Our first paper is entitled "Integrating Pre-test Probability and Point-of-care-Ultrasound in the Emergency Department Diagnosis of Small Bowel Obstruction" by Krol et al in *Cureus*[1]. Let's go through a case to illustrate what clinical questions can be answered by this paper. Let's say you have a 55-year-old male with prior surgical history notable for appendectomy, presenting with one day of recurrent nonbilious emesis and abdominal pain. He hasn't had a bowel movement in about a day and is unsure if he is passing gas. He has some mild diffuse abdominal tenderness and is mildly distended but not peritoneal. Vital signs are within normal limits. As an added wrinkle, let's say you don't have access to a CT scanner – perhaps the machine is down for maintenance, or the radiology tech can't make it in due to extreme weather, or you're just in a very remote location. Can you use point-of-care ultrasound to evaluate this patient's probability of having a bowel obstruction? Can this help decide whether to place an NG tube or transfer the patient out for definitive imaging?

The authors of the paper aim to find out by performing an observational diagnostic study. Using a convenience sample, they captured 106 patients with signs or symptoms of a bowel obstruction who came through the Long Island Jewish Medical Center ED, a tertiary care center, between April 2017 and December 2022.

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[1] Krol et al., "Integrating Pre-Test Probability and Point-of-Care Ultrasound (POCUS) in the Emergency Department (ED) Diagnosis of Small Bowel Obstruction (SBO)."

Based on the methods section, here is how I imagine the encounter going: 1) The patient's provider obtained an H&P with a nontrivial chance of SBO; 2) A "POCUS-certified" provider was approached to perform an abdominal ultrasound (this provider being the patient's attending, PA, or ultrasound faculty performing "scan shifts); 3) This provider would risk stratify the patient into low, mild, moderate, and high probability of SBO, with the cutoffs being <20% for low, 20-50% for mild, 51-80% for moderate, and >80% for high; 4) The provider would then scan looking for signs of an SBO; 5) The patient would then go for a CT scan. To go into more detail regarding the actual scan, the providers used either a linear or curvilinear probe in a "lawn-mowing" pattern back and forth across the entire abdomen, looking for at least one of the following signs:

- 3 fluid-filled loops > 2.5 cm with adjacent collapsed bowel
- "To-and-fro" sign, where the same food bolus gets tossed back and forth
- Decreased or absent peristalsis
- Positive "keyboard" sign (visible and well-defined plicae circulares)

In terms of overall results, the paper redemonstrated the good test characteristics that ultrasound has for a small bowel obstruction – a recent systematic review and meta-analysis showed pooled sensitivity of 0.93, specificity of 0.80, and accuracy of 0.96 (which is the number of true positives and true negatives over the total)[2].

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[2] Motavaselian et al., "Diagnostic Performance of Ultrasonography for Identification of Small Bowel Obstruction; a Systematic Review and Meta-Analysis."

This paper showed a sensitivity and specificity of 0.92 and 0.90, and the authors did show enough data to check their work in a 2 by 2 table.

	CT+	CT-	Prev = 24.5%
US+	24	8	PPV = 73%
US-	2	72	NPV = 97%
	Sn = 92%	Sp = 90%	

- LR+ = 9.2
- LR- = 0.09
- LR+ calc = sensitivity / (1 – specificity)
- LR- calc = specificity / (1 – sensitivity)
- Pre-test odds = (pretest prob)/(1 – pretest prob)
- Post-test odds = pre-test odds x LR
- Post-test probability = (post-test odds)/(post-test odds + 1)

The other part of the paper investigates the effect of point-of-care ultrasound on the decision to get a CT scan in patients with concerning signs/symptoms of a bowel obstruction; in particular, they want to explore how the likelihood ratios affect the post-test probability. It's a truism that almost all tests – exam, labs, imaging, etc. – do not have the role of perfectly ruling in or ruling out the condition of interest, but rather changing the pre-test probability of a condition where we would rule in or rule out a certain intervention. This change is known as the likelihood ratio, derived from specificity and sensitivity values.[3] For most ED providers, I think the D-dimer is the quintessential example of where this comes into play elsewhere in medicine. If you have a patient with a red hot swollen calf presenting with shortness of breath, tachycardia, and hypoxia disembarking from a 12-hour plane

[3] Parikh et al., "Likelihood Ratios."

ride after getting cancer surgery, a negative D-dimer will decrease your odds by a factor of 0.1 (the negative likelihood ratio)[4]. If you imagine this patient has a roughly 90% probability of a PE, that translates to a pre-test odds of 9-to-1, and multiplied by 0.1 ends up with a post-test odds of 0.9-to-1, translating to a post-test probability of 52%. Thus, getting a D-dimer is useless since the chance of having a PE in this patient is still pretty high and in fact north of 50-50. Inversely, if you have a stable patient with chest pain with low risk for chest pain but can't PERC them out – let's say you have a pre-test probability of about 5% based on your gestalt, translating to odds of 1-to-19, a negative D-dimer multiplies that 1/19 by 0.1, giving a post-test odds of 1-to-190. This translates to a post-test probability of 0.005. No further testing is necessary at that point, since the chances of a positive PE are far less than 2%, the chances of symptomatic bleed on an anticoagulant.

Getting back to the bowel obstruction paper, the authors report a process where the scanning providers stratified the patients into low (<20%), mild (20-50%), moderate (51-80%), and high (>80%) risk of SBO. They derived the PLR (9.2) and NLR (0.09) from the sensitivity and specificity values. Then they took the pre-test probabilities, converted them to odds, multiplied them by the PLR and NLR, and obtained post-test odds and probabilities, similar to the D-dimer example

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[4] Glober et al., "Use of the d -Dimer for Detecting Pulmonary Embolism in the Emergency Department."

earlier. These data can be found in Table 6. Across the board, the patients with negative POCUS for an SBO had a post-test probability of less than 1%, with low and mild risk patients each having probability calculated to 0.0%. They did find that post-test probability of low-risk patients with a positive U/S was 2.1%, which would likely change management.

While I think their overall assumptions and logic are sound, I do have some questions regarding their numbers. Unlike the calculations for overall sensitivity/specificity, there are no data regarding how many patients were risk stratified into each group, nor were there any objective data on risk factors or historical/exam features that led to stratification into each group such as history of bilious emesis, obstipation, abdominal surgeries, or malignancies. While the likelihood value numbers are based on sensitivity and specificity that are in broad agreement with previously attained values in systematic reviews, I'd be interested to see the subset sizes, especially as they didn't provide confidence intervals for these probabilities either. The data are likely too granular to assess the true post-test probability of SBO in the low- and mild-risk stratified patients, as I doubt it is truly 0.0%.

Other limitations include the convenience sampling which could lead to selection bias and the lack of blinded assessors to evaluate the ultrasound images to check for inter-rater reliability. It's also unclear the amount of ultrasound training the scanners had – there were 17 providers who were "credentialed in performing and interpreting ultrasounds for SBO," which could imply anything between ultrasound fellowship-trained providers all the way down to residents/midlevels who completed a course.

Overall conclusions from this paper: I think this is a useful piece of data helping confirm the usefulness of ultrasound to evaluate for bowel obstruction. The PLR and NLR do suggest a good effect size in evaluating the probability of having an SBO or not, and while not definitive, I think it is reasonable to follow the authors' recommendation that a patient with a very low pretest probability of SBO with a negative ultrasound be treated as essentially ruled out, with testing and treatment accordingly (e.g. pursuing a different intra-abdominal pathology). I do think the experimental model itself is sound, but does require further study with more data.

Returning to our case: Our 55-year-old s/p appendectomy with one day's worth of mild abdominal distension and nonbilious emesis could reasonably be risk stratified as mild or moderate. If I were in a setting without a CT scanner, I would certainly reach for the ultrasound probe and use it to further my clinical decision making to ship him out for further imaging if positive and pursue alternate etiologies if negative.

Our next paper is entitled “Contrast-enhanced point of care ultrasound for the evaluation of stable blunt abdominal trauma by the emergency physician: A prospective diagnostic study,” published in the Journal of the American College of Emergency Physicians Open by Donner et al. Here’s a case to kick us off: A previously healthy 30-year-old female is brought to your ED as a CAT 1 TRAUMA HERE NOW as an MVC going about 45 miles per hour (that’s 72 kilometers per hour for those of you outside the U.S., or 20.11 meters per seconds for those of you who insist on SI units) who swerved off the road to avoid hitting a deer and plowed her SUV into your hospital’s radiology suite. Airbags deployed and she was wearing her seatbelt, no LOC, but there was significant intrusion into her passenger compartment requiring prolonged extrication. Sadly it appears the CT scanner is also totalled. She is speaking full sentences with equal breath sounds bilaterally and pulses in all 4. GCS 15. Tachycardic to 110s but not hypotensive with a negative shock index. She does have a positive seatbelt sign and is complaining of lower abdominal pain. Her EFAST exam is negative for intraperitoneal free fluid, pericardial effusion, hemothorax, and pneumothorax. Is there a different mode of diagnostic imaging you can use in this somewhat contrived scenario?

The authors of this paper seek to answer the clinical question, "Can emergency physician-performed contrast-enhanced abdominal ultrasound be used to rule out clinically significant solid organ injury following blunt trauma?" The EFAST exam has been widely used in the initial workup of trauma, but it is best suited to rule *in* intraperitoneal hemorrhage, with a 2019 meta-analysis showing sensitivity of 74% and specificity of 98%[5]. Meanwhile, contrast-enhanced ultrasounds (CEUS) have shown promise in identifying intra-abdominal injury with increased sensitivity, especially in children where it is better to avoid unnecessary radiation exposure. You may be familiar with bubble studies to examine the right heart, and contrasted ultrasounds work in a similar manner; instead of agitated saline bubbles, they use injected microspheres made up of proteins or polymers surrounding inert sulfur hexafluoride gas, which highlight the blood vessels in a manner similar to IV contrast on a CT scan and thus can illustrate active extravasation, buildup of a hematoma, or lack of bloodflow concerning for a solid organ avulsion. A systematic review/meta-analysis examining the performance of CEUS in 10 studies evaluating 1,359 adult and pediatric patients showed a sensitivity of 0.933 and

[5] Netherton et al., "Diagnostic Accuracy of eFAST in the Trauma Patient."

specificity of 0.995[6]. Another SR/MA examining 234 pediatric patients across 7 studies found a pooled sensitivity ranging between 85.7 to 100% and specificity of 89-100%.[7] Ultrasound contrast has also had a good safety profile, with the pediatric SR/MA showing an adverse reaction rate of 0.7%.[8] (A quick PubMed search did not turn up any results looking at the teratogenic effects of ultrasound contrast, though case reports otherwise do seem to show safety in pregnancy.) The factor linking all of these studies is that the CEUS studies were all performed by Radiologists. Per the authors of this study, there have been no studies examining how well EPs can perform CEUS in the setting of trauma. Perhaps this is for good reason, as there are some limiting factors that CEUS more difficult for the emergency physician. Not only does it require more training, especially regarding the timing of contrast washout among different organs and appropriate gain setting, it requires a specialized contrast mode. Basically, the higher the energy of the sound waves, the greater the chance they will pop the contrast microsphere bubbles; the contrast mode uses lower energy sound waves (aka a low "mechanical index") to minimize this possibility. An informal survey of "ultrasound machines where I work" came up empty regarding availability of a contrast mode, which does throw a wrench in the works in trying this technique out in the future.

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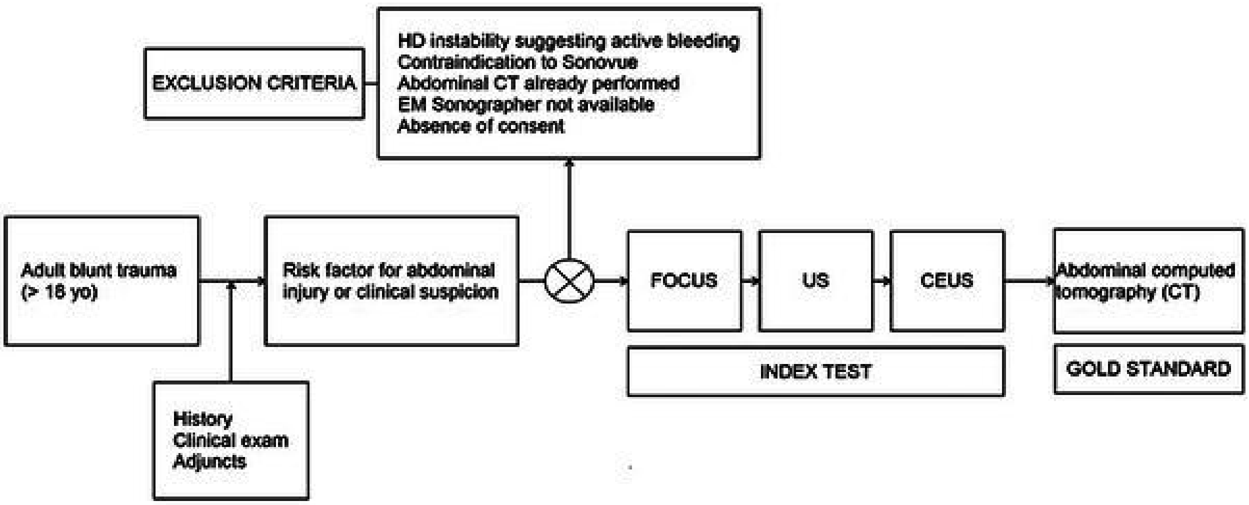
[6] Sutarjono et al., "Is It Time to Re-Think FAST?"
[7] Pegoraro et al., "Contrast-Enhanced Ultrasound in Pediatric Blunt Abdominal Trauma."
[8] Pegoraro et al.; Muskula and Main, "Safety With Echocardiographic Contrast Agents."

All that aside, let's examine this paper. The authors studied a population of blunt abdominal trauma patients presenting to a tertiary care center in Bern, Switzerland between August 2015 and May 2019 via a convenience sampling method. Based on a preplanned power analysis, they had initially hoped to recruit 197 participants to detect a 10% in sensitivity between CEUS and normal abdominal ultrasound with 80% power, assuming a 30% prevalence of solid organ injury. Unfortunately they only recruited 33. These 33 patients were examined by "trained EP sonographers" who were "certified in POCUS emergency US by the Swiss Society for Ultrasound in Medicine" and received 3 hours of CEUS training. They had the usual FAST exam performed, and afterwards the scanner proceeded to a more complete B-mode evaluation of the solid organs to evaluate for "distortion of the normal anatomy" or "focal area of hyper- or hypo-echogenicity." After this, the patients were given 2 doses of 2.4 mL Sonovue contrast via an IV in the antecubital fossa; scans were performed of the kidneys, then liver, then spleen; this is based on how quickly the contrast washes in and out of each organ. The scan was deemed positive for solid organ injury if "a focal anechogenic area of the parenchyma (suggesting laceration)"; "total absence of contrast enhancement of the organ (suggesting avulsion)"; or "focal contrast enhancement" suggesting active bleeding was present. The authors report the scans were all performed within 15 minutes. These scans were compared to a gold standard of a CT of the abdomen and pelvis with IV contrast, which were positive if "hemoperitoneum, [solid organ injury], hollow viscus injuries, abdominal vascular injuries, and retroperitoneal or extraperitoneal hematoma" were present; bony injuries were deemed outside the purview of this study.



For the results, the authors report excellent sensitivity for CEUS when compared to the FAST exam and abdominal ultrasound, but the applicability of this is hampered by wide confidence intervals. They report a sensitivity of 0.65 with the FAST exam which detected 11 true positive intra-abdominal injuries out of 17, with a 95% confidence interval of 0.38-0.86. The specificity was low at 0.75 (compared to prior values in the 90s), detecting 12 true negatives out of 16 with a confidence interval of 0.48-0.93). Abdominal U/S picked up an additional 2 true positives (13/17), and CEUS ended up finding 16 out of the 17 intra-abdominal injuries, leading to a sensitivity of 0.94 and a confidence interval of 0.71 to 1.0. The specificity was the same for both abdominal and contrast-enhanced ultrasounds compared to FAST.

	CT+	CT-	Prev = 0.52
CEUS+	16	4	PPV = 0.80 (0.63-0.99)
CEUS-	1	12	NPV = 0.92 (0.63-0.91)
	Sn = 0.94 (0.71-1.0)	Sp = 0.75 (0.4-0.93)	Acc = 0.85 (0.68-0.95)

- From sensitivity of 0.65 with FAST, calculated 11 TP's detected
  - 95% CI 0.38-0.86
  - Sp 0.75, CI 0.48-0.93
- From sensitivity of 0.76 with abdominal US, calculated 13 TP's detected
  - 95% CI 0.50-0.93
  - Sp 0.47, CI 0.48-0.93

Now, to assess the study quality. The clinical question was well defined, clearly defining a population in the ED with outcomes of intra-abdominal injury detected on CEUS and appropriate reference standard with a CT scan. I do have a concern regarding the low number of recruited patients – I wonder what underlying difficulties they had leading to a study population of 33 over four years. When I think back to my trauma bay experiences, we have ATLS pretty much protocolized so that the patient arrives, the primary and secondary surveys occur along with the EFAST exam, and then the patient gets whisked off to the CT scanner once the Trauma team knows which ones they want (usually all of them). I don't know about the Trauma surgeons at the Bern hospital, but I can imagine our surgeons being quite vexed by waiting a quarter hour for us to fiddle around with the contrasted ultrasound prior to getting any scans. Perhaps the researchers had a similar issue getting Trauma on board, or perhaps there was no good opportunity to get consent during the primary and secondary survey. I could also imagine there may have been availability issues with having the CEUS-trained scanners around. I am curious to know how many trauma patients with abdominal injuries were entered into the hospital system during the timeframe.

Other issues that I noticed: there was no blinding performed with either the sonographers or the radiologists, and there was also no independent blinded assessor. I did not see what specific scanning protocol the researchers used for their B-mode abdominal scan, although it seems reasonable to assume they probably looked through the entirety of the liver, spleen, and kidneys in two axes. And lastly, I found the writing hard to parse at times whether they were considering test characteristics of ultrasound for abdominal injuries or patients having abdominal injuries, or, in other words, whether the denominator was 132 abdominal injuries or 33 patients. The latter would be more clinically relevant, as it would be more important to immediately know whether or not a patient has an injury that could decompensate requiring IR or an exploratory laparotomy rather than how many injuries there are. The study did include test characteristic data for both, but no raw data; however, I was able to back-calculate the number of true and false positives and negatives to construct a 2x2 table.

Despite these issues, I think this paper is a good hypothesis-generating study. It is consistent with prior data showing that contrast improves the performance of ultrasound in detection of intra-abdominal injury. In addition to not involving radiation, it is easily repeatable at the bedside and allows for dynamic evaluation if, say, the patient's hemodynamics suffer or if after admission the patient is noted to have a big drop in hemoglobin. This is worth further research to explore the feasibility of introducing EP-performed contrasted studies, such as obtaining contrast-capable ultrasound machines or upgraded software packages; this would be particularly useful if available on portable, vehicle-mounted, or handheld ultrasound devices. The contrast agent itself would also need to be shelf- and temperature-stable to be consistently usable in austere environments such as military deployments. The scanners in this study were all "trained EP sonographers" who were "certified in POCUS emergency US by the Swiss Society for Ultrasound in Medicine," and it is unclear whether this means they were fellowship trained. A similar study could be done to validate the results with CEUS training alone in undifferentiated EM attendings or residents. While the concept of EP-performed contrasted US studies is definitely not ready for prime-time now, I anticipate it could be an area that could fall under our scope of practice in the future.