack of standardized approach to diagnosing elevated ICP, possible spectrum bias, inclusion of intraoperative measurements, among others. Since the examined diagnostic modalities failed to significantly increase the post-test probability of elevated ICP, the authors recommend that physicians not exclusively rely on them in isolation to make their clinical decisions. Physicians should consider the overall clinical picture of the patient and consider empiric treatment with invasive monitoring if elevate ICP is a concern.

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Comment: This study demonstrates the difficulty in identifying patients with elevated ICP through non-invasive modalities and as a result, that patients where there is a high clinical suspicion should undergo invasive ICP monitoring. Clinicians at facilities lacking capability of invasive ICP monitoring should advocate for patient transfer if there is any concern for elevated ICP. We agree with the authors in that further research to establish a clinical decision instrument for more accurate risk stratification could be beneficial. Additionally, more definitive ONSD thresholds combined with further research may be particularly beneficial to the emergency medicine clinician.

☐ ASSOCIATION OF BLOOD COMPONENT RATIOS WITH 24-HOUR MORTALITY IN INJURED CHILDREN RECEIVING MASSIVE TRANSFUSION.

Butler EK, Mills BM, Arbabi S, et al. *Crit Care Med* 2019;47(7):975-983

Trauma resuscitation in unstable adult and pediatric trauma patients consists of controlling bleeding, limiting crystalloids, permissive hypotension, and balanced blood transfusion. In adults it is commonly accepted that a 1:1:1 ratio of fresh frozen plasma (FFP), platelets, and packed red blood cells (PRBCs) is the ideal balance of blood products, however this has not been well studied in pediatric patients and is unknown.

The purpose of this study was to determine if a specific ratio of blood products in pediatric trauma patients is associated with improved survival at 24 hours. In this retrospective cohort study, the Pediatric Trauma Quality Improvement Program Database was reviewed for pediatric patients aged 14 years old or younger who sustained a traumatic injury requiring massive transfusion between 2014 and 2016. The database includes patients from level 1 and level 2 trauma centers within the United States. Massive transfusion was defined as receiving greater than or equal to 40 ml/kg of total blood products in the first 24 hours. Exclusion criteria included death within the first 30 minutes of arrival to the hospital, unknown outcomes, and those who did not receive PRBCs during massive transfusion. The blood products were evaluated based on ratios of FFP:PRBC and platelets:PRBC. Within each of these groups, they were subcategorized by the amount of the ratios. For FFP:PRBC, they were subcategorized into low (<1:2), medium (≥1:2 and <1:1), and high (≥ 1:1). For platelet:PRBC there was significantly less platelets given overall so they were subcategorized into none (0), low (>0 and <1:2), and high (≥1:2). The primary outcome was 24-hour mortality. Secondary outcomes included were in-hospital mortality, any complication, hospital length of stay (LOS), intensive care unit (ICU) LOS, number ventilator days, and hospital disposition.

Five hundred and eighty three patients were included in the study. Overall, the average age was 5 years old, 60% of the patients were males, and the majority of the injuries were blunt trauma (73.8%). At 24 hours, overall mortality was 19.7% (95% CI, 16.6-23.2). Using the low FFP:PRBC group as a reference group, the medium group had an aRR of 0.60 (95% CI, 0.39-0.92) and the high group was 0.49 (0.27-0.87). The overall 24 hour mortality aRR for platelet:PRBC was 0.94 (95% CI, 0.51-1.71). Using the no platelet:PRBC group as a reference group, the low group had an aRR of 1.29 (95% CI, 0.81-2.05) and the high group was 1.04 (95% CI, 0.52-2.09). Overall the complication rate was low at 15.6% with the only statistically significant complications being deep venous thrombosis in those receiving FFP with an aRR of 1.77 (95% CI, 1.22-2.57) and pneumonia in those receiving platelets with an aRR of 1.94 (95% CI, 1.14-3.28). The only statistically significant secondary outcome was a decreased in hospital mortality in those receiving FFP with an aRR 0.72 (95% CI, 0.55-0.96). The limitations of this study include possible type 2 error of the platelet analysis as well as the analysis of the complications as there was a very low number of both. Survival bias is also a potential limitation which they attempted to account for by excluding patients that died early in their ED course. Finally, the database used in this study did not include information on other therapies that could potential affect outcomes such as use of tranexamic acid, recombinant factor VIIa, or volume of crystalloid administration.

The authors concluded that pediatric trauma patients had an improved mortality with higher ratios of FFP:PRBC when

massive transfusion was required, but was unable to define the role of platelets in these patients. They investigators suggest to maintain a higher ratio of FFP:PRBC for pediatric trauma patients in hemorrhagic shock of at least 1:2.

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Comment: This is the first large study investigating the ideal balance of blood products in civilian pediatric trauma patients. This is also the first study to show that higher ratios of FFP:PRBC correlate with lower mortality. Although this is a retrospective study, it does suggest that transfusing FFP at a ratio of greater than 1:2 could improve survival. More studies are needed, particularly prospective, to help better define the ideal blood ratios in pediatric trauma patients.