Clinical Applications of Point-of-Care Lung Ultrasound in Pediatric Patients Pediatric Grand Rounds-6-11-26-Meeting Recording

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Calderon, Delia started transcription

Calderon, Delia 0:06

Recording has started.

Wu, Theodore 0:11

Thanks.

Good morning, everyone. Thank you for joining UT Health San Antonio Pediatric Grand Rounds. I'm Ted Wu. I'm A pediatric intensivist and one of the faculty here as well. Set me in for Dr. Ranch. As a reminder, before we start, please don't forget to mute your devices as you log on.

Also, the CME presentation or participation code is placed in the chat periodically, so you can check in there for the code. And I have the pleasure to introduce one of our pediatric critical care fellows, Dr. Carla Uberez Rivera.

who's our fellow here at UT Health San Antonio in our pediatric ICU. A little bit about her, she earned her medical degree with magna *** laude honors and completed her pediatric residency at University of Puerto Rico, where she was named, twice named. resident of the year. She's board certified in general pediatrics and soon to be board eligible in pediatric critical care. She's had various academic interests, but today she's going to share with her experience of point of care ultrasound and QI and its use in pediatric patients and specifically

Leigh Shapleigh 1:24

Oh.

Wu, Theodore 1:35

Hopefully today she'll talk about lung ultrasound. But her dedication to education is evident and through her involvement with a lot of curriculum development and focus

and simulation-based training and a lot of resident teaching initiatives as well. So please join me in welcoming Dr. Uberez.

Lluberes Rivera, Carla Gilmar 1:57

Thank you, Dr. Wu. Good morning, everyone, and thank you for being here. Today, I want to talk about point of care ultrasound in children, but not as a shiny new gadget or a replacement for clinical judgment. I want to talk about it as a bedside tool that can either sharpen our decision making
or quietly mislead us if we use it without discipline or guidance. The practical question is not whether lung ultrasound is impressive, it is. The useful question is in which pediatric diseases does it actually add information? When can it help us reduce radiation and when
Can it push us into overdiagnosis or false confidence? This presentation is based on a pediatric narrative review of evidence organized by disease because that's how we think at bedside. And the goal is that by the end, you have a shared language and disease specific mental model that works whether you practice in the ED
the wards or the ICU.
So, disclosures are straightforward. I have no financial conflicts of interest and no commercial relationship with ultrasound manufacturers or imaging vendors. The more important disclosure is more methodological. This is a narrative review, not a systematic review or meta-analysis. And the narrative review gives us some room to organize heterogeneous literature in a clinically meaningful way.
but it does not give us like a pool effect size or a formal risk of bias table or scoring. Anything that sounds like a pathway today is meant to clarify thinking, but it's not an institutional protocol or anything like that.
So this talk is not only for intensivists or people that already know and love ultrasound. Lung focus is increasingly part of how children with respiratory diseases are evaluated across settings. On the words, you may be thinking about fever, focal exam findings, hypoxemia, or whether a pneumonia has developed a complication.
In the ED, the mental motor is a little bit different. The question may be rapid diagnosis while avoiding unnecessary radiation. When we are talking about ICU, the question is often more serial reassessment. Is there more pleural fluid? Is there an air leak? Are bee lines improving after their assist? Is that dependent consolidation recruiting?
Even if you never hold a probe, you will read the note and you will be able to

understand, respond to the decision, and explain their reasoning to the families.
There are four things I want to leave you with. First, a little bit of reframing our question and ask whether this can changes management for this child with this disease and at this moment. Second, learn the language and the jargon of the ultrasound. If terms like A lines, B lines,
Bleural sliding, long point effusion, consolidation, and airborne chromas are fuzzy. The evidence will remain a little bit fuzzy too. Third, know the evidence by disease. Pneumonia, effusion, pneumothorax, edema, consolidation, reliability are not supported equally throughout the literature.
And 4th, it's important to stay honest. Lung focus can be highly, highly valued, but only when the clinical question, operatorial skill, and disease biology line up. Otherwise, it becomes a fast way to overcome non-specific findings.
So a little bit of our roadmap and the structure for this morning is very simple. First, we will talk a little bit about how the review was built, the search, the screening process, and why the final Pediatric evidence base narrows so quickly. Second, we will build the vocabulary because
The room needs a little bit of visual language before we can talk about the evidence. Third, we will talk and go through the pediatric data based by disease. And finally, we will finish with the reality, reliability, implementation, quality assurance, and the knowledge gaps that we have in the literature.
So, let's start with our methods. Pediatric lung ultrasound is heterogeneous. Different settings, operator protocols, and definitions. Pediatric lung ultrasounds feel clinically common, especially in acute care, but when you ask, when we ask about pediatric studies that directly address diagnosis, monitoring, or reliability,
The evidence base becomes much smaller than expected.
So for this narrative review, we decided to go with a narrative review, not because the question lacks importance, but because the available pediatric evidence is very, very heterogeneous. The current literature encompasses diverse patient population, clinical settings,
disease processes, ultrasound protocols, reference standards, and outcome measures. Rather than representing a single uniform body of diagnostic accuracy studies, the Pediatric lung ultrasound Leticia also addresses different different, assesses different clinical questions. So A narrative review provides more flexible a way to synthesize these broad based
evidence and identify recording themes, highlighting knowledge gaps, and place

individual findings within the appropriate clinical context. A study asking whether ultrasound detects community acquiring pneumonia in the EDA is not asking the same question as a PQ study asking whether serial ultrasound detects effusion, pneumothorax, pulmonary edema, autoelectasis, or consolidation in a ventilated children. Tuberculosis imaging in a hybrid setting is another different question altogether. And a lot of like recent evidence, it's been published among tuberculosis. So the practical decision was to synthesize this by disease and by setting. For every disease, we should ask the same questions.
Does focus add information? Can it safely reduce radiation? Does it risk over diagnosis, and what training does it demand?
The search was built with one of our librarians, and we run it through three different databases. The target population was children older than one month and younger than 18 years. Neonatal only lung ultrasound was intentionally kept out because neonatal lung ultrasound, it is
its own field with different diseases, different physiologies, and a much more larger body literature. So we focus on lung or thoracic focus used for diagnosis, monitoring, and reliability. The initial database search identified 170 records, and after duplication, we had 107.
And after reassessing abstracts, we only got 9 pediatric or pediatric including articles for the synthesis.
This is the search flow in a simple way. Here, the point is not only that we filter papers, it is that the Pediatric evidence is very, very lumpy. Community-acquired pneumonia dominates, but pleural effusion, pneumothorax, pulmonary edema, and picosterial monitoring are all clinical pedi, but
They lean heavily on, they only lean heavily in Pediatric studies.

Willey-Courand, Donna Beth 9:49
I can.

Lluberes Rivera, Carla Gilmar 9:54
These are the rules that shape the final group of our study. Eligibility was built around the clinical questions. What do we know about lung focus in children outside neonatal only literature? We included pediatric or pediatric including population when lung or thoracic focus was clinical central. Studies

Willey-Courand, Donna Beth 9:57
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Lluberes Rivera, Carla Gilmar 10:12
could compare ultrasound with chest x-ray, clinical diagnosis, disease category, expert review, or operator agreement. Reliability studies were included just because interpretation is also important, as well as detection.
This first table give us a little bit of orientation. It is here, so you can see the evidence base before we go disease by disease. So, the first five papers are pneumonia heavy, Kapiti in 2008, Shaw in 2013,
2014 and GED in 2016 and GMAS in 2017. All those papers, all around community acquired pneumonia or respiratory districts. And it's fairly consistent. Lung ultrasound detects consolidation and associated effusions well, sometimes identifying findings such as X-ray misses.
but that's not automatically make a replacement for all imaging. Shaw particularly is very useful because it shows that after focus training, clinicians could use focus with meaningful sensitivity and specificity, and specificity improved when the consolidation was larger than one centimeter and had
or bunker arms. GERA was particularly noteworthy because lung ultrasound findings correlated with inflammatory markers providing biological validation for the observed sonographic abnormalities. And this association is important because it strengthens the clinical relevance of ultrasound findings by demonstrating that they reflect underlying disease activity
rather than simply representing imaging artifacts or visually detectable abnormalities.
The second half of the table shows why this review cannot be reduced to pneumonia alone. Samsung here, it's another ED study with another ED pneumonia data set with good specificity. SACDEV is the only and major PQ study
It has around 413 children and around 1000 per ultrasound and chest x-ray episode across multiple pathologies. That single story carries a lot of the pediatric signal for effusion, pneumothorax, pulmonary edema, autoelectasis, and consolidation. Bellar is one of our most recent
or new innovative research in tuberculosis. And it's where ultrasound is not only being used for lung tests, but also as a portable way for extrapulmonary disease and to monitor response. GREVIL is a reality check. Here they talk about children,

different zones,
and agreement overall between the primary operator and the expert review.
And notice that the retained set is only not articles because the Pediatric data is very lacking.
So before discussing the evidence, let's pause a little bit and talk about ultrasound basics and a common language. For clinicians who do not routinely use ultrasound terms such as A lines, B lines, lung sliding, long point, airborne
can sound like technical jargon rather than a clinical meaningful findings.
Understanding these concepts is essential because lung ultrasound operates very differently from imaging like chest x-ray and CT scan. Unlike CT scans, which directly visualize lung anatomy,
Ultrasounds cannot penetrate normal aerated lung. As a result, many of these findings we rely on are not images of structures themselves, but rather artifacts that are created by the interaction between the ultrasound waves, the air fluid,
the tissue, and the pleural surface. In many ways, lung ultrasound is less about seeing the lung and more about interpreting the patterns generated when normal lung architecture changes. A lines represent normal earthy lung. B lines reflect increased fluid or loss of aeration within the lung interstitium.
Lung sliding demonstrate movement of the visceral pleura against the parietal pleural, and helps to exclude pneumothorax at the point of examination. The lung point identifies the boundary between the normal pleural position and the pneumothorax, and is highly specific for pleural. Consolidation appear when normally aerated lung becomes tissue-like due to
infection or lactasis, while air bronchiomes represent residual air within bronchi coursing through the consolidated lung. Pleural fusions are among the most intuitive findings because fluid collision appearing between the lung and the chest wall. These terms for the vocabulary of the form of vocabulary for the lung
Ultra San.
So, POCUS is not intended to replicate a comprehensive imaging study, nor should it be expected to provide the same depth or information as a complete comprehensive radiologic examination. Instead, POCUS is best understood as an extension of our physical examination. It is designed to answer POCUS clinical questions in real time and within specific clinical contexts.
A good focus can start with a clinical hypothesis. Does this child have pleural effusion? Is lung sliding present? Is there a subpleural consolidation? Are B lines

increasing compared with earlier? Is there a complication of pneumonia? The scan matters only if the answer changes what we do next.
observe, start or stop antibiotics? Are we going to join in a fusion? Are we going to change our ventilator strategies? Or are we going to order formal imaging? A good focus note and documentation should answer the clinical question and state the limitations. It shouldn't be I saw some B lines. This report should be
in this child with worsening oxygenation after cardiac surgery, there's a moderate right pleural effusion, and that might explain our ventilator changes.
The probe choice and patient position are not technical details. They change the answer. They check what we see. A linear probe is excellent for the pleural line, lung sliding, pneumothorax signs, and small superficial lesions. A curvilinear or phase array probe give us a deeper penetration and is often better for effusion, especially in larger children
or dependent windows. Position matters because air and fluid behave very different. Pneumothorax tends to collect anteriorly and superiorly in a supine child, while pleural effusion tends to collect dependently and posteriorly. So a normal anterior scan does not exclude a small posterior effusion.
And a complete bedside scan usually thinks in so, anterior zone, lateral zone, and posterior zone in both sides of the chest.
This is a central concept. And as I mentioned a little bit earlier, lung ultrasound usually does not image normal lung anatomy directly. It reads the artifact generated by air, fluid, and tissue at the pleural surface. Normal aerated lung is mostly
Normal aerated lung is mostly air. And air is a terrible ultrasound medium. Because ultrasound does not travel well through air, the blue line behaves like a mirror. In a normal aerated lung, that mirror creates repeated horizontal reverberation artifacts. And that's what we call A-lines. And we can see it in the image right here.
When there is more fluid or density near the pleura, vertical artifacts are bigger, and that's when we shift to bee lines. When the lungs lose air and become tissue-like, it can look almost like a liver, and that's why we call it hepatization. That is why it's an excellent,
Scan is excellent for pleural and subplural disease, and weaker for deep central disease surrounded by area lung, because the area is a terrible meter, I cannot conduct really good.
are the kind of normal background pattern. They are horizontal because the pleural line reflecting sound are back and forth. In a patient with dyspnea, an alien dominant

pattern with long sliding may be reassuring at that occasion, but aliens are local. So Alans at one scan spot only tell you about that local window. They do not exclude posterior pneumonia or dependent diffusion if you never scan there. A child can have normal anterior alans and still have a posterior fusion, a dependent consolidation, or central pneumonia does not reach the pleura. So alans are reassuring, but they are not.
A global loan clearance certificate.
Bee lines on the other side are where many people overcall the disease. A few bee lines, especially independent stones, can be normal. Bee lines are bright vertical and they arise from the pleural line and extend to the bottom of the screen, usually moving with long sliding. They tell you that there is an increased fluid density or alter aeration near the pleural surface.
They do not tell you why. That and that distinction is critical and very important. Cardiogenic edema can produce B lines. Pneumonia can produce B lines. Bronchiolitis can produce B lines. ARDS can produce B lines, contusion, inflammation, interstitial disease. A few dependent B lines can be normal. So the strongest way to use B lines is not as
standalone, yes or no diagnosis. They're more useful as a trend and they're more useful as a trend tied to our physiology. Are B lines increasing as fluid balance worsens, decreasing after diuresis, focal alarm consolidation, or diffusing a child with cardiac disease? The context is what is going to guide and lead our diagnosis.
are diagnostic.
Long sliding is a very high jeal sign. The pleural line is the bright horizontal line that we can see here, and it's above the line just below the ribs. Long sliding is the shimmering movement of the visceral and parietal pleura against each other, which is respiration. So this is one of the most useful and misunderstood finest. If a long sliding is clearly present at a scan
pneumothorax is essentially excluded at that particular spot because the pleural surfaces are moving. But absent sliding is not automatically pneumothorax. Sliding can be reduced or absent with apnea, mainstream intubation, severe hyperinflation, pleural adhesions, prior surgery, or just the operator skills with technical limitations. So, a present sliding is very reassuring because that that exclude pneumothorax, but absent sliding is a clue that needs a more investigation. It's a clue that needs a pattern. Do we have absent B lines? Do we have another sign? Do we have long point? What is our clinical study?

So, pneumothoracis provide one of the most elegant examples of how long reflects underlying physiology. Under normal conditions, the visceral and parietal pleura remain in contact and slide against one another with each respiration, producing the characteristic of the lung sliding. When air accumulates,
within the pleural space, those pleural layers become separated and the lung sliding disappears. So this physiologic change is also reflected in one of the modes in our ultrasound, what is called the M-mode imaging. Normal lung sliding generates the classic seahort.
Seashore sign, which we can see it here, and.
In the static chest wall appears as parallel lines above the pleural line, while the moving lung creates A granular pattern below it. In the presence of pneumothorax, the loss of pleural motion causes this pattern to disappear, resulting in the barcos sign or statosphere sign, where the parallel horizontal lines extend throughout the image.
Rather than representing an isolated imaging finding, these signs directly visualize the facial consequence of the air separating the pleural surfaces.
For pneumothorax, ultrasound is asking a very focused question. Is there pleural air separating the visceral and parietal pleura where I'm scanning? And as I already mentioned, the signs are absent lung sliding, absent B lines, a barcode or stratosphere pattern on M mode, and ideally a lung point.
The long point is the transition where the normal sliding lung meets a pneumothorax. It's specific, but it's not always visible, particularly in large pneumothorax where the entire anterior surface is separated. The teaching point is that pneumothorax diagnosis could never rest on absent sliding alone. For example, in a crashing ventilator child, a rapid scan can accelerate your action and your management.
but in a stable child with a cubicle findings and you are not sure where you're looking at, confirmation is often reasonable.
Effusions are probably the cleanest application because fluids transmit ultrasound. Instead of artifacts, you often see an hypochoic space above the diaphragm. This is why pleural fluid can be obvious on ultrasound long before it is clear on a portable theme. Ultrasound is especially useful for dependent or posterior fluid that can be subtle or invisible on a supine fan.
But the first hard lesson is that seeing fluid is not the same as knowing what to do with it. A tiny rim of fluid may not matter, but a complex septator enlarging infusion

in a sick shell absolutely may matter. So this scan identifies the finding, but the shell is going to tell us what it means.
Consolidation is one of the most visually satisfying ultrasound findings, and it occurs when the lung loses air and becomes tissue-like. Normal alines are going to vanish, and the lung is going to look like a tissue. On ultrasound, this can look like liver, which is why people use the term hepatization, as we mentioned a little bit earlier. Within that tissue-like lung, you may see bright air bronchograms. A dynamic air bronchogram with move with each respiration can support pneumonia because air is moving through the bronchi within consolidated lung. However, a static air bronchogram may be more consistent with autolectasis, but this is not absolute.
Consolidation is one of the places where ultrasound can tempt us into overconfidence. The image can look dramatic, but the differential is broad. Pneumonia, autolectasis, collapse, inforts, conditions, or dependent changes.
Now, we need to be a little bit more fair with the chest x-rays. The chest x-rays are familiar, are available all fast.
And they embedded in pediatric practice. It shows the whole chest at once, including tube, lines, mediastinum, bony structures, and central findings that ultrasound may miss. But it's not a perfect chew machine. Portable films, especially in a supine or ventilary children, can be limited by position.
rotation, low volumes, overlying devices, hidden areas behind the heart, the diaphragm, or mediastinum. Also, chest x-rays use ionized radiation that dose from one film is slow, but repeated imaging in children are not mean as late.
So the film is going to give us a global context. Portable films can underperform in the sickest children. The film gives an atomic picture that ultrasound cannot always provide, but in a supine ventilated child, as we mentioned now, we can blunt some of the findings such as small pneumothoracis or effusions.
For pleural air and fluid, x-ray has predictable blind spots. A large pneumothorax may be obvious, but a small or anterior pneumothorax in a supine child can be subtle. A large effusion may blunt the caustophrenic angle or create a dense hemithorax, but smaller posterior fluid can be missed, especially on a portable film.
Ultrasound attacks the program from a different angle. It can look directly where fluid collects and where pleural sliding should occur, but again, ultrasound has its own blind spot. It is local and operator dependent. It does not survey the whole chest in one image, so the question should not be which test is more or less superior. The question is which

Tess best answer the immediate clinical problem.
So which one is better? The question shouldn't be which one is better. The question is disease specific. In pneumonia, it might reduce radiation. In effusion, it detects fluid beautifully but does not define drainage thresholds. In edema, it trends fluid but lacks specificity.
A pneumothorax is fast but operator and window dependent. The better question has four parts. First, when does lung focus at information we should not otherwise have? Second, when can it safely reduce imaging and radiation? Third, when does it risk over diagnosis by finding abnormalities that are real but clinically irrelevant? And 4, what training and quality assurance
Are required before we act on it.
So here is when the talk becomes a little bit more practical. Now we move from vocabulary into evidence. We will go disease by disease because the evidence behave very differently depending on the clinical question. The Pediatric literature is not evenly distributed, so our confidence should not be
evenly distributed. Pneumonia has the strongest evidence base. Effusion has strong detection signal. Pneumothorax and edema are clinically compelling, but thinner in pediatric data, and adult ectasis consolidations are where the advantage flattens.
So let's start with community acquired pneumonia because this is where pediatric lung ultrasound has its strongest case. These are mostly ED or inpatient diagnostic studies asking whether lung ultrasound can identify pneumonia or associated findings compared with chest x-ray or clinical diagnosis. The reason ultrasound performs well here is biological.
Pediatric pneumonias are often reach the pleura surface, and ultrasound is excellent as superior, superficial, or subpleurous disease.
The pneumonia numbers are strong. In the studies, Sposito reported very high sensitivity and specificity for lung ultrasound in hospitalized children with community-acquired pneumonia. Sampson, another study, also found good sensitivity and high specificity in pediatric ED population.
Gilmar compared ultrasound and chest x-ray against final clinical diagnosis and found ultrasound agreement was higher than x-ray agreement. One important detail from Gilmar is that ultrasound identified pneumonia in several children whose initial x-ray had been read as clear. Guerra also found that ultrasound detected more consolidation and infusions than chest x-ray
and the finest track with inflammatory markers such as fever duration, neutrophils,

and CRP. That last point matters because it suggests that ultrasound finest were not harmless, not just harmless artifacts, but they also connected a clinical disease biology.
Yeah.
And this is where we need a little bit more of guidance. High sensitivity does not automatically mean ultrasound should replace the film in every child. Many studies use x-ray as a reference standard, but chest x-ray is not true gold standard for pediatric pneumonia. It misses lesion and there is inter-observer variability.
At the same time, ultrasound has its own blind spot. It sees pleural and so pleural disease very well, but it can miss central lesions that does not contact the pleura. So these tests are not identical competitors. They have different failure modes. A defensible claim that we can make is that lung focus is a strong
Adjunct or alternative in selective children when imaging is needed and radiation reduction matters.
Ultrasound can help identify pneumonia and complications, but the image alone should not be used to determine bacterial versus viral disease. It is tempting to look at the ultrasound morphology and said, this looks bacterial, this looks viral, this child needs antibiotics, this child does not, but evidence does not support that level of confidence.

Williams, Janet F (Dr.) 31:57
Person.

Lluberes Rivera, Carla Gilmar 32:07
Spotsy does show good overall accuracy for pneumonias, but poor concordance when trying to classify pneumonia type by imaging appearance. Bacterial pneumonia, viral infection, bronchiolitis, autoelectasis, reactive airway disease, they all can share the same sonographic features. Bee lines, blur integrity,
small subpleural consolidations, and even larger consolidations depending on the gaze. So ultrasound can rise or lower suspicion and detect complications, especially as fusion. It should not be used alone to decide pathogen class or antibiotic need.
That decision still belongs to the whole clinical picture.
So, where is Long Pogo's most defensible for community acquiring pneumonia?
It is useful when the child has moderate to severe symptoms, hypoxemia, focal exam findings, diagnostic uncertainty after the exam, or concern for complicated

pneumonia. It is also useful when we want to avoid or defer radiation and ultrasound answer could reasonably change our management.
The harder case is the well-appearing child with mild uncomplicated illness. For that child, the real question is not ultrasound versus x-ray. The real question is whether any imaging is needed at all. Adding a scan to a child who did not need imaging is not stewardship. It's just a faster way to find incidental and non-specific findings
That may not help the child.
So moving into the ICU world, the mental model changes here. In the ED, ultrasound often behaves like a diagnostic test at one moment in time. In the ICU, its real value may be serial reassessment. Is the fusion growing? Is the pneumothorax still present? Are B lines improving? Is this a recurring
consolidation that's getting better. The strongest Pediatric PQ data set comes from SACDEF, so many of the slides are going to be based on that study.
Bleura effusion is one of the cleanest wings for lung ultrasound, because it the ultrasound can transduce very well that the fluid medium. In the study of SACDEV, PICU cohort ultrasound detected many effusions that chest X-ray did not.
The pattern is similar in pneumonia studies, where ultrasound found more effusions than x-ray. This makes sense physically because fluid transmit ultrasound really well. And it makes sense clinically because the children in whom effusion matters more are often the ones who get the worst films, supine, ventilator,
post-op, unstable, or hard precision. Ultrasound can identify dependent fluid at the bedside without radiation and can be repeated as the shall changes. That is a real advantage, especially in PICU and post-operative cardiac patients.
On ultrasound, pleural fluid can look very direct and hypoechoic on echoic space above the diaphragm, sometimes with compressed lung, moving with it. On chest x-ray, fluid is inferred from shadows, blunting, opacity, laddering, or asymmetry, and those signs can be sorted or distorted by positioning.
That does not make X-rays useless. It just means that X-ray and ultrasound are answering different questions. Ultrasound asks, is there fluid in this space right here? X-ray asks, what is the global projected effect of everything in the chest? For effusion, the local question is often more useful.
And this is one of our major gaps in literature. Ultrasound is very good at detecting infusions, but detection is not management. What size matters? How should we grade complexity? Which findings should trigger drainage? Pediatric data do not yet give us any clear answer or any threshold for that.

A tiny rim of fluid found only because we look carefully may not matter, but enlarging septated loculated infusion in a child with respiratory compromise may change antibiotics from drainage or alter ventilatory change. Pediatric studies have not fully defined the thresholds that connect finding to action.
And we need better practice data on size, cutoff, complexity, septations, relationship to oxygenation and ventilation, and timing for drainage. Until then, ultrasound give us a better detection, but clinical judgment still decides what the finding means.
Pneumothorax is one of the most compelling bedside use of ultrasound because the question can be urgent and the physiology is favorable. Air in the pleural space removes the normal lung sliding at the scan location. In fact, the ultrasound detected more pneumothoraxis than chest
x-ray, and nearly all radiographic pneumothoracis were also seen by ultrasound. That is encouraging, but the pediatric evidence is very thin, and performance can depend on size, windows, dressing, subcutaneous emphysema, chest sups, and hyperinflation. So we should use ultrasound aggressively when it helps
us answer our urgent question at bedside, but we should not pretend that evidence is as deep as it is for pneumonia or effusion detection.
The bedside value is very real and important for a pneumothorax. For example, if you have a ventilator shell suddenly that's suddenly showing the duration, lung ultrasound can accelerate recognition. If sliding is clearly there, you are more reassured because that means that pneumothorax is excluded.
Pulmonary edema and interstitial syndrome are useful but tricky. Ultrasound can detect beeline burden and can be repeated at bedside, which makes it attractive for training lung water in children with cardiac disease, renal disease, fluid overload, ARDS, or evolving respiratory failure. The weakness is
specificity. Venus do not distinguish cardiogenic edema from infection, inflammation, contusion, or RDS. A pattern over time tied to a pattern over time tied to fluid balance, cardiac function, ventilatory settings, and oxygenation can be more useful in this setting.
This slide reinforces the same concept. Beelines are a shared artifact across diseases. Diffuse bilateral beelines in a child with poor cardiac function and positive fluid balance tell one story, but focal beelines around consolidation and irregular pleural line tell another.
Patchy B lines in ARDS, inflammation, or contusions is going to tell another story. The artifact is visually similar, but the physiology is different. So when someone says the

ultrasound shows edema, we need to think and we need to ask, what else supports that? What is the cardiac study? What's the fluid balance, the oxygenation study, the distribution? What's the trend?
Villains are just a clue, but they are not a diagnosis.
Autolectasis and consolidation are where the ultrasound advantage patterns. In SacDev, PQ data set, ultrasound and chest X-rays were roughly tied for detecting autolectasis and consolidation. That is important because it prevents us from overselling the tool.
Tissue-like lung in tissue-like lung is non-specific. A consolidated looking area can represent pneumonia versus collapse versus dependent allurelactasis versus conduction versus artifact. Ultrasound can show us that lung has become airless near the pleura, but it may not rely
reliably tell us why. In the PQ, the most useful application may be serial change. Does the area improve with recruitment, repositioning, suctioning, diuresis, antibiotics?
And this is where the child matters more than the image. Features that support pneumonia include fever, inflammatory markers, focal pleural abnormalities, dynamic urban programs, and associated fusion, clinical trajectory consistent with infection.
Features that support our electasis include
Dependent location, volume loss, static air broker arms rather than dynamics, and improvement after recruitment maneuvers.
The PQ takeaway is pretty much straightforward. Lung ultrasound offers the greatest advantage when the clinical question involves pathology at or near the pleural surface. This includes detection of pleural fluid, pleural air, and superficial interstitial fluid, making ultrasound particularly valuable for evaluating pleura effusions, pneumothorax, and monitoring pulmonary edema.
The advantage is less clear for autolectasis and consolidation, where tissue like lung is non-specific and chest x-ray may perform similarly.
Tuberculosis is a different use case. In Bellar's study of children with suspected pulmonary TB in South Africa, the ultrasound protocol looked beyond the lung. It assessed fluid, pericardial fluid, abdominal fluid, lymph nodes, and splenic or hepatic lesions. Focus positivity was higher in children with confirmed or unconfirmed TB compared with unlikely TB.
And pleural effusion and abdominal lymphadenopathy were common findings. The point is not that the ultrasound diagnoses TB by itself. It does not replace the exposure history or the HIV status and microbiology. The point is that the portable

ultrasound can map the disease and extend and monitor
bonds, especially where CT access is limited or radiation is a major concern.
I.
Reliability is a real world test of any ultrasound finding. If trained clinicians cannot agree on what they see at the bedside, this sign has limited clinical value. Gravel study of 71 children and more than 800 lung zones comparing our primary operator with the expert review.
Agreement was moderate overall. B lines were among the more reliable findings, while plural lines irregularity performed poorly. Effusion, clear sliding, clear pneumothorax patterns, and larger consolidations are different from minor plural irregularity. The more subtle the finding, the more careful we need to be before making management decisions from it.
Implementation is not a technology problem. The success of long ultrasound depends on standardized protocols, structured training, image archiving, ongoing quality assurance, and thoughtful integration of ultrasound findings with the patient's overall clinical picture.
Minimum documentation should include the clinical question, the views or zones obtained, the positive and negative findings, limitations, interpretations, and whether images were archived. The archive should include representative clips or images for each positive finding, and enough negative views to show the scan was adequate. If a scan changes antibiotics, drainage,
ventilation, or images, that image should be reviewed. QI should be routine and educational, not only for reactive after a mistake.
So not every clinician requires the same level of ultrasound expertise. However, all providers should understand basic long ultrasound terminology and recognize both the strengths and limitations of point of care ultrasound finance. Clinicians who use long ultrasound regularly should undergo competency-based training focused on common clinical applications.
including pleural effusions, pneumothorax, pneumonia-related complications, assessment of pulmonary edema trends. The objective is not for every provider to perform every scan. Rather, the goal is to establish your standards and common language. When wards, attendees, emergency physician, intensive is fellows, residents, medical students are consistent or using a consistent terminology and diagnostic criteria, the communication becomes more reliable and clinical decisions become more accurate. Standardization helps prevent both over-interpretation of

non-specific findings and failure to recognize
clinically significant abnormalities.
So several key knowledge gaps must be addressed before the periodic lung ultrasound can achieve its clinical potential. First, future studies require more robust reference standards. Chest radiography is in perfect compare and is not a great comparison and should not be considered the definite true.
But instead, diagnostic accuracy studies should incorporate composite reference standards that include clinical course, expert radiology interpretation, microbiology data when available, selective CT imaging, and longitudinal follow-up. Second, disease-specific protocols are needed. Pneumonia, pleurifusion, pneumothorax, and pulmonary edema represent distant clinical questions, and should
not be evaluated using a single scanning or reporting framework. Standardized protocols tailored to each condition would improve consistency and interoperability across studies and clinical settings. Third, research must move beyond diagnostic accuracy alone. Demonstrating that ultrasound is accurate is no longer sufficient. Fusion investigations should evaluate patient-centered and system-level outcomes, including radiation exposure, antibiotics stewardship, timing of fluora drainage for procedures, hospital and ICU lengths of stay, ventilator duration, and health care cost.
Fourth, training standards remain poorly defined. While numerous studies demonstrate the feasibility of lung ultrasound training, far fewer establish the level of experience required to achieve reliable and reproducible performance. Competency-based training thresholds and maintenance of proficiency deserve greater attention in our literature and the research.
And finally, important evidence gaps persist in pediatric critical care. Prospective pediatric studies are particularly needed to define the role of lung ultrasound in pneumothorax detection, pulmonary edema monitoring, and pleura effusion management, including clinical meaningful thresholds that should trigger interventions
or alter our management.
The future should move beyond asking whether ultrasound can see something. Accuracy is an intermediate outcome. Practice changes when we show better patient center or system center endpoints. Can lung focus reduce chest x-rays without missing clinically important disease? Can it reduce diagnostic uncertainty that leads to unnecessary antibiotics?

Can it shorten time to recognition and drainage of complex effusion? Can it affect ventilator days, ICU lengths of day, escalation of care, or costs? Equally important, future studies must assess potential harms. The absence of radiation does not make a test inherently harmless. Increased sensitivity may identify incidental or clinically insignificant abnormalities that would otherwise
ever have affected patient outcomes. If these findings lead to unnecessary testing, interventions, or treatment, their results may be over-diagnosis rather than improved care. Therefore, the true value of a lung ultrasound should be judged not only by what is detected, but by whether it is used improved care.
patient outcomes, supports very clinical decision and avoids unintended consequences.
For CAP diagnosis and complications, confidence is relatively high. Lung focus is a strong adjunct or alternative in selected children, but not a standalone pathogen classifier. For pleural infusion detection, confidence is high, but management thresholds are less defined.
For pneumothorax, the physiology is compelling and the bedside value is real, but pediatric data are thinner. And this is kind of like the nutshell of the studies and data results.
So a few take home points. First, ask a clinical question before we or you scan. Do not scan because the machine is nearby. Scan because you have or you want an answer that could change your management. Second, it's important to understand the physics. Lung focus is strongest at the pleural surface and weaker at central diseases.
Third, separate detection from action. A fusion seen is not a fusion drain. B-line seen are not edema diagnosed. Fourth, do not overcool etiology. Ultrasound can support pneumonia, but it cannot reliably tell bacteria from viral disease alone. Fifth, it's important to build a program. Training,
Archiving documentation and QR are what make the tool trustworthy. And finally, it is important to use it like a clinician and let the probe extend our judgment, but not replace it.
So, thank you.

Wu, Theodore 50:34

That's great. Thank you, Doctor Bettis, for that great review on using a Pocus and ICU process.

Ye.
Please, you know, if you have any questions.
free, please free to raise your hand or enter your questions in the chat.
As you're gathering questions here, Dr. Giberez, in your review of some of the articles there, the tough part that we've always had is in children, you know, that they're developing lungs. And I know in the adult literature, you know, there's actually pretty standardized ways to
look at lungs on ultrasound. Was there anything that anyone developed as to how to account for lung development, especially for NICU population? You know, like how do you, is there a way to kind of describe that or does each patient create their own baseline, you know, of their lung disease? You know, is there a way to differentiate? you know, chronic lung disease versus like acute lung disease, anything that kind of comes through the literature.

Lluberes Rivera, Carla Gilmar 51:46
No. The literature is very heavy with pneumonia and pneumonia in the ED. So basically a lot of the literature talk about how you diagnose and how you identify pneumonia, but there's not a lot of talking on how you scan a children.
the different anatomic spaces in children versus adults.

Wu, Theodore 52:10
Okay.
Let's see, I'm just kind of seeing if anyone had any other questions here. Might be some.
In the chat here, Doctor Williams, as are any particular challenges with age or body weight?
Oh, that's, yeah, yeah.

Lluberes Rivera, Carla Gilmar 52:42
Yeah, with body size, it's going to be like the technique. So that's why choosing probes and having good skills and a good operator is going to be helpful in detecting like any pathology.

Wu, Theodore 53:15
Yeah, we do know that this is kind of a rising field in focus, uh, you know, and using.

especially for children who are on ECMO, and we want to use a different tool to assess, you know, lung pathology and progression. We, you know, right now we only use like x-ray, the ventilator as really as a
way to gauge compliance.
Yeah, this is another modality. We probably underutilize it in our unit, you know, so there's a lot of potential that's here. So definitely more to come, you know, so.

Lluberes Rivera, Carla Gilmar 53:59
Hmm.

Wu, Theodore 54:00
All right, Doctor Williams, wish you best wishes and great overview, so.

Lluberes Rivera, Carla Gilmar 54:06
Thank you.

Wu, Theodore 54:08
This.

Lluberes Rivera, Carla Gilmar 54:09
Mm.

Wu, Theodore 54:12
All right. Well, with that, thank you, everybody. Thank you, Dr. Yvette. No more questions. I wish everyone to stay cool and go Spurs go. All right. Thank you.

Lluberes Rivera, Carla Gilmar 54:26
Thank you.
OK.

Calderon, Delia stopped transcription