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12th WINFOCUS World Congress on

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in Emergency & Critical Care

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TABLE OF CONTENTS

PLENARY LECTURES

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POCUS is improving the access to a better quality of health in critical and remote scenarios, all over the world.

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CHANGING THE PARADIGMS: WINFOCUS VISION AND MISSION

The word **Paradigm** comes from Greek παράδειγμα (paradeigma), "pattern, example, sample".

The Oxford English Dictionary defines the term paradigm as "a typical example or pattern of something; a pattern or model". In the Merriam-Webster's Learner's Dictionary Paradigm is defined as "a theory or a group of ideas about how something should be done, made, or thought about".

But may be the best definition to understand what a medical paradigm means is the one of the historian of science Thomas Kuhn in his book "The Structure of Scientific Revolution". He gave it its contemporary meaning when he adopted the word paradigm to refer to the set of concepts and practices that define a scientific discipline at any particular period of time: "universally recognized scientific achievements that, for a time, provide model problems and solutions for a community of practitioners. (The Structure of Scientific Revolution, Kuhn, Thomas S. 3rd edition. Chicago: University of Chicago Press, 1996)

In his work Kuhn saw the sciences as going through alternating **periods of normal science**, when an existing model of reality dominates a protracted period of puzzle-solving, **and revolution**, when the model of reality itself undergoes sudden drastic change.

During the periods of "normal science" the conviction that the current paradigm is reality tends to disqualify evidence that might undermine the paradigm itself.

Kuhn used the expression **"paradigm shift"** for the process between these two periods. This period can be compared to the perceptual change that occurs when our interpretation of an ambiguous image "flips over" from one state to another. The rabbit-duck illusion is an example of an ambiguous image: it is not possible to see both the rabbit and the duck simultaneously.

("Kaninchen und Ente" ("Rabbit and Duck") from the 23 October 1892 issue of Fliegende Blätter)

Perhaps the greatest barrier to a paradigm shift, in some cases, is the reality of **paradigm paralysis**: the inability or refusal to see beyond the current models of thinking. For well-integrated members of a particular discipline, its paradigm is so convincing that it normally renders even the possibility of alternatives.

We are fortunate because we are living in an age of changes. We are in the middle of a revolution period.

We are in the middle of a change of the paradigm on the way we have been doing medicine until today. And this is due to the use of Point of care ultrasound in the medical practice.

Point of care ultrasound has changed and empowered the whole management of patients in almost all the specialties and scenarios, both in hospital and in prehospital settings. But at the same time ultrasound is also changing the way of teaching and learning medicine.
Medical doctors have been using medical devices since ancient times.
Some devices have been completely useless while others have completely changed the paradigm of medical care. The microscope and the stethoscope are just a few examples.

When Renee Laennec rolled a paper for hearing the back of a patient he probably didn't realized that he was changing the way of doing medicine for the next generations.

At the very beginning this simple and revolutionary device was resisted by many leaders of the medical community, (the paradigm paralysis), but the stethoscope has been used for more than 150 years and there is no doubt that the stethoscope really empowers the clinical decision making process.

In the last 50 years the improvement in technology with the onset of fast computers, video capabilities and connectivity have completely change the way of living of the humanity.

And these new technologies have had a great impact in the medical practice: almost 40 years ago, another medical device, the Diagnostic Ultrasound, again has completely changed the paradigms and the way of doing medicine.

Many diagnostic and therapeutic algorithms have completely changed based on ultrasound findings. Just one example: The term "exploratory laparotomy", the final step of many diagnostic algorithms some years ago, has almost disappeared.

Ultrasound is a powerful and worldwide accepted diagnostic tool but it is not always available especially in critical settings. Because of this in the middle seventies German surgeons used an ultrasound device for the first time with just a focal goal: to detect free abdominal fluid in trauma patients in order to take rapid decisions.

This was the beginning of the use of point of care ultrasound by non-radiologist with just focal purposes. After that many papers about the focal use of Ultrasound began to appear. Focal ultrasound of the airway, the lung, the heart, the lung, the abdomen, and the extremities where published by different specialists: anesthesiologists, cardiologist, surgeons, emergency physicians, intensivists in order to improve medical care.

Point of care ultrasound is a limited study, not to do describe a detailed anatomy of an of an organ as conventional ultrasound, but to obtain rapid answers to simple medical questions and empower clinical decisions:

- Has this patient with abdominal trauma free fluid: yes or no?
- Is this patient with vaginal bleeding pregnant: yes or no?
- Will this hypotensive patient benefit with the reposition of fluids: yes or no?

The answer of this simple question can help us to make rapid therapeutic decisions or to search the better place to refer the patients if we are in a prehospital setting.

But again, at it happened with the stethoscope, at the beginning some resistance from part of the medical community appears. But the use of focal US is continuously growing worldwide.

The use of focal ultrasound permits to obtain rapid information that has rapid influence in our diagnostic and therapeutic decisions, not only in primary care and in the prehospital scenarios, but also in the emergency room, the ICU, and the resuscitation.

In prehospital scenarios POCUS permits an enhanced triage, an enhanced physical examination, and monitoring the response to a treatment.

In 2006 many pioneers of the point of care ultrasound decided to gather and create a worldwide society, called WINFOCUS, integrated by experts in POCUS coming from different specialties and from different regions of the world but with a common goal: to promote the use of ultrasound in different scenarios for a better care of patients.

The integration of all these pioneers results in an integration of all the focal protocols. Focal ultrasound became in multi focal ultrasound approach, using ultrasound as a holistic tool, using ultrasound from head to toes, integrating the use of ultrasound as a visual stethoscope, as an extension of the physical examination.
All these multifocal utilities of ultrasound have completely changed the paradigm of medical care especially in critical patients, in primary care and in remote locations.

As the stethoscope some years ago focal ultrasound is changing the way of doing medicine nowadays.

At the same time the miniaturization of the devices allowed a fast worldwide spreading and its use in many different in hospital and prehospital scenarios.

But, why all the doctors are not using focal ultrasound today?

There are 2 reasons:

- The first one is related with the technical resource: Not all doctors have an available US device
- The second one is related with the human resource: Not all doctors are well trained yet.

What is Winfocus doing to change this?

<u>About the technical resource</u> probably in the next years with the miniaturization of the devices and the increase of the sales probably we will see a drop in the costs. And probably everybody will have an ultrasound device hang around their neck….

<u>About the education of the human resources</u> Winfocus has been doing an amazing educational activity during the last 12 years not only through the organization of congresses and courses, training more than 40000 doctors in more than 60 countries in all continents. but also organizing consensus conferences gathering worldwide experts of focal ultrasound

The already published consensus on Lung Us, Echo US and Vascular access and the ongoing Trauma CC (from Fast to FAST ABCDE) and the Education CC are just part of this.

WINFOCUS is promoting the integration of ultrasound in the pre graduate curricula at the universities because we are convinced that the real revolution and change of the paradigm will occur when all medical doctors finish their studies knowing how to use multifocal ultrasound as an extension of the physical examination.

Winfocus is doing a restless work and has become the world leader society in promoting and teaching multifocal point of care ultrasound, but we need more people involved as pioneers of this revolution, as trainers to help as in every region of the world to spread the use of multi focal ultrasound in the maternal language of each country.

I formally invite all of you to join Winfocus today, to help us to spread the focal use of ultrasound to improve the access to a better quality of health of every single person all around the world.

We are in the middle of a revolution. We are in the middle of a paradigm shift. The change of the paradigm of medical care by the use of Point of care ultrasound is occurring right now.
We have the know how
We know what we have to teach
We know how to teach
Join Winfocus and let's do this revolution all together.

www.winfocus.org

Dr. Tomislav PETROVIC, MD
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Head of SMUR Bobigny, EMS SAMU 93, France
Chair of research, education and quality sub-department on Clinical Emergency Ultrasound, France

Founder and Past-President of WINFOCUS, current president of WINFOCUS-France, organizer of 3rd WINFOCUS Congress held in Paris, May 2007, co-author of various publications on the subject and strong believer of the first hour in Clinical Emergency Point-of-Care UltraSound (CE-POCUS).

"May the Ultrasonography be with you"

WHY #POCUS?

One of signs of human gregariousness is to always try to be part of a community, sharing a common environment and interact for the good of all. In fact, living alone is extremely difficult from many points of view. In medicine, the behavior is comparable, bringing people to share ideas in which they trust for the good of their patients. But creating a community is most of the time very hard. Indeed, convincing people of the merits of an idea, especially of a disruptive one, is naturally leading to get easier convinced of its triviality. But once the idea is enough documented and accepted – it usually takes at least a decade in medicine - the community is growing exponentially.

When Dr Laennec wrote his book on "Mediated auscultation" in the end of 19th century, most of his colleagues were doubtful about his new "technology". Who would nowadays challenge the impact of stethoscope in our daily practice? When Dr Beclère was accused by his peers to become a photographer at the beginning of the 20th century, no one apart him could imagine the importance that radiography would hold today. When few pioneers sensed that clinical examination, remaining the same as it was 200 years ago, could be empowered in emergency and critical care medicine by a new usage of a known technology trapped in hands of some specialists, they faced criticism and obscurantism. Some times even insults. One and a half decade later, after hard work, lots of communications in congresses, training sessions, discussions and scientific publications, the community, built around point-of-care clinical ultrasound (POCUS), has tremendously grown and evolved worldwide, making one even think of a kind of Tsunami. It has almost its own life, extending its tentacles in all parts of medicine, from medical education, to all medical specialties imagining their own procedures with ultrasound. In the hands of a trained practitioner, whatever his specialty, ultrasound switches standard clinical examination to augmented clinical examination, bringing new data that can be directly integrated into medical reasoning. By this, ultrasound empowers initial decisions and favors a closest follow-up, particularly in emergency and critical care medicine.

Finally, the question to be asked is not "Why #POCUS" anymore, but "How #POCUS". The community exists, lives, and evolves everyday by helping new members to bringing their own ideas, knowledge and skills. It is becoming obvious that POCUS will be completely integrated in modern medicine in next decades. Therefore, medical students, physicians and also other healthcare providers need to be trained as soon as possible for ultrasound to be naturally part of our everyday practice.

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RISE OF LUNG ULTRASOUND AND DEMISE OF CHEST RADIOGRAPHY

It is true that the application of lung ultrasound (LUS) is spreading more and more in recent years, but the real challenge for the next future is to understand how to integrate LUS in the diagnostic armamentarium that includes and will continue to include chest radiography (CXR). However, there are some applications where LUS is not only recommended by the experts, but needful. Without the use of LUS it is not possible to maintain a safe level of diagnostic accuracy in some applications, especially in emergency. A list of these applications include diagnosis and quantification of pneumothorax, the first diagnosis of acute decompensated heart failure, pulmonary infections, pleural effusion and pulmonary contusions in trauma patients. Depending on the setting and clinical scenario, LUS is often much more accurate than CXR, especially in the ability of ruling out the disease (sensitivity). Many original studies comparing LUS and CXR vs CT scan and clinical judgment, showed this superiority that is now strongly evidence based.

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Life-saving information in critically ill can be acquired by POCUS by anybody who has "know how". When such information is available, it has to be used correctly, thoughtfully and with care.

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IS IT "FOCUS" OR "EMERGENCY ECHO"

It is the fact that ultrasound examination of the heart may save lives in cardiac emergencies. While comprehensive emergency echocardiography remains gold standard in evaluation of unstable patient with suspected cardiovascular pathology, the point-of-care, focus cardiac ultrasound examination (FoCUS) is increasingly used in cardiovascular emergencies. In reality, not only cardiologists, but a wide range of specialists are involved in emergency cardiac diagnostics and treatment, including anesthesiologists, intensive care specialists, emergency physicians, surgeons, even fellows.

From the ethical point of view any medical professional, sufficiently trained to obtain valuable information ultrasound examination of the heart should be encouraged to use it in emergency settings. However, these medical professionals need to be educated to correctly interpret acquired data and to use them in line with clinical context. They must recognize and admit major differences between echocardiography and FoCUS. The crucial difference is the amount of obtained information: FoCUS examination provides sufficient information for mostly qualitative gross assessment of cardiac morphology and function, reported as 'absent/present', or 'yes/no' (i.e. qualitative assessment). In real life, comprehensive echocardiography should not be considered as mandatory in cardiac emergencies, simply because it is impossible (and NOT necessary) to be always comprehensive in emergency situations due to time constrains and actual logistics. Since there is an obvious lack of expert echocardiographers (cardiologists) at all places where critically ill are diagnosed and managed compromises have to be made. What really matters, however, is an information! Often we do not need all information that could be acquired by comprehensive echocardiography in order to make critical decisions. Thus, we can efficiently use restricted information obtained by FoCUS in many situations to start therapy and save lives. This limited approach surely carries risks of overlooking important abnormalities and of false readings of an incomplete dataset. Although these types of errors could certainly occur also during comprehensive echocardiography, their expected rates might be considerably higher for the FoCUS, and can be especially high in situations where the operators are not fully trained in echocardiography and/or cardiology. Failure to appreciate the limitations of the FoCUS may lead to serious misinterpretation of the findings with devastating clinical consequences. Recognition of these limitations must be incorporated in any training protocol for the FoCUS.

FoCUS should always be followed by comprehensive echocardiographic examination. The use of FoCUS should never deprive the patient of the opportunity of a better diagnostic test.

Both cardiologists and non-cardiologists can perform either emergency echocardiography or FoCUS depending on clinical circumstances, available equipment, and their expertise/competence. However, for critically ill patients, it is not important whether the life-saving information is acquired by *non-cardiologist* performing FoCUS, or by the *expert cardiologist* performing echocardiography. When such information is available, it has to be used. However, for the benefit of the patients, the involved medical professionals should have the necessary knowledge to understand the obtained information entirely, and to use it correctly, thoughtfully and with care.

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Never doubt that a small group of thoughtful, committed citizens can change the world. Indeed, it is the only thing that ever has."(Margaret Mead)

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WINFOCUS AND HEALTH FOR ALL: FROM VIRAL DEVELOPMENT TO A SUSTAINABLE SCALE-UP

The presentation will provide a brief analysis of what makes ideas go viral and in so doing it will shed some light on WINFOCUS' powerful global development that has made it a viral global force and pioneer of point-of-care ultrasound worldwide, as well as a promoter of "health for all". The question of "what next?" is then asked. The presentation will address the potentialities of scaling-up WINFOCUS' experiences locally, nationally and worldwide, with important repercussions on accessibility, quality and sustainability of healthcare. Finally, the development and implementation of a multi-dimensional index to apply across the WINFOCUS network will be suggested as a potential measure of impact, quality assurance and source of inspiration for continuous value-driven progress and evidenced-based contribution to the noble goal of health for all.

Track A1: POCUS IN PREHOSPITAL AND ED

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PARIS ATTACKS: COULD POCUS MAKE A DIFFERENCE?

Key points:

1. In mass casualties, the priority remains the fast triage,
2. For penetrating injuries, the damage control resuscitation is the key point of the prehospital management,
3. POCUS could permit a better diagnosis of lesions, especially for torso injuries without vital signs abnormally,
4. Small devices can permit the use of POCUS in triage setting.

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VALUE OF LUNG ULTRASOUND IN PREHOSPITAL ARENA AND EMERGENCY DEPARTMENT

Introduction

Lung ultrasound (LUS) as a part of point-of-care ultrasound (POCUS) was introduced in critical care by Lichtenstein et al., who proved that lung can be imaged and its images interpreted in meaningful ways. Liechtenstein proposed BLUE protocol (bedside lung ultrasound in emergency; Fig. 1) in his landmark paper, describing excellent diagnostic accuracy for immediate diagnosis in patients with acute respiratory failure [1]. To interpret ultrasound findings of the lung, it is crucial to be familiar with patients presenting symptoms, relevant past medical history, physical examination and other imaging findings. Lung ultrasound images have their specific sonographic pattern of either »true« images (direct ultrasound findings, i.e. fluidothorax) or indirect signs (sonographic artefacts) [2]; combined allow us to accurately diagnose critical and most frequent causes of ARF: pneumothorax (PTx) [3], interstitial syndrome [4, 5], pleural effusion (FTx), alveolar consolidation [6, 7] and pulmonary embolism [8].

Short Review

Baseline sonographic pattern of healthy lung is "A-profile" consisting of A-lines, pointing towards lung being aerated and pleural sliding, proving that lung is being ventilated (mechanically or spontaneously) and that there is no pneumothorax. Figure 2. shows normal "A profile". B-lines (vertical hyperechogenic artefacts in Fig. 3) are one of the lung sonographic artefacts and are considered as a partial loss of aeration and increased density of peripheral lung parenchyma [9]. They are defined as discrete laser-like vertical hyper-echoic reverberation artefacts that arise from pleural line, extending to the bottom of the screen without fading, and move synchronously with lung sliding. Their presence indicates interstitial syndrome of different causes, such as pulmonary edema (including cardio- or non-cariogenic oedema), interstitial pneumonia or pneumonitis, diffuse parenchymal lung disease (pulmonary fibrosis), pulmonary contusion or infarction [10]. B lines alone or in combination with NT-proBNP have high diagnostic accuracy in differentiating acute heart failure related from COPD/asthma-related causes of acute dyspnea in the prehospital emergency setting [11].

The number of sonographic B-lines correlated with both the radiologic estimate of extra vascular lung water EVLW [12], findings at invasive measurement of pulmonary capillary wedge pressure [13] and NT-proBNP values [14]. Therefore, the lung ultrasound could be also used for monitoring the success of treatment. Noble et al counted the number of B-lines before, at midpoint and after dialysis. They concluded that in haemodialysis patients' B-lines resolution appears to occur real-time as fluid is removed from the body and that thoracic ultrasound is a useful method for evaluating real-time changes in (EVLW) [15]. Furthermore, Volpicelli et al showed that B-line pattern mostly clears after adequate medical treatment of acute decompensated heart failure (ADHF) and represents an easy-to-use alternative bedside diagnostic tool for clinically monitoring pulmonary congestion in patients with ADHF [16]. In addition, Liteplo et al described a case report of a patient with pulmonary edema treated with CPAP. They suggest that lung ultrasound could be used to diagnose and to monitor the response to treatment in real-time fashion [17]. It was also shown that LUS could be used for monitoring the effectiveness of treatment with CPAP in patients with ADHF [18] or in patients treated with positive end expiratory pressure (PEEP), showing reaeration of the lung [19]. Fluid administration limited by lung sonography (FALLS protocol) in patients with acute circulatory failure provide a direct biomarker of clinical volemia [20].

POCUS is also an accurate and reliable method for confirming the proper orotracheal tube placement in trachea and it is feasible for out-of-hospital implementation [21].

Lung ultrasonography is suitable and easy to comprehend with high sensitivity and specificity. Medical students with no prior experience in lung ultrasonography can acquire skills to detect thoracic wall structures and identify lung sliding with high degree of sensitivity and specificity [22]. Similarly, the pre-hospital critical care providers can also quickly acquire and retain skills necessary to detect lung sliding by the use of ultrasound [23].

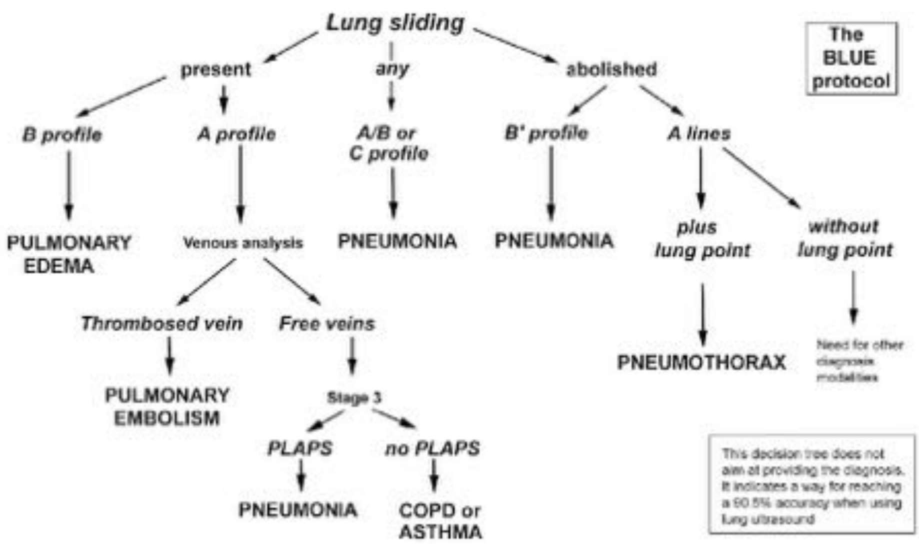
Conclusion

Lung US at the bedside has proven to be effective, accurate, non-radiating, repeatable and affordable tool in hands of clinicians taking care of (potentially) ill.

Although most of the studies showing its worth were conducted in ED or ICU settings, its worth is all the more in prehospital arena, where lack of diagnostic modalities is even more pronounced. Having reliable, handheld tool that can quickly confirm or exclude most critical pathology is outright revolutionary!

In our own prehospital setting in reani-mobile, authors have learned to use and rely upon LUS for key critical scenarios;

Airway management: identifying pleural sliding and diaphragm excursions on both sides, it is easy to confirm bilateral ventilation in seconds!
In patients with (pleuritic) **chest pain**, it is easy to exclude/identify pneumothorax with pleural/lung sliding sign, pneumonia or even pulmonary infarcts (PE). Adding FoCUS (Focused cardiac US) to the exam, can easily identify pericardial effusion (if history and ECG point in this diagnostic direction).
Key pathologic entities we find in patients with **dyspnea**/ac. respiratory failure are (cardiogenic) pulmonary oedema (acute, diffuse, bilateral B-lines), pneumonia (interstitial-B lines/lobar - consolidations), fluido-thorax, pneumothorax and indirectly, by confirming bilateral A-profile with lung slinding, strongly heading towards AE of asthma/COPD or PE. It is clear from former, that to identify pathology primarily not affecting pleura (bronchial obstruction), one still needs stethoscope.
Controlling for LUS profile (disappearing B-lines) during treatment of patient with ac. heart failure adds whole new dimension, as one can very quickly confirm/refute direction of initial treatment.
LUS use in primary **trauma** exam is even more straight-forward and truly indispensible, especially in prehospital setting; since major thoracic pathology in trauma is pneumo- and/or haemo-thorax of various degrees, with pulmonary contusion and/or flail chest, it is clear, that quick, six point lung scan (bilaterally) can identify majority of immediate threats. During primary trauma exam, we put the probe on highest level anteriorly (PTx), in anterior axillary position and in posterior axillary position just above diaphragm (FTx).



POCUS (as ultrasound in general) is completely operator dependant, thus potential bottleneck or basis of explosive growth will be effective education!

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Ultrasound IS operator dependent. Like every other important thing we do (lac repair, bedside manner, etc.). So practice!

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CAN FOCUS PREDICT OUTCOMES OF CARDIAC ARREST PATIENTS?

Although there is great variability in prehospital protocols around the world, out-of-hospital cardiac arrests are universally cared for on-scene. Thus, providers are left caring for these unstable patients with resources that are limited compared to what is available in a hospital setting. Increasingly, ultrasound is being incorporated into prehospital care- its role during cardiac arrest will likely be similar to how it is used in any other critical care environment.

Role in hemodynamic instability

Many descriptive studies have been published which detail various protocols for ultrasound use in shock or arrest:

- UHP protocol
  Rose JS et al, Am J Emerg Med 2001 (PMID: 11447518)
- Trinity Protocol
  Bahner D, JDMS 2002
- RCT of ultrasound in hypotension
  Jones AE et al, Crit Care Med 2004 (PMID: 15286547)
- FATE: Focused Assessed Transthoracic Echocardiography
  Jensen et al, Eur J Anaesthesiol 2004 (PMID: 15595582)
- FEER: Focused Echocardiographic Evaluation in Resuscitation
  Breitkreutz et al, Crit Care Med 2007 (PMID: 17446774)
- CAUSE: Cardiac Arrest Ultrasound Exam
  Hernandez et al, Resuscitation 2008 (PMID: 17822831)
- RUSH: Rapid Ultrasound in Shock and Hypotension
  Weingart et al, emcrit.org 2008, EMedHome 2009
- ACES: Abdominal and Cardiac Evaluation with Sonography in Shock
  Atkinson et al, Emerg Med J 2009 (PMID: 19164614)
- RUSH: Rapid Ultrasound in Shock
  Perera P et al, Emerg Med Clin N Am 2010 (PMID: 19945597)
- EGLS: Echo Guided Life Support
  Lanctôt, Valois, et al. http://www.echoguidedlifesupport.com/

In these studies, we see many variations on the same theme: Multisystem organ assessments with ultrasound to assess for common treatable causes of shock, and evaluation of common causes for cardiac arrest.

Most authors recommend at minimum an assessment of the heart for contractility (or lack thereof), pericardial tamponade, and IVC assessment for plethora (suggesting fluid resuscitation would not be helpful) or depletion (suggesting fluids are indicated). Beyond these assessments clinical care and provider skill should dictate whether assessment of the thorax, abdomen, extremities, or other areas would be high-yield in our most critically ill or coding patients.

There has been much written on prognosis of cardiac arrest. Presenting rhythm, duration of the code, timing and quality of CPR, end-tidal CO_2 assessment, and others have been studied. In addition, the presence or absence of cardiac activity on ultrasound has been studied as an independent predictor of ROSC.

A recent metanalysis of the use of ultrasound in cardiac arrest pooled data from eight studies:

Blyth L, Atkinson P, Gadd K and Lang E. Bedside Focused Echocardiography as Predictor of Survival in Cardiac Arrest Patients: A Systematic Review Acad Emerg Med 2012 19:1119–1126

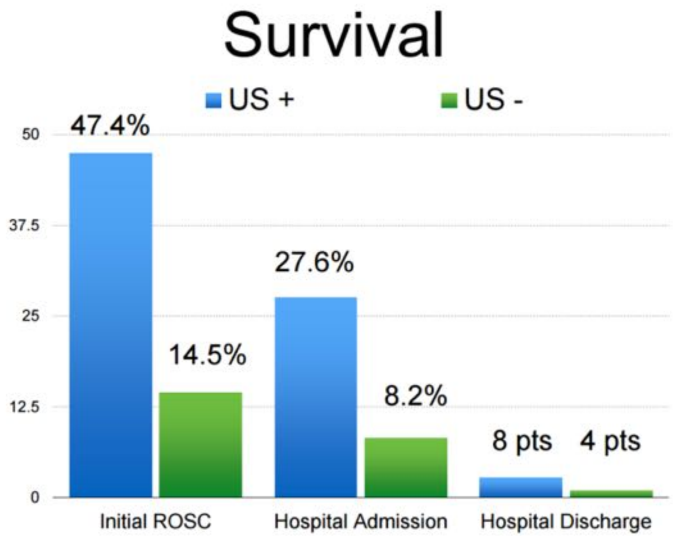
Study	Outcome Measure(s)	Population	US Methods
Blaivas (2001)[7]	Survival to hospital admission	*n* = 169 Convenience sample Nontraumatic arrests	Performed by US-trained residents Aloka 2000, 2.5-MHz curved-array and phased-array transducer
Salen (2001)[13]	Survival to hospital admission	*n* = 102 Nonconsecutive convenience sample	EPs, residents, and attending physicians had a minimum 4-hour trauma US course Pie Medical Scanner 200 GE RT 3200 Advantage II Both used a 3.5-MHz curvilinear transducer
Tayal (2003)[16]	ROSC Survival to hospital discharge	*n* = 20 Nontraumatic arrests	EPs were trained with a 20-hour US course Shimadzu SDU-400 gray-scale, 3.5-MHz probe
Salen (2005)[14]	ROSC Survival to ED discharge Survival to hospital discharge	*n* = 70	EP ultrasonographers 3.5-MHz curvilinear or sector probes
Schuster (2009)[15]	Survival to ED discharge Survival to hospital discharge	*n* = 27 Traumatic and nontraumatic All patients presenting in or progressing to PEA	US-trained residents performed US under supervision of credentialed EP or trauma surgeon Phillips EnVisor, 5-MHz curvilinear probe for subxiphoid images or phased array for parasternal views
Breitkreutz (2009)[11]	Survival to hospital admission	*n* = 88	Emergency physician trained in periresuscitation echo Modified hand-held US device with 3.5-MHz probe SonoSite i-Look 15 with a curved array probe
Hayhurst (2010)[12]	ROSC Survival to ED discharge Survival to hospital discharge	*n* = 50 Traumatic and nontraumatic arrests Convenience sample	ED physicians and specialist trainees who already held Level 1 competency in emergency US Primary view obtained was xiphoid using a curvilinear probe with the option to proceed to another window using either a curvilinear or a phased array probe
Aichinger (2012)[6]	ROSC in the field Arrival to ED with spontaneous circulation Survival to hospital discharge	*n* = 42 Nontraumatic arrests Nonconsecutive sample	EPs underwent a 2-hour introduction and training session

The authors concluded:
Meta-analysis of the data showed that as a predictor of ROSC during cardiac arrest, echo had a pooled sensitivity of 91.6% (95% confidence interval [CI] = 84.6% to 96.1%), and specificity was 80.0% (95% CI = 76.1% to 83.6%). The positive likelihood ratio for ROSC was 4.26 (95% CI = 2.63 to 6.92), and negative likelihood ratio was 0.18 (95% CI = 0.10 to 0.31). Heterogeneity of the results (sensitivity) was nonsignificant (Cochran's Q: $\chi 2$ = 10.63, p = 0.16, and I2 = 34.1%).

While we might have hoped for a clearly binary result predicting with certainty which patients would survive or not, we are left with a test which has good characteristics but must be placed into clinical context.
The largest prospective, observational study of ultrasound in cardiac arrest was recently completed:

National Institutes of Health. REASON 1 Trial: Sonography in Cardiac Arrest. Available at: http://clinicaltrials.gov/ct2/show/NCT01446471. Preliminary data have been presented at national meetings but a peer-reviewed article has not yet been published so data should be interpreted accordingly. Presentation is available online at:
http://caep.ca/sites/caep.ca/files/caep/CAEP2015/Presentations/reason_final_caep_version_ppt_2.pdf

Patients – 815
Age - 63yo
Male - 62%
OOHCA - 84%
Length of resus - 18 min
Initial activity on US - 32.7%
ROSC - 26.3%
Hospital Admission - 15.2%
Survival to Hospital DC - 1.5%



Authors' conclusion:

US is not a reliable independent test to predict cardiac arrest outcome in ED patients, overall, or even in PEA (LR+ve 1.64 - 2.85; LR-ve 0.42 - 0.49)

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"May the Ultrasonography be with you"

HEMODYNAMIC MONITORING WITH POCUS IN PREHOSPITAL AND REMOTE SETTINGS

Clinical Emergency Point-of-Care Ultrasound (CE-POCUS) has been largely studied, proving its added value in management of acutely ill patients, whether in in- or out-of-hospital scenarios. Despite the necessity of equal level of healthcare quality, out-of-hospital conditions of work are depending on specific time and space constraints. Thus, Prehospital Emergency Medicine (PHEM) is, more than any other, relied on personal skills, knowledge, and embedded material, to provide fast and adapted decisions for diagnosis, treatment, and orientation, particularly in patients hemodynamically unstable, traumatic or not.

In this specific situation, almost all patients look the same from the outside: pale, blotchy skin, sweating, tachycardic, tachypneic, low blood pressure, etc. But from the inside, they are most of the time different.

Three closely linked parameters responsible for hemodynamics state can be assessed by ultrasound:

1. The pump, by focused cardiac ultrasound. Hyperkinetic or, on contrary, impaired contractility of left ventricle (LV), dilation of right cavities, large pericardial effusion with signs of tamponade are some elements needing only 2D ultrasound, when mitral massive regurgitation becomes obvious with color Doppler.
2. The tubes, by vascular ultrasound. If aortic dissection might be difficult to visualize, abdominal aortic aneurism (AAA) is much easier; an uncompressible vein of a lower limb is a simple but very sensitive sign of deep venous thrombosis.
3. The tank, by inferior vena cava (IVC), peritoneal, pleural and lung ultrasound. IVC diameter is correlated to circulating volume and central venous pressure. Collapsed IVC is in favor of hypovolemia (absolute or relative); dilated and fixed is in favor of maximum expansion or of high venous pressure. The detection of an effusion in a serous cavity (pleural, pericardial or peritoneal) is now considered as the first-to-learn part of clinical ultrasound and taught for years all around the world. Its importance is extended to evolved protocols.

Various protocols have been designed to ensure fast and systematic review of focused ultrasound assessments: FATE, FALLS, RUSH, or even FEEL for extreme hemodynamic state in cardiac arrest. For each parameter, ultrasound has a high diagnostic accuracy leading to more precise stratification of patients. Nevertheless, for an optimal hemodynamic evaluation and to avoid pitfalls, they always should be interpreted together (i.e. ruptured AAA with hyperkinetic kissing heart, collapsed IVC, peritoneal effusion and "dry" lung; pulmonary embolism (PE) with dilated right cardiac cavities, dilated IVC, "dry" lungs; etc.) and combined with clinical data (history, clinical examination, vital parameters, etc.). When correct evaluation is done, two main questions can then be answered: 1) should be vascular volume expended, and/or 2) should catecholamines be used?

Once decision made and treatment set on, ultrasound is used as a monitoring tool, to follow up patients' evolution, and to adapt or modify therapy depending on its tolerance and efficacy. A "dry" lung becoming "wet", sign of interstitial syndrome, associated to dilated IVC, show exceeded capacities of the "tank" after volume expansion, and/or impaired function of the "pump" by a worsening of cardiac contractility. Combined to clinical repeated examinations, ultrasound monitoring then increases security and comfort by earlier treatment adaptations and, if necessary, changes in final orientation.

In the hands of a trained clinician, whatever his specialty, ultrasound switches standard clinical examination to augmented clinical examination, bringing new data that can be directly integrated to medical reasoning. By this, ultrasound empowers initial decisions and favors a closest follow-up, particularly in difficult situations as hemodynamic instability.

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CASES SAVED BY POCUS: TRAUMA IN ED

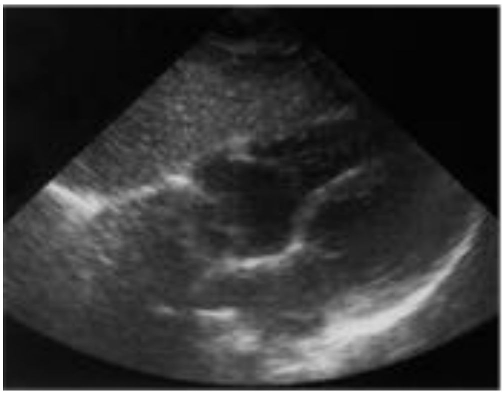
Traditionally ultrasound or the "FAST" exam in trauma was used to identify those patients who were unstable because of hemorrhage and to expedite the decision bring them to the OR. In many ways "FAST" was used as a less invasive and more facile diagnostic peritoneal lavage test.

However, over the last twenty years, the management of traumatic injuries has changed. Trauma patients are often managed expectantly; i.e. not all injured spleens are removed, not all pneumothoraces are drained and not all patients with abdominal hemorrhage need chest tubes prophylactically or the operating room. Indeed, not all thorocotomies need the pericardium opened - especially in the age of ultrasound. The beauty of ultrasound is that we can identify the injury causing hemodynamic instability and address this in a time sensitive manner - while reassuring ourselves that other invasive procedures can be avoided safely because the hemodynamically significant injury is not present.

Now that is smart medicine. The following is an example of how this can be used in practice….

FAST - Where is the bleeding?

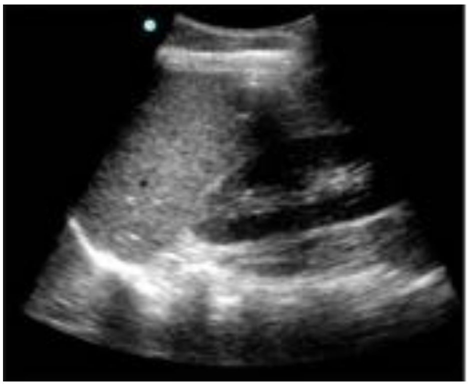
#1 - Is there pericardial injury causing bleeding and tamponade?

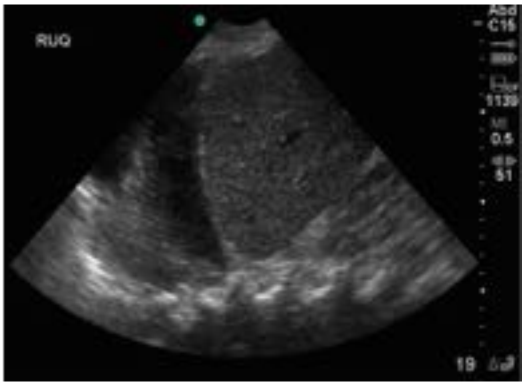


If no (picture on the left) - then move on to exam the thorax and the peritoneum
If yes (picture on the right) - then open the chest and pericardium with a thorocotomy - in the OR if there is time or in the ED if no time

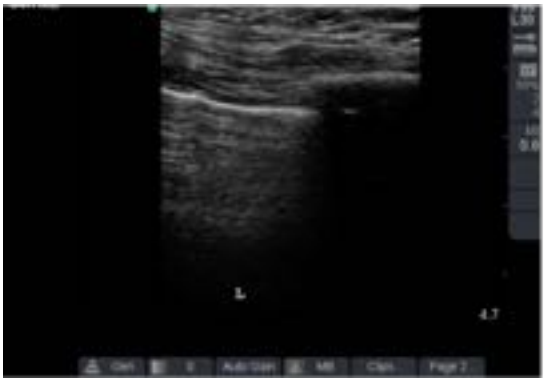
#2 - Is there bleeding in the chest?

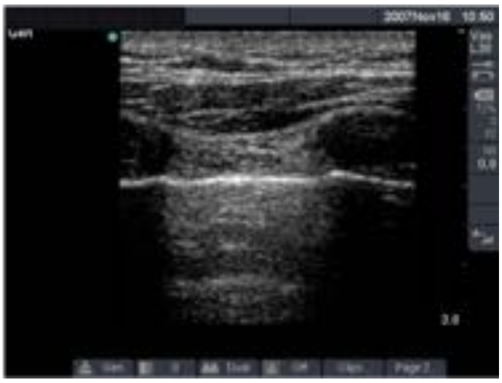
If no (picture on the left) - then move on to exam for pneumothorax and the peritoneum
If yes (picture on the right) - decide if it is significant and needs a tube thorocostomy





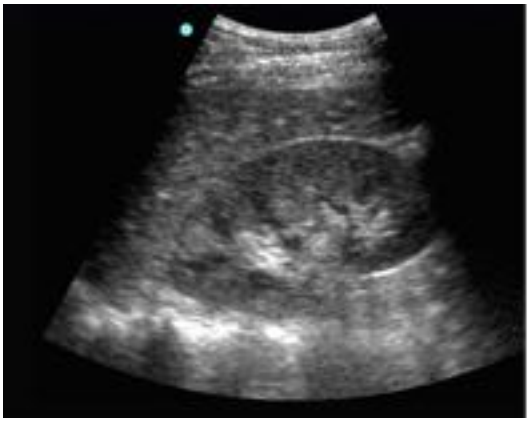
#3 - While we are looking at the thorax is there a pneumothorax?

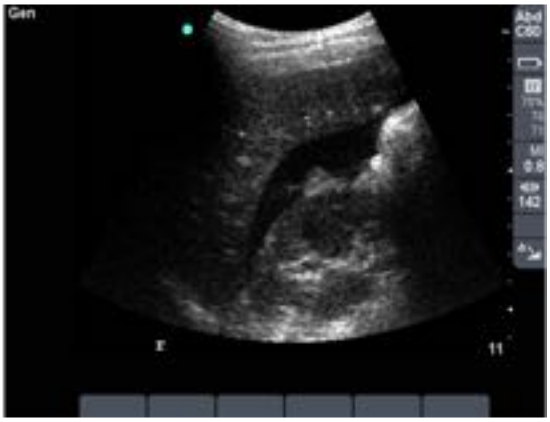




If lung sliding anteriorly in the supine patient (picture on the left) - your patient does not need an emergent chest tube and move on
If lung sliding is not visible anteriorly and there is no lung pulse or blines (picture on the right) then tube thorocostomy and move on.

#4 - Is there bleeding in the abdomen? (MUST look between liver and kidney, around the spleen AND between bladder and rectum/uterus or your sensitivity for hemorrhage goes way down)





If no bleeding in the peritoneum (negative right upper quadrant picture on the left) and patient is still hypotensive, think about spinal shock, myocardial contusion, or precipitating medical illness before trauma

If bleeding is identified (picture on the right), other causes of hypotension (blood in chest or pericardium) are ruled out AND the patient doesn't respond to one liter of volume then think about laparotomy.

Track A2: FOCUS AND CRITICAL CARE ECHO

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ECHOCARDIOGRAPHIC ASSESSMENT OF CARDIAC OUTPUT, PULMONARY ARTERY PRESSURE AND FILLING PRESSURES: HOW RELIABLE?

Echocardiography is the most important imaging modality in cardiology. In addition to providing basic parameters of cardiac morphology and function in enables assessment of many hemodynamic variables, especially by using novel Doppler techniques. In many aspects it has become a non-invasive Swan-Ganz catheter (1).

Cardiac output (CO) can be assessed by using two-(or even three-) dimensional echocardiography and measurement of left ventricular volumes. Two-dimensional echocardiographic volume calculations are based on the biplane method of disks summation which uses bullet-shape assumption of left ventricle geometry. Due to foreshortening of the left ventricle the volumes can be underestimated. The issue of foreshortening is less relevant in 3D data sets. In patients with good image quality, three echocardiographic measurements are accurate and reproducible they do not rely on geometric assumptions (2). If there is no significant mitral or aortic regurgitation CO can then be easily calculated by multiplying the left ventricular stroke volume with the heart rate. Even more often CO is assessed by pulsed Doppler echocardiography and measurement of velocity time integral (VTI) in left ventricular outflow tract. Left ventricular stroke volume is obtained by multiplying VTI and LVOT area that is calculated from its diameter. Both values can be measured easily, but can result in underestimation of stroke volume because the LVOT is usually not circular.

Echocardiography is used to image the effects of pulmonary hypertension on the heart and estimate pulmonary artery pressure (PAP) from continuous wave Doppler measurements. Systolic PAP can be estimated using tricuspid regurgitation velocity, and diastolic PAP can be estimated from the end-diastolic pulmonary regurgitation velocity. Mean PAP can be estimated by the pulmonary artery acceleration time (AT) or derived from the systolic and diastolic pressures. In the echocardiography laboratory, systolic PAP is more commonly measured and reported. Unfortunately, despite the strong correlation of tricuspid regurgitation velocity (TRV) with a tricuspid regurgitation pressure gradient, Doppler derived pressure estimation may be inaccurate in the individual patient. In patients with severe tricuspid regurgitation, TRV may be significantly underestimated and cannot be used to exclude pulmonary hypertension because of an early equalization of right ventricular and atrial pressures (3).

Left ventricular filling pressure can be assessed using different parameters. In patients with depressed ejection fraction (EF) the mitral inflow pattern by itself can be used to estimate filling pressure with reasonable accuracy. Many additional Doppler parameters can be used in specific patterns of early vs. late mitral inflow patterns. The estimation of LV filling pressure in patients with normal EFs is more challenging. In this patient group, the early mitral inflow to early tissue Doppler velocity of mitral annulus (E/e´) ratio should be calculated (4). Both parameters can be easily acquired and are highly reproducible. In early studies the E/e´ ratio has been shown to correlate well with left ventricular filling pressure measured invasively (5,6) and since then has been used as a basic tool for assessment of left ventricular diastolic function. The E/e´ ratio can identify patients with low filling pressure (with the value measured at septal annulus <8) and those with high filling pressure (the value >15). Even different equations for quantitative calculations were derived in different subgroups of patients, such as pulmonary artery wedge pressure = 1.91 + 1.24 E/e´ for patients in sinus rhythm.

Echocardiography without a doubt enables assessment of many hemodynamic parameters. As any echocardiographic result its accuracy is echocardiographer and patient dependent. In difficult to image patients in suboptimal conditions (as many patients in emergency medicine actually are) the reliability of assessment is lower, but skilled echocardiographer can give some information about CO, PAP and filling pressures using integrative approach with combining different echocardiographic modalities and clinical data. Although the result usually is only semiquantitative, in addition to its diagnostic value, it can guide clinical decisions regarding fluid replacement and treatment with inotropes. Being non-invasive and easily bed side performed echocardiography has become an essential tool in emergency and intensive care departments.

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Track A3: POCUS OF THE ABDOMEN

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ULTRASOUND OF ABDOMINAL AORTA AND VISCERAL ARTERIES

The imaging modalities performed to diagnose an aneurysm of abdominal aorta include ultrasound, CT angiography, MR angiography and digital subtraction angiography but a simple US examination of the abdomen is the best way to diagnose an AAA in almost all patients. Ultrasound can reliably image aorta in 99% of subjects, but difficulty visualising the aorta may occur in some cases and this must be recognised (1.2% in the MASS trial). The incidence of false-positive scans is small and of little clinical consequence as they are likely to be detected on surveillance rescanning or confirmatory CT.

There are many limitations concerning the US measurement methods as screening modality, the most important being the imaging plane used. There is evidence to support the utilization of anterioreposterior rather than transverse measurements, since the former has better reproducibility. Aortic diameter can be measured by ultrasound as inner to inner, outer to inner and outer to outer. MASS trial, the largest of the population-based aneurysm screening trials, was based on the measurement of internal aortic diameter. The Viborg aneurysm screening trial and most other screening programmes have used external aortic diameter, and these differences influence the reproducibility of measurements. The recent meta-analyses have shown that inter-observer reproducibility for measurement of AAA with ultrasound is often poor, varying from 1.6 to 7.5 mm. Also, usually there is a gradual size increase of the aneurysm on a series of US examinations, and aneurysm does not decrease in size during the follow-up. The pulsatility of aneurysmal sac and variability of its diameter during the cardiac cycle can be evaluated by using M-mode. Accurate measurement is important because a 5 mm or greater difference in AAA diameter measurement may be relevant for surveillance protocols where strict millimetric criteria are applied to justify an intervention. The management of AAA depends on the size or diameter of the aneurysm and is a balance between the risk of surgery and aneurysmal growth. The general concensus is that the determination of the supra- and infra-renal borders of an AAA, the presence of periaortic disease, and of additional iliac aneurysms is not reliable on ultrasound. The aortic wall protrusion visualized onscreen has a symmetrical or fusiform shape. Occasionally it may be saccular and appears like a bleb or small asymmetrical blister. In case of aortic dissection the diameter of the aorta is usually increased, but not as dramatically as with a true aneurysm. Color and power Doppler imaging can be used to demonstrate the presence of the thrombus inside the enlarged artery and of the patent lumen.

Inflammatory perianeurysmal fibrosis is a rare complication of unknown etiology. By using B-mode imaging of the aorta it is visualized as an hypoechoic and homogeneous soft-tissue mantle that partially or completely surrounds the aorta and may extend bilaterally into soft tissue of retroperitoneal space, but the sensitivity of US is low and CT and MR much better characterize the extent and severity of the inflammatory perianeurysmal fibrosis.

Regarding the role of US in emergency it is well known that the US exam is less sensitive than CT in diagnosing of rupture of an AAA. However in patient with an unstable clinical presentation, an emergency surgical operation is indicated, and only a rapid, portable, non-invasive, fast ultrasound exam of the aorta and iliac arteries is required to confirm the presence of an aneurysms, and if it is possible to recognize fluid collection, hematoma (<5%), AV fistula; to detect the hemoperitoneum or an expanding retroperitoneal hematoma. The rupture into the intraperitoneal or retroperitoneal space is the most important predictor of mortality. The spontaneous rupture can cause an expansion of hematoma into the retroperitoneal space, which can occasionally be visualized by using sonography. The spontaneous or primary dissection of the abdominal aorta, not associated with trauma or with descending thoracic aortic dissection, is a very rare condition and less frequent than true aneurysm. Its prevalence is less than 2%, when compared to that of ascending thoracic aortic dissection (70%), descending thoracic aortic dissection (20%), and dissection of the aortic arch (7%). The aortic dilatation is not always present and the aneurysm develops as a result of a chronic dissection. The Doppler analysis of the aortic branches should differentiate dynamic or static visceral hypoperfusion. Arterial dissection can cause stenosis or occlusion of branches vessels and duplex sonography can provide valuable information about these complications.

The critical aortic stenosis is a possible complication in old patients suffering a diffuse and severe atherosclerotic disease of the abdominal aorta. The critical aortic stenosis caused by severe atherosclerotic disease of the abdominal aorta can evolve toward complete acute aortic occlusion, due to of complete thrombosis, in about 8-12% of cases. Complete obliteration of the aortic biforcation is called Leriche syndrome. The complete thrombosis is potentially dangerous for the risk of cranial progression up to the origin of visceral branches.

Regarding mesentering arterial pathology the most challenging situation is the acute bowel ischemia that is caused by an acute visceral hypoperfusion syndrome. The primary cause is generally the embolic occlusion of SMA, more rarely the thrombosis of SMA or SMV. In 20% of patients a functional cause is identified. Atrial fibrillation or chronic ischemia are present in about 46% of patients. The acute ischemia is characterized by non-specific symptoms and an early diagnosis is required. Interventional procedures can include the use of PTA or stents. In specific clinical situation, like this the color Duplex doppler scanning allows a correct diagnosis of arterial occlusion, avoiding further imaging modalities. The chronic mesenteric ischemia, so called "abdominal angina ", is a relatively rare disease, characterized by post-prandial abdominal pain and weight loss due to chronic atherosclerotic occlusion or stenosis of mesenteric arteries. It is often difficult to demonstrate the relation between vascular occlusion and symptoms, although the occlusion of two visceral arteries represents an indication for endovascular treatment with. The "two-vessel rule" is used in clinical practice for the diagnosis of chronic mesenteric ischemia. The stenosis or occlusion of a single vessel does not usually produce symptoms in light of a patent collateral network. Noninvasive vascular imaging modalities, such as color-duplex US and MRA, are valid tools in detecting of vascular lesions. A systemic atherosclerotic disease, involving both abdominal aorta and its arterial branches, is frequently present in these patients.
Several pitfalls should be considered in the evaluation of the mesenteric arteries. Doppler insonation of the mesenteric vessels can be difficult due to vessel tortuosity and it may not be possible to maintain a constant angle of insonation in these vessels. The median arcuate ligament syndrome is a potential pitfall for celiac artery stenosis, as increased velocities are noted in the celiac artery during expiration. The simple surgical division of the median arcuate ligament may cure the patient and sometimes the revascularization of the celiac axis may also be necessary.

Visceral arterial aneurysms are not frequent, but severe complications can occur, especially after spontaneous rupture. Splenic artery is more frequently involved. They are usually asymptomatic, but spontaneous rupture can cause hypovolemic shock. They are often an occasional finding during US examination, and they appear like dilatation along the arterial course or as hylar or parenchymal cystic formation of the spleen. US examination allows dimensional evaluation of the aneurysm and demonstration of complications.

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CEUS USE IN ABDOMINAL TRAUMA, SEPSIS AND ISCHEMIC DISEASES

Introduction

Contrast enhanced ultrasonography (CEUS) is a quite recent introduced procedure in the routine medical practice. The main application is to detect very subtle modifications in the capillary system. In a way CEUS is complementary to Doppler. The two-ultrasound procedures allow the examiner to evaluate with precision in and outflow vessels (arteries, veins) and also the micro vessels. Micro vessels are the territory where angiogenesis, inflammation and necrosis occur so exploration of this area is very important in some specific circumstances.

Theoretical considerations

CEUS is based on injection into a peripheral vein of a small amount (1,2 – 1,6 cmc) of contrast ultrasound specific agent (in Europe the accepted product is SonoVue produced by Bracco, Italy; some other substances are also available in Japan, China etc.). When exposed to a low mechanical index ultrasound beam, the microbbubles of gas that compose the substance resonate and produce harmonic echoes which are the basis of the harmonic ultrasound image. The procedure of evaluation is continuous and real time, the total duration of the examination being around 5 minutes. So there will be enough time for the examiner to evaluate a process of penetration (arterial phase), distribution into the capillary network and leave of the vascular bed (venous phase). Liver and spleen present a supplementary phase – called tissular or late (> 2 minutes) because of a capture of the contrast agent in reticulo hystiocitar tissue. There is a similitude between the phases of transit of the contrast agent in computer tomography with contrast and CEUS. The great advantage of CEUS is high temporal and spatial resolution; lack of toxicity of the substance (because of rare number of sulph allergy and small amount of substance injected in blood flow); metabolisation of the substance in liver and evacuation of the gas through the lungs that makes the procedure kidney function independent. The CEUS can be applied to patients in very critical status and kidney dysfunction. The disadvantage of the procedure is related to the cost, complexity of the ultrasound machine, operator experience and need to focus on only one region of interest. The main applications are ischemia, congestion, necrosis, and laceration of parenchyma.

CEUS in trauma. In traumatic patients with laceration, CEUS is very sensitive for detection of small area of parenchyma damaged. Indications of CEUS are related to small trauma when computer tomography is no indicated. In arterial phase the very typical pattern is that of lack of enhancement secondary to devascularisation, ischemia and thrombosis. Very clear indications of the procedure are spleen trauma (in order to detect small laceration, subscapular hematomas or rupture of the spleen) but also liver, kidney or pancreas fractures (fig. 1 – Liver laceration after sever abdominal trauma) (fig.3 – Spleen subscapular hematoma after trauma of the abdomen).

CEUS in sepsis. The principles of CEUS diagnosis are similar to those from computer tomography: there will be inflammations around the septic cavity that enhances very early in the arterial phase. This very typical sign is useful for the diagnosis. The procedure is useful for detection and characterization of liver and spleen abscesses. Small and unapparent abscesses in grey scale ultrasonography can be easy detected with CEUS (fig. 3 – Liver abscess).

CEUS in ischemic diseases. CEUS is very sensitive to harmonics from blood flow. The rule is: "presence of signals = presence of blood flow". When there is no signal there will be a certification of ischemia of infarction of the tissue. The procedure is indicated whenever there is suspicion of necrosis the only condition to be achieved is to have a good acoustic window and a good quality grey scale picture (fig. 4 – Spleen infarcts).

Conclusion

CEUS is a complementary procedure to Doppler evaluation in order to detect vascular disturbances like inflammation, ischemia, necrosis, and laceration of different organs of the abdomen.

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ULTRASOUND GUIDED INTERVENTIONS IN ABDOMEN

Interventional US has been successfully used in several medical specialties for more than three decades.

Technical development enabled its more accurate diagnostic value and safer therapeutic use.

US is one of the best imaging modalities for detecting free abdominal fluid and often can also characterize it. Interventional US can be a useful and simple tool for safe aspiration of the fluid and determination of its nature – transudate, exudate, blood or other possibilities after surgery and trauma.

Us-guided biopsies are used in diffuse or focal lesions of the solid abdominal organs like liver, pancreas, spleen, kidneys, adrenal glands and lymph nodes as well as other intraabdominal masses to obtain material for cytologic or hystologic analysis.

Interventional US is a technique used in drainage of abscesses, gallbladder empyemas, pancreatic pseudocysts, dilated renal collectig system, sclerotherapy of the cysts, percutaneous biliary drainage and ablations of tumors (PEI, RFA…). In all the cases, it is essential that the targets are clearly visible by US and accesible by the needle.

Recently, we are able to improve and ease US-guided interventions using contrast-enhanced US and volume navigation with fusion US.

For all the planned US-guided interventions patients should be adequately prepared (informed consent, cooperation, coagulation tests…).

The operator should be experienced and aware of the possible complications: bleeding, perforations, infection and malignant cells spread…

Good postprocedural care and diagnostic follow-up is important to avoid the complications or to diagnose and treat them in time.

Track A4: POCUS IN THE ICU

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"Ultrasound is not harmful, only decisions based on it could be!"

INTERVENTIONAL ULTRASOUND IN THE INTENSIVE CARE UNIT

Introduction

There is a frequent need for invasive procedures in critically ill patients. When performed with the aid of ultrasound, they are more precise and safer. Some procedures can be done at the bedside exclusively under ultrasound guidance. Ultrasound provides insight into anatomical structures and visualisation of the target.

One of the prerequisites for a successful ultrasound-guided puncture is a correct three-dimensional understanding of tissue structures. Proper probe orientation and understanding of the two dimensional orientation of the obtained image on the screen is important for a safe action. In general, it is recommended that the orienetation of the image on the screen be of the same orientation as the field in front of the operator. Probe movement and serial two dimensional scanning allow for understanding the third dimension of the tissue structure. Customary probe movements include gliding, tilting and rotation to define the target and surrounded structures, after which the optimal crossection and the most suitable route toward the target can be defined.

For some interventions, it is enough to perform an ultrasound examination for spatial orientation, after which the procedure is performed blindly using anatomical landmarks on the surface. This is called ultrasound assisted intervention. Ultrasound-guided interventions require simultaneous ultrasound scanning of the target while introducing the needle. This can be performed using the out-of-plane technique in which the needle's path toward the target is not followed or with in-plane techniques where the needle passes through the tissue toward the target in the same plane as is the ultrasound beam's plane. This provides direct permanent visualisation of the needle on its way through the tissues. After having chosen the most suitable cross-section, the probe must be held still and the needle should be controlled to stay within the ultrasound beam's plane, monitoring the needle's path closely on the screen. It is important to note that needle visualisation will be lost upon exiting the ultrasound beam's plane. Keeping the needle in the same plane as the probe requires precise coordination and spatial orientation. Needle guides attached to the probe, or specially formed puncture probes, somewhat reduce this problem, but can have other limitations.

Although metal has signifficantly different accoustic properties than tissue and is a strong reflector, it is not always easy to precisely discern a smooth needle in the display monitor, depending on characteristics of the surrounding tissue, needle characteristics and angle in relation to the ultrasound beams. Sometimes it is easier to estimate the position of the needle by following the tissue movements caused by its advancement. Very small forward and backward movements of the needle will cause tiny movements of the surrounding tissue which will enable the examiner to estimate the needle's position. High frequency probes can identify the characteristic shape of the needle tip, which should be recognised and followed on the screen during insertion. Some needles have special rough surfaces near their tips to increase ultrasound scattering, which enhances needle tip visualisation. Some ultrasound devices also have software which enhances needle visualization. By making measurements of the distance from the surface to the target prior to the incision, additional confidence can be obtained.

All such procedures should be done according to the principles of asepsis. A sterile field is maintained by placing the ultrasound probe in an impermeable sterile sheath. A contact medium inside the sheet is required. In the instance that more appropriate sheets are missing, sterile rubber gloves can be used, but there will be a higher risk of contamination by an unprotected cable. Wireless probes can be more practical. Many operators use sterile gel as a contact agent. Sterile water, saline solution or a disinfectant that was used for final skin disinfection, e.g. chlorhexidine solution, can be used as a contact agent, too. These types of agensts are not as slippery as gel, so it is easier to fix the probe in place once the optimal probe position is defined. Liquid contact medium that evaporates should be repeatedly added during the procedure. Disinfectants used as contact media can damage some ultrasound probes, but using a cover sheet eliminates this potential problem.

Ultrasound guided blood vessel punctures

One of the most common procedures in ICU is placement of intravascular devices such as central or peripheral venous catheters. The visualisation of blood vessels by ultrasound can facilitate these procedures.

While placing central venous catheters, a variety of mechanical complications can occur: pneumothorax, nerve injuries, artery punctures with haemorrhage, catheter malposition, etc. The frequency of mechanical complications depends on the experience of the person inserting the catheter. Rates of mechanical complication as high as 10% to 12% were reported when the procedures were done blindly (1, 2, 3, 4, 5). Anatomical variations, disturbances of anatomical relations, narrow vein caliber, vein thrombosis, and other circumstances can be the cause of failure. The risk of mechanical complications rises with the number of vein puncture attempts, which can be reduced by ultrasound guidance.

The placement of central venous catheters under ultrasound guidance is safer and more precise than when done blindly, using the landmark technique (6, 7, and 8). This particularly refers to placements of central venous catheters using the jugular approach (9, 10, 11, 12, 13, 14, 15, 16, 17, and 18). Ultrasound provides vein identification, vein position and dimensions, vein patency i.e. exclusion of thrombosis, and gives insight into its relation to the adjacent structures, such as the accompanying artery. Orientational ultrasound examination should be performed before field disinfection after which the most suitable vein is chosen.

Flowing blood has no acoustic echo and, therefore, vessels are shown on screen as anechogenic black areas. By probe compression, veins collapse while arteries do not. In the case of venous thrombosis, due to thrombus echogenicity, a greyish content in the vein is demonstrated on the screen. Thrombotic veins do not collapse after applied pressure by the probe. Compression tests should be used carefully in order not to cause an embolism.

It is important to emphasise that during the examination, the probe pressure has to be very mild, just sufficient enough to maintain contact between the probe and contact medium on the skin. Higher pressure can compress the veins, preventing them from being identified, particularly if they are superficial ones.

The internal jugular vein is usually located laterally from the carotid artery, but anatomical variations exist when the vein is located in front or even medially from the artery (19, 20, 21). Usually the right jugular vein has a wider lumen than the left one, but it can also be the other way around. In about 23% of cases, the jugular vein has a transverse section of less than 0.4 cm2 (22).

The subclavian vein is somewhat more difficult to demonstrate throughout its complete length due to its flow underneath the clavicle. Therefore the axillary vein or the peripheral part of the subclavian vein is usually chosen for catheter placement under direct ultrasound visualisation (23).

Placement of central venous catheters in the femoral vein is a last resort due to the high frequency of infectious complications, even though in some situations it can be an important site, e.g. in performing cardiopulmonary resuscitation procedures (24). Usually, the femoral vein is located medially from the femoral artery, but there are also anatomical variations, and in 12% of cases it is partially or completely behind the artery (25).

Placement of central venous catheters under direct visualisation by ultrasound increases the accuracy and efficacy of the procedure. The procedure can be done by one person holding a probe in one hand and a needle attached to the syringe in the other, or it can be done by two people, where one person holds the probe and the other inserts the catheter. Since these procedures have to be performed under aseptic principles, the probe has to be put in a sterile impermeable sheath.

In general, two methods of ultrasound-guided intravascular device placement are used. One is when a transverse vessel cross-section is chosen, and the other is when the visualisation of the longitudinal section of the vessel is used.

In the out-of-plane method, the image of the transversal vessel section has to be placed in the middle of the screen; therefore, the vessel has to be situated precisely underneath the centre of the ultrasound probe. After estimating its depth, the vessel is targeted by a needle underneath the centre of the probe at an angle that allows the needle point to meet the vessel immediately whenthe plane of ultrasound beams is reached. Usually, it is best to choose an angle of 45o and start the skin puncture at the same distance from the centre of the probe as is the vessel's depth under the skin. Therefore, in this method we cannot follow the passage of the needle through the tissue at all times, but the entry of the needle point in the blood vessel will be seen if the depth angle and direction are correctly chosen.

This method is simple to learn. It provides identification of the vein position and it helps in choosing the proper needle direction. The screen has to be placed in front of the person inserting the catheter. Correct probe orientation is necessary so that all anatomical structures correspond in orientation to their picture on the screen. The probe should stay still, fixed on the skin by the fingers of the nondominant hand that is holding the probe. When the needle tip crosses the ultrasound beam's plane and appears on the screen, small corrections in the direction of the needle can be performed, if required. At the moment when the entry of the needle tip into the blood vessel lumen is shown, blood enters the syringe by aspiration. This method is considered the method of choice for jugular vein puncture, particularly for those less skilful in ultrasound use (26), and it is recommended for femoral vein or artery puncture, too. Again, it should be stressed that the disadvantage of this method is that the needle cannot be tracked through the initial stages of the procedure.

A modification of this out-of-plane method provides more control while the needle is passing through the tissue on its way toward the target. This method requires occasional tilting of the probe for the beams to reach the needle tip and see it on the screen while is still on the way. Gradual progression of the needle is controlled by occasional tilting of the probe.

Catheter placement with a longitudinal blood vessel image which enables permanent needle visualisation along its way through the tissue is called the in-plane technique. It does, however, require a certain amount of skill and coordination. First, an adequate image of the longitudinal vessel section is obtained and then the probe is held still at that position. The skin is entered with the needle close to the ultrasound probe at the same plane as is the ultrasound beam. The needle's path should be followed on the screen throughout the procedure. While advancing the needle through the tissue, it is important to maintain it within the ultrasound beam's plane. If the needle strays away from the ultrasound beam's plane, the tip cannot be seen and control is lost. This method could be particularly favored for subclavian i.e axillary vein cannulations.

After having placed the catheter or guide wire, its position in the blood vessel can be checked by ultrasound. Pneumothorax can be excluded by demonstrating lung sliding in the second intercostal space in a patient in the supine position.

The same techniqes are used for the percutaneous insertion of electrostimulator electrodes. Similar principles are valid also for the introduction of peripheral arterial or venous catheters.

Pleural effusion evacuation with the aid of the ultrasound

Ultrasound is superior to the chest x-ray in the diagnosis of pleural effusions and can precisely detect even small amounts of fluid in the chest (27). It is also more specific.

A pleural effusion is shown on ultrasound as anechogenous or hypoechogenous content in the chest (28). Complex effusion with echoes, septated or homogenous, is always exudate, while anehogenous effusion could be exudate or transudate (29, 30).

With the aid of ultrasound, the precise punctures of small pleural effusions to collect samples for analysis can be done safely. In the case of a larger amount of pleural effusion, ultrasound helps in choosing the most suitable intercostal space and enables higher safety and efficacy by minimizing the risk of complications (31).

Direct visualisation of the needle is usually not necessary. Eventual measurements of the thoracic wall thickness could be welcomed. The site of the puncture is always along the upper rib edge. The most suitable intercostal space for a puncture is the one which is sufficiently low for successful evacuation of the effusion and is sufficiently high above the bottom of the phrenicocostal sinus that there is no risk of liver or spleen lesion. During punctures of small effusions, the patient has to hold his/her breath. It is best to perform the puncture in a patient who is sitting, but with the aid of ultrasound, safe punctures are also possible in supine mechanically ventilated patients (32).

In the majority of patients with an anechoic effusion, it is possible to make a single evacuation with a thin cannula. A green intravenous cannula of 18 G (1.2 mm) has a sufficient diameter in the majority of cases, but those of 14 G (2.0 mm) can also be used. After skin disinfection at the site of the puncture, we progress with the cannula until we enter into the pleural space. This is felt as a loss of resistance.

Puncturing too deeply is also avoided by simultaneous aspiration by the attached syringe so that the fluid enters the syringe at the moment when the cannula enters the pleural space. Naturally, the patient must cooperate by remaining still throughout the procedure. Finally, when we are in the pleural space, the metal needle is taken out and only the plastic cannula is left. The plastic cannula is then attached to a closed system for effusion suction. The tip of the plastic cannula will not damage the lungs when the effusion is removed because the lungs are brought closer to the thoracic wall. Care should be taken that the plastic cannula is not moved or bent while the evacuation is taking place. If there is a stop during suction, it could be that the visceral pleura is temporarily leaning on the tip of the plastic cannula and after release of the negative pressure, it has to be withdrawn approximately a couple of milimetres in order to completely evacuate the effusion. In our experiencee, smooth introduction of a green intravenos cannula is less painful than the application of a local anesthetic, so we avoid local anesthesia in cooperative patients for such procedures. This was tested on several of our patients who needed serial pleural punctures and after experiencing procedures with and without local anesthesia, they preferred procedures without local instillation of an anaesthetic agent prior to the pleural tapping. By using ultrasound and plastic cannulas instead of needles, we have never once experienced pneumothorax or significant bleeding as complications of thousands of pleural tapping in the last 25 years, even though the procedure was often performed by completely inexperienced medical students under close senior supervision.

In some cases, it is more efficient to use a thin catheter, as in mechanically ventilated patients who can not sit, in whom the lateral and dorsal approach in the patient's supine position in the bed requires passage through the muscle latissimus dorsi. A thin cannula is usually insuficient for this approach and can easily bend. A catheter intended for central venous catheterisation can also be used (33). An image of a dense effusion with fibrinous septa indicates an inflammatory process, which causes uncertainty that the evacuation of the effusion with a thin cannula will be completely successful, and the need for wider drainage equipment should be taken into consideration. Intracavital instillation of the fibrinolytic agent in selected patients can significantly improve the drainage of organized collections and the risk of potential side effects does not seem to be high.

With ultrasound guidance, a pig-tail catheter can be placed in the pleural space using Seldinger's method or a thoracic drain with the help of a trocar (34). Naturally, for all these procedures, it is necessary to anesthesize the skin, subcutaneous tissue, and the pleura at the site of the drain placement. A surgical method of placement of a thoracic drainage in the mid axilliary line does not necessarily require use of ultrasound, but a preprocedural ultrasound examination can be welcomed.

Pneumothorax evacuation

In well ventilated lungs, the ultrasound reflection from the air in superficial alveoli sliding underneath the parietal pleura caused by the action of diaphragma can be shown. This is called "lung sliding sign". In pneumothorax, the layer of free air between the parietal and visceral pleura reflects the ultrasound waves and, as a result, no lung sliding can be seen (35). Usually it is possible to demonstrate the pneumothorax border, the line where visceral pleura starts to be separated from parietal by a free air layer. When crossed by the ultrasound beam's plane, the point which separates the part of the pleural line with and without lung sliding is called the "lung point", which is certain proof of pneumothorax (36, 37, 38). In this way, it is possible to determine the borders of the pnemothorax and with the aid of ultrasound, urgent drainage can be made safer (28, 39). One must be conscious that the depth of the free air layer cannot be determined by ultrasound, but can be estimated according to the position of the lung point.

A small pneumothorax which does not compromise the condition of the patient should only be observed (40). If the pneumothorax is clinically significant, urgent evacuation should be performed. In a patient in the supine position, the cannula is inserted into the pleural space through the second intercostal space in the midclavicular line, passing along the cranial rib edge. It is possible to turn the patient on his/her side and place drain laterally in the midaxillary line on the highest part according to the ground, where the greatest amount of free air is expected. Frequently, in a large tension pneumothorax, air will come out from the chest by itself under pressure. Further evacuation can then be accomplished by using a large syringe or suction equipment. A soft plastic cannula can be used, but it is usually better to place a small bore chest tube. The drain should be attached to negative pressure or a Heimlich's valve. Drainage with a large bore thoracic tube is rarely needed in patients with pneumothorax in medical ICU.

Pericardiocenthesis

The indications for pericardiocentesis are pericardial tamponade and/or the need to obtain an effusion sample for determining the effusion aetiology (41, 42, 43, 44, 45).

Pericardial tamponade is a condition where there is an accumulation of pericardial effusion under pressure, which leads to compression of cardiac chambers and reduced filling of the right side of the heart. It can be a life-threatening condition which requires an urgent effusion evacuation.

In addition to the effusion quantity, the time in which the effusion accumulates is important since the pericardial sac cannot dilate rapidly. With the gradual filling of the pericardial sac, the pericardium will stretch from day to day, therefore, the pressure in the pericardial sac will be lower and circulatory compromise will be less pronouced.

The impeding effects on circulation will be manifested by dyspnoea, tachypnea, hypotension, and the development of shock.

Ultrasound usually shows a thicker layer of pericardial effusion unless the tamponade has occurred very rapidly. A "swinging heart" can be seen within the effusion, particularly during inspiration. At the moment when the pressure in the pericardial sac is greater than the pressure in the cardiac chambers, they collapse, especially those on the right side of the heart due to a thinner wall. The collapse of the right atrium occurs at the end of diastole when the pressure in the atrium is the lowest and the pressure in pericardium is the highest. If it lasts longer than 1/3 of the cardiac cycle, it is a highly sensitive and specific sign of tamponade (46). The collapse of the right ventricle occurs in the first phase of diastole when the pressure in the ventricle is at its lowest. It is less sensitive, but a very specific sign (47, 48). The collapse of the left atrium occurs in about 25% of cases and is very specific. The collapse of the left ventricle occurs very rarely. In patients with tamponade, one can also find a dilated inferior vena cava which minimaly changes its diameter with breathing.

In the past, pericardiocentesis was carried out blindly or in conjunction with fluoroscopy. The needle was inserted from the epigastrium, in the area between the left costal arc and xiphoid process, towards the left shoulder at a 60o degree angle. Thanks to ultrasound, now it is possible to check other more suitable puncture sites using the intercostal approach, to determine if the path to the pericardium is shorter and safer. Contact with the tip of the needle and the heart should be avoided, though the puncture of a ventricle by the needle usually does not lead to significant problems. However, a laceration of a coronary artery is dangerous. A thickness of the effusion layer of 1 cm or more can be considered a precondition for a safe puncture and this estimate has to be brought individually depending on the patient's condition, weighing possible risks and benefits.

If the epigastrial approach is chosen, the patient has to be in a semi-sitting position. The patient has to be monitored and venous access has to be ensured. An ultrasound examination is performed which gives us the basic orientation. The ultrasound probe is directed from the epigastrium towards the heart. The best path is determined by locating where the effusion thickness is sufficient enough not to risk heart injury. Usually, the path chosen corresponds to the classical guidelines for blind punctures. Then, the skin is disinfected and the ultrasound probe is placed into a sterile sheath in order to verify the path that has to be followed. This is done immediately before introduction of the needle. Local anesthesia should be applied before the procedure. The distance to the effusion has to be measured. To do this accurately, pressure should be applied with the probe on the skin which should mimic the pressure of fingers applied during the puncture. Then, the probe is removed from the site and a needle with an attached syringe is placed in the chosen direction and is advanced towards the effusion while simultaneously performing aspiration. After the pericardial content enters into the syringe by aspiration, needle advancement should stop. It is possible that small tissue particles may block the needle. Therefore, it is good to take some saline solution in the syringe and when the needle tip is close to the effusion, we can rinse the needle by spraying a small amount. Needles with a plastic sheath can be used. The sheath can serve for catheter insertion or can be used as a catheter. One has to keep in mind that the plastic sheath is a few millimetres shorter than the needle. Therefore, after obtaining the content by aspiration, the needle has to be pushed a little bit deeper, which can be unpleasant and potentially dangerous if the layer of pericardial effusion is thin. It is safer for the plastic sheath to pushed further over the needle. Seldinger's technique to introduce a catheter over a guidewire could also be used. For checking the catheter tip position by ultrasound, the image of the catheder's tip is more easily located by spraying saline through the catheter which will be seen as tiny bubbles in the area around the catheter tip.

The intercostal approach can be used after chosing the best place for insertion and later the procedure can be performed blindly progressing with the cannula by careful aspirations. In the parasternal approach, care should be taken not to damage the mammary artery which can be identified by detailed ultrasound examination. An alternative way is insertion of the catheter by the in-plane method using a high frequency probe located in the intercostal space. By direct visualisation of the needle, entering under the angle, optimal control of the procedure can be achieved. Introduction of the needle not perpendicular to the heart but under the angle results in better needle visualization, more space for needle insertion and less angulation of the guide wire and catheter.

In patients with a haemodynamically significant effusion, a dramatic improvement in the condition usually occurs after pericardiocentesis with the disappearance of dyspnoea and recovery of haemodynamic parameters. Depending upon the etiology of the effusion, the catheter is usually left for some time, normally 24-48 hours, sometimes longer, until the daily effusion production is less than 25 ml/24 hours. Frequent catheter rinsing by saline is sometimes important for maintaining its patency.

Abscesses drainage

The diagnosis of the source of sepsis in the critically ill is essential for their survival. Pus accumulation anywhere in the body requires evacuation. In such situations, bedside ultrasound can be very helpful (49, 50, 51).

The infected accumulated fluid can be diagnosed by ultrasound and evacuated by placing a percutaneous drainage with the aid of ultrasound (52, 53).

The accumulations of fluid can be seen as an anechogenous or hypoechogenous area. Abscesses most frequently look like hypoechogenous or anechogenous areas and can be of various sizes and shapes. Abscesses can be located in parenhimal organs, can be interintestinal, located in retroperitoneal space, in the abdominal wall or elswere in the body.

With the aid of ultrasound, free abdominal fluid can be obtained by passing through the abdominal wall at any place where it is found to be suitable. Care should be taken to avoid the epigastric artery which can be identified and located by ultrasound (51). Usually the largest amount of free peritoneal fluid is found on the classical site for paracenthesis, which is on the first third of the line between the left anterior superior iliac crest and the umbilicus.

Clinical picture and morphologic characteristics of fluid collection can suggest whether that collection is suppurative or not, but for final diagnosis, a sample of fluid should be obtained under ultrasound guidance. A thin needle puncture for obtaining the fluid sample is not risky and the passage through the gut is made possible without significant risk of complications.

For the placement of a percutaneous drainage catheter by ultrasound, a safe access point near the abscess has to be chosen. The needle and drain have to avoid the gut. When possible, percutaneous drainage is the method of choice for pus evacuation, which in some patients can lead to complete recovery and in other patients will lead to sufficient improvement to facilitate further surgical procedures (54).

Before the procedure, the area where the catheter will pass has to be anaesthetised with a local anaesthetic. Rarely, the procedure requires general anaesthesia. The catheter is inserted under direct ultrasound guidance following the needle all the way through the tissues to the target. Guides attached to the probe, which keep the needle in the ultrasound beam's plane, can be helpful but also clumsy. Most frequently, Seldinger's method of catheter placement is used. After obtaining pus, a guide wire is inserted through the needle. Before catheter insertion, the channel is dilated with a dilator via the guide wire, so that the drainage catheter can finally be inserted. Catheters can be of the pig tail or basket type. Liquid pus can be successfully evacuated by catheters 10 Fr or narrower, while wider ones, about 14 Fr, should be used for more dense abscess content. After checking the position, the catheter should be fastened to the skin and spontaneous drainage in a closed system with a sac should be enabled. Connection of the catheter to a suction system with negative pressure could facilitate drainage.

Multilocular collections, abundant deposit, and infected necrosis are the most frequent reasons that percutaneous drainage is sometimes not sufficient for a definite cure. Intracavital application of a fybrinolytic agent can provide better drainage.

In acute pancreatitis, there is a frequent concern whether the nectrotic tissue is infected or not. Microbiological analysis of the content obtained by a thin needle puncture is crucial. Proof of infected necrosis means that surgical intervention is necessary, though percutaneous drainage should also be taken into account. Intestinal paresis and meteorism somewhat compromise the ultrasound examination in acute pancreatitis because strong ultrasound reflection from gas in the bowels results in no ultrasound reaching deeper structures, creating a so-called "ultrasound shadow". It is for this reason that CT is a superior diagnostic tool for retroperitoneal analysis in patients with acute pancreatitis, which, with the use of contrast, can more reliably discern necrotic from viable tissue. CT guided punctures are also considered more reliable. Apart from that, the failure of percutaneous management of pancreatic abscesses is not rare (55). In a significant number of cases, infected pseudocysts can be treated by percutaneous drainage. For definitive treatment of large pseudocysts, permanent drainage is necessary, performed endoscopically or surgically.

Abscesses of parenchymatous organs, particularly liver abscesses, can be seen well by ultrasound (Figure 4). Ultrasound-guided percutaneous drainage of liver abscesses through parenchyma is the method of choice along with antimicrobial treatment, while smaller abscesses need only be punctured by needle and the pus is evacuated (56, 57, 58, 59). Kidney abscesses can be also drained percutaneously, but they usually respond well to antimicrobial therapy.

Drainages of obstructed kidneys

It is important to ensure urine derivation from a blocked kidney, particularly if an infection has developed which can lead to life-threatening sepsis. One of the methods is placement of ultrasound-guided percutaneous nephrostomy. Usually Seldinger's method is used. With direct ultrasound visusalisation, the needle is followed by ultrasound through the subcutaneous tissue, muscle, and through the kidney parenchyma to the dilated pylon. The guide wire is introduced into the pylon through the needle, and then the dilator and finally a "pig-tail" catheter are placed.

Organ biopsies

Sometimes, in order to establish an exact diagnosis, an organ biopsy must be performed. Liver and kidney biopsies can be performed using an automated spring-loaded biopsy device and specially constructed needles. While performing kidney biopsies, ultrasound control enables the safe arrival of the needle tip to the lower pole of the kidney (usually the left one). After pressing the button, the needle runs into the kidney parenchyma and a cylinder of tissue is obtained (60, 61). Direct visualisation is not necessary for liver biopsies, but it best to do an ultrasound orientation baseline before the biopsy to define the most appropriate entry site and avoid large vessels. Core biopsy of lymphonodes on various sites can be performed under direct ultrasound guidance.

Airway management

Endotracheal intubation can be facilitated by ultrasound. Prandial status can be checked before the procedure to avoid aspiration. Measurements of tracheal diameter particularly in pediatric patients can help in the selection of the apropriate tube size (62). The intubation can be monitored by locating the ultrasound probe across the left side of the neck, by visualising the oesophagus. In the case of oesophageal intubation, a hyperechoic reflection appears in the oesophagus and a picture of "double trachea" can be seen. This is particularly useful in circumstances of cardiopulmonary resuscitation, because the determination of the tube position by a stethoscope can compromise chest compressions for a significant amount of time. Lung sliding demonstrated on both sides after the intubation proves that both lungs are ventilated.

Tracheostomy can be facilitated by ultrasound. It can help in recognition of tracheal rings to prevent cranial misplacement and can identify blood vessels which should be avoided during the procedure. In case there is a changed anatomy of the neck, e.g. due to haematoma or other causes, ultrasound can help locate the trache and find the optimal site for tracheostomy placement (62, 63).

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"Ultrasound is not harmful, only decisions based on it could be!"

ETIOLOGY OF ACUTE RESPIRATORY FAILURE IN THE ICU: IS POINT OF CARE ULTRASOUND ENOUGH?

Today ultrasound is a valuable tool in the recognition of the cause of respiratory failure. Based mainly on the scientific contributions of Daniel Lichtenstein, lung ultrasound became an important field of ultrasound application (1,2,3,4,5). By integrating the principles of lung ultrasound into the clinical algorithm called BLUE protocol (Bedside Lung Ultrasound in Emergerency), quick, efficient, reliable, and bedside-available information on the ethiology of acute respiratory failure can be obtained (6). The specificity of BLUE protocol to stratify patients according to the etiology of acute respiratory failure is around 90%.

Using ultrasound, it is possible to recognise or exclude states with excessive extravascular lung water so respiratory failure with "dry" or "wet" lungs can be distinguished (1,2,7,8,9,10,11). By some ultrasonographic characteristic hydrostatic cardiogenic lung edema can be distinguished from inflammatory lung edema in ARDS (12). For the diagnosis of cardiogenic lung edema, ultrasound has sensitivity of 97% and specificity of 95% (6). In combination with N-ProBNP, it rises to almost 100% (11). Excess of extravascular water can be estimated regionally as interstitial, interstitial/alveolar or lung consolidation (1,2,14). Thus pneumonia and ARDS can be followed up and response to the treatment estimated semiquantitatively (15). Serial lung ultrasound in the follow up of patients with ARDS can dramatically reduce the need for repetitive chest X-rays and CT scans. Lung ultrasound is almost as valuable as CT in patients with ARDS (16,17). Alveolar recruitment can be estimated semiquantitatively by lung ultrasound (15,18,19).

Respiratory failure with no excess of extravascular lung water is often caused by pulmonary embolism or exacerbation of COPD or asthma. A lines profile with present lung sliding is the usual lung ultrasound finding. Detection of signs of vein thrombosis, at least the rest of thrombie in the calf veins after the main mass of thrombus was transferred by blood flow into the pulmonary arteries, dramatically rises the probability of lung embolysm in a dyspnoic patient. Sensitivity of ultrasound to diagnose lung embolysm following BLUE protocol is 81% and specificity is 99% (6). CT angiography today is a golden standard in the diagnosis of pulmonary embolism. In some cases, when a clinical condition is not raising additional questions and there is no need for eventual fibrinolytic treatment, a diagnosis of significant deep venous thrombosis is sufficient for the institution of anticoagulant treatment. In such cases, documentation of lung embolism by CT angiography will not change the therapeutic option, and it is questionable whether or not one should search for it. Rather, the diagnosis of suspected lung embolism should be based on clinical data and ultrasound. Signs of acute right ventricular overload detected by ultrasound additionaly support the diagnosis of lung embolysm.

In the case of pneumothorax, free air is interposed between the parietal and visceral pleura so that the lung sliding normally seen by breathing is missing (3,20,21,22,23). Reverberations caused by reflection of the ultrasound from the free air under the parietal pleura and the ultrasound probe generate A lines pattern and no B lines can be seen there (13). Demonstration of the border of the pneumothorax, by showing the "lung point" which separates the side of the pleural line with lung sliding from the side with abolished lung sliding confirms the diagnosis of pneumothorax with 100% reliability (4). The depth of the free air layer cannot be measured directly by ultrasound, but the amount of free air can be estimated by the dislocation of the lung point. If the patient is unstable due to pneumothorax, then the amount of free air is significant so the percutaneous chest drainage can be performed safely. Ultrasound is superior than a chest X-ray, particularly if supine anterior chest X-ray performed in bed is an option (24,25,26). There is no need to do a chest CT scan in searching for pneumothorax. If there is enough time, clinically significant pneumothorax can be documented by chest X-ray, in addition to ultrasound, prior to the invasive procedure.

Ultrasound is powerful in the detection of pleural effusions. It is superior to chest X-rays, showing higher sensitivity and specificity, and it is almost of the same power as is CT (27). Ultrasound can be used alone to establish the indication and to perform the pleural puncture or drainage. In our experience, both ultrasound-assisted pleural puncture and drainage are safe procedures with no complications.

In medicine, we work with probabilities, and a single diagnostic method is rarely 100% powerful, usually only contributing with some certainty to the mosaic of the clinical picture. Interpretation often depends on the clinical presentation. A good indication for the diagnostic investigation is when the treatment will depend on its result. Balance between the potential benefit of a diagnostic test should be judged against its harm, cost and time. Complementary diagnostic methods raise the certainty of the information and should be added before important decisions about potentially risky treatments are considered. In the ICU, some decisions are of vital importance, so they must be well founded. Surprisingly, in the most severe critical cases, risky procedures are often founded on basic investigations. This is the case when there is no time or condition for additional investigations but the decision must be based on point-of-care available data. Examples are the fibrinolytic treatment in near fatal cases of pulmonary embolysm, or life threatening pneumothorax or pericardial effusion when immediate drainage is a lifesaving procedure.

The advantages of ultrasound in comparison to CT are that is bedside available and has no irradiation exposure. Irradiation exposure from chest X-rays is of minor importance, but the need for routine daily chest X-rays in the ICU is obsolete if ultrasound is available. The amount of CT irradiation exposure is significant and should be avoided whenever possible (28). The use of ultrasound reduces the need for radiologic investigations in ICU patients (29,30).

One of the disadvantages of ultrasound in comparison to radiology imaging modalities is that its documentation is less valuable evidence when legal questions arise. X-ray and CT scans keep all information stored on the image so that it can be reevaluated independently, if need be, which is not in the case with ultrasound. More standardisation of ultrasound examinations and reporting is required to somewhat improve this weak side of ultrasound. The implementation of standardised ultrasound courses and the release of international recommendations were the first steps in this process (27,31).

In conclusion, ultrasound can provide important information in dyspnoic patients and can contribute in clarification of the ethiology of respiratory failure. The decision to use ultrasound as a definitive diagnostic procedure must be made on an individual basis, depending on the particular patient and situation. Because ultrasound is relevant, practical, bedside-available, simple, not time-consuming, and without side effects, ultrasound examination should be included in the stratification of patients with respiratory failure, as well as in those patients' follow ups. Consciousness about the limitations of this method and the critical judgement on the reliability of ultrasound findings in the particular clinical condition, taking the experience of the examiner into account, is a prerequisite for the safe usage of ultrasound in medicine.

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"The best friend first aids in troubles."

TRANSCRANIAL DOPPLER ULTRASOUND IN INTENSIVE CARE UNIT

More than thirty years ago in 1982 dr. Aaslid published a research paper about recording flow velocity in intracranial basal arteries with Doppler ultrasound (US). Until then we believed that US waves can't penetrate through bones. And so the new era for using transcranial Doppler (TCD) in neurology and intensive care began.

For TCD examination we use low frequencies (usually 2 MHz probe). By using the Doppler effect, TCD enables recording of velocity and direction of blood flow so that with this »blind« method we can imagine basal arteries according to localisation, depth of the signal direction of the flow and waveform morphology. Ultrasoud waves are transmitted intracranialy through the »acoustic windows« (transtemporal, transforaminal – occipital and transorbital). Up to 10- 15% of patients don't have transtemporal acoustic window because the temporal bone is too thick. We also use transcranial color coded Doppler (TCCD) which has some advantages. We can see B- mode image of cerebral structures, and can visualise cerebral vessels with different colours according to direction of the flow and can also perform more accurate measurements of the velocities of blood flow. Stenoses are better visualised in colour Doppler because of the turbulent flow.

We use TCD for the monitoring vasospasm in subarachnoid hemorrhages, for the identification of vessel stenosis and occlusion, arteriovenous malformations, for detecting microemboli and for sonothrombolysis. TCD serve also as a confirmatory test for diagnosis of cerebral circulatory arrest. In pediatric patients TCD is used as an accurate tool for predicting stroke risk in children with sickle cell disease.
We use TCD in intensive care units most often for detecting and monitoring of vasospasm in subarachnoid hemorrhage. TCD is useful, non-invasive, non-harmful and has good specificity and sensitivity for the detection of high flow velocities in intracranial internal carotid artery, middle cerebral artery and basilar and intracranial vertebral artery. For improvement of the sensitivity of TCD to detect vasospasm we use Lindegaard (ratio) index (mean flow velocity in intracranial artery/mean flow velocity in internal carotide). We use modified Lindeggard index for basilar teritory. Index lower than 3 is normal. Mean flow velocities above 200cm/s in middle cerebral artery and Lindegaard's index above 3 are tipical for severe vasospasm. Severe vasospasm is more frequent in patients with poor grade subarahnoid hemorrhage and can result in delayed cerebral ischemia. TCD is used as part of multimodality monitoring of the patients with subarachnoid hemorrhage.

In the Intensive care unit we can use TCD as the confirmatory test in diagnosing brain death. In many countries, also in Slovenia, brain death is defined as the irreversible cessation of all hemispheric, cerebellum and brainstem neurologic functions. We use clinical tests to confirm death of brainstem, followed by instrumental tests which confirm cerebral circulatory arrest (scintigraphy or TCD) or confirm absence of electrical acitvity of the brain (EEG). When intracranial pressure (ICP) rises, diastolic flow velocity decreases and becomes zero when ICP exceed above diastolic pressure. With ICP rise furthermore, it exceeds mean arterial pressure and in that moment cerebral perfusion is gone. On TCD the diastolic flow become retrograde, neto flow is zero. If this patern persists for more than 30 minutes in all intracranial arteries, this finding confirms the cerebral circulatory arrest. Later we can detect on TCD only minimal sistolic spikes and later on there is no more detectable flow. The sensitivity of TCD for the confirmation of cerebral circulatory arrest is 88% (absent acoustic window, decompressive craniectomy, external ventricular drainage) but specificity is 100%.

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I've started using the ultrasound from sheer necessity – sometimes it is the only way to see. Life without it would be much simpler, but nobody can ignore what they see. So, not from love, I've had to learn how to walk in the ICU with the ultrasound, trying not to fall over that cable... again.

"Use ultrasound – not because of love, but because of necessity."

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TUBE AND LINE POSITIONS IN MY ICU PATIENTS – CAN POCUS HELP?

Introduction

Ultrasound guidance has become a method of choice for various procedures that are common in intensive care units and emergency departments. For some procedures guidelines prescribe the optimal insertion technique in detail, e.g. for ultrasound guided insertion of central venous catheters to internal jugular position single-operator, real-time, short-axis view technique is recommended, along with the recommendation to use ultrasound post-procedure to exclude pneumo-hematothorax (1). However, for majority of the procedures performed in critically ill there are no guidelines regarding the use of ultrasound (e.g. endotracheal intubation) or only general recommendations to use ultrasound assisted insertion (e.g. for insertion of pleural drains) (1).

Ultrasound can be used pre-procedure to determine anatomy, during the procedure to ensure the puncture/passage of the correct structure, and post-procedure to confirm the correct catheter tip position and exclude procedure-related complications (1). Here we present a review of grey-scale sonographic techniques that can be used to confirm the correct position of the most commonly used tubes and lines.

Intravascular catheter position

Pre-procedure sonographic examination of patient anatomy can be performed prior to any intravascular device insertion, regardless of vessel or cannula/catheter to be inserted. For arterial cannula insertion sonographic views can be easily obtained for radial, brachial, axillary, femoral and dorsalis pedis arteries (2). Likewise, sonographic views of peripheral veins, internal jugular and femoral veins are easily obtainable (1, 3). Usually, a satisfactory view of subclavian vein can be obtained, and if the subclavian vein cannot be visualized, the continuum of axillary-subclavian vein can be seen (4).

Single-operator, real-time, short-axis view technique with linear probe can be used during the procedure for majority of the vessels. If Seldinger technique is used, the lead wire can be visualized before dilator insertion, confirming the positioning of the lead wire within the correct vessel (5).

For venous catheters where the tip of the catheter is positioned in right atrial position, the catheter can be visualized by transthoracic echocardiography, and for both right atrial or superior vena cava catheter position the location of the tip of the catheter can be ascertained by rapid injection of small volume (10 ml) of agitated saline through the distal port (6). It should be noted that a hyperechoic jet must be visualized immediately after injection, and that the sensitivity of ultrasound techniques is reduced in case multiple central venous catheters are inserted (1). Additionally, in some cases transesophageal ultrasound is required (3), e.g. to confirm the location of lead wires and large-bore cannulas used for extracorporeal circulation.

Post-procedure for internal jugular and subclavian central vein catheterization standard lung and pleural cavity ultrasound should be performed to exclude pneumo-hematothorax (1). In spite of similar or greater sensitivity and specificity for pneumo-hematothorax, it is not yet completely accepted that ultrasound examination can be used in place of traditional chest radiography (1), however, in case of time constraint it seems reasonable to start using the internal jugular and/or subclavian central venous catheters after sonographic examination and wait for chest radiography after other life-saving procedures are performed. Post-procedure for all procedures local anatomy can be examined to exclude haematoma, and, in case of vascular access, thrombus formation (1).

Endotracheal tube position

There is very little data to support a routine use of ultrasound to assist in endotracheal intubation. However, because ultrasound is noninvasive and can be deployed rapidly in a point-of-care setting, it would seem reasonable to use it. Pre-procedure local anatomy can be studied, especially in patients where landmark technique is difficult (obese, short neck, goiter, after surgery/radiotherapy on the neck). The larynx and trachea can be identified easily, and ultrasound can additionally be used to assess the diameter of trachea. Using the linear probe in transverse (out-of-plane) orientation the trachea forms a curvilinear hyperechoic structure with air-artefacts (7, 8).
In case of esophageal intubation the neck anatomy post-procedure will reveal an additional curvilinear hyperechoic structure with air-artefacts adjacent to the trachea („double tract sign"). The change in neck anatomy will be more pronounced if pre-procedure screening is performed (8), or in case real-time sonography is performed during intubation (9). Also, post-procedure standard lung ultrasound can be performed to evaluate the presence of lung sliding; unilateral absence of lung sliding, especially left-sided could be a sign of right main bronchus intubation (10).

Drainage tube position

Insertion of pleural effusion and ascites drainage tubes is discussed in greater detail, however, regardless of the procedure to be performed, ultrasound examination can be performed pre-procedure to determine anatomy using either a linear or a convex probe. Landmark technique can be used to determine initial area of interest, and ultrasound can then be used to select the most preferred approach. The volume of fluid collection to be drained can be assessed by ultrasound and should be noted for later comparison (11).

During the procedure, real-time view can be used in majority of the procedures. Alternately, static (pre-procedure only) view can be used, which in case of larger pleural effusions is not associated with an increased risk of complications compared to landmark technique (11), and in case of ascites is associated with significantly greater success rate of insertion (12). If Seldinger technique is used the positioning of the lead wire can be determined prior to insertion of the dilator.

Post-procedure the location of the drainage tube can be determined by comparing the volume of the fluid collection after drainage to before drainage. The drainage tube itself can usually be visualized as a hyperchoic structure with multiple parallel lines. Additionally, the location of the tube can be determined by rapid injection of small volume of agitated saline. Visualizing the tip of the drainage tube can be very difficult (13).

Conclusion

To determine the location of the most commonly used catheters, cannulas and tubes in the critically ill, ultrasound should be used in all three stages of the procedure: pre-procedure to study the patient's anatomy and increase the likelihood of successful insertion, during the procedure to visualize the passage of the needle/tube to the correct structure, and post-procedure to determine the position of the catheter and to exclude procedure related complications.

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Track B1 & B2: EDUCATION AND SOCIAL MEDIA

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Ultrasound IS operator dependent. Like every other important thing we do (lac repair, bedside manner, etc.). So practice!

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HOW TO TEACH IN 21ST CENTURY: FLIPPING THE CLASSROOM

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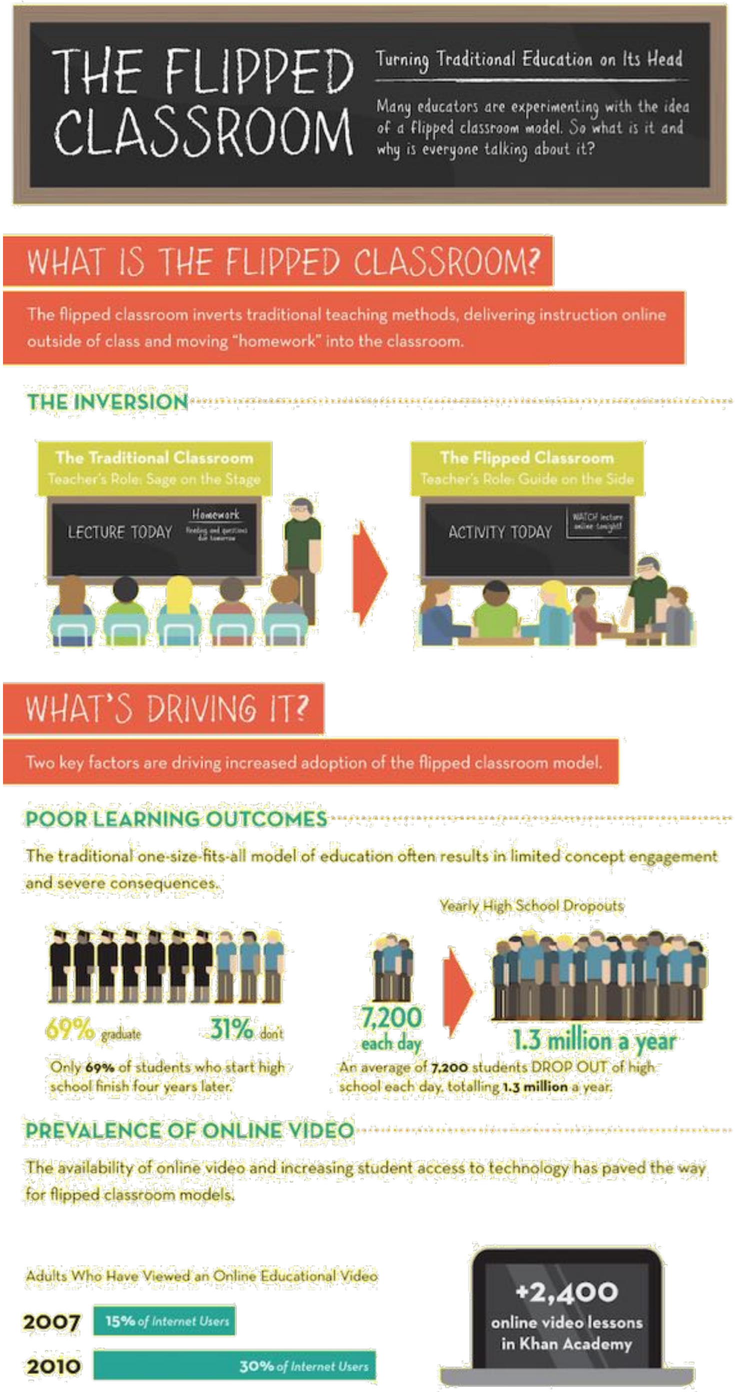

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TOP TEN TIPS FOR POINT-OF-CARE ULTRASOUND EDUCATORS

There are multiple aspects to teaching point of care ultrasound. The most important of these occurs at bedside, with real patients. This session focuses on the value of these sessions when educating ultrasound trainees.

1. **Clearly define goals of session.**
    - Decide in advance which applications you're going to focus on.
    - Base this on trainee self-assessment and your objective assessment of their needs.
    - Start with their weaknesses.

2. **Select the right patient.**
    - Patients with a clinical indication.
    - Patients with interesting pathology.
    - Patients who are skinny and nice.
    - Everyone else.

3. **Set the atmosphere.**
    - Clearly explain the purpose to patient.
    - Focus on the patient's comfort.
    - Set up the room for success.
    - Lighting.
    - Music?

4. **Incorporate all three aspects of clinical ultrasound.**
    - Image acquisition.
    - Image interpretation.
    - Incorporation of findings into clinical decision-making.

5. **Let the scanner struggle.**
    - Failure is okay in an educational setting.
    - Avoid the urge to take the probe–handholding is better.

6. **Stay focused on point-of-care ultrasound questions.**
    - Remember the dichotomous endpoint of each point-of-care application.
    - Try to avoid extraneous scanning.

7. **Max out on applications.**
    - A few additional views can dramatically increase your scan numbers.
    - Minimize loss of inertia by maximizing scans per patient.

8. **Use an iPad to show optimal views and abnormal pathology.**
    - Much easier to show textbook examples and abnormal pathology than to describe it!

9. **Correlate findings with clinical history, exam, other tests.**
    - Tremendous value in performing your own real-time external QA.

10. **Communicate your findings.**
    - Carefully explain to the patient's what you saw, what you didn't see, and how this fits into their management.
    - Don't overstate your findings.
    - Communicate findings with the clinical team.
    - Document appropriately.
    - Don't be left holding the hot potato!

Track B3: QUALITY, SAFE, SUSTAINABLE AND VALUABLE PATIENT CARE – ROLE OF POCUS

Challenges and solutions in the future of healthcare

Representative of Ministry of Health, Slovenia

Assessing the added value of new technologies in healthcare: the hows and the whys

P Došenovič Bonča, SLO

How do we define the value of POCUS in policymakers and budget decision-makers?

L Melniker, USA

Pay-per-POCUS; incentivised payment mechanisms as a tool to disseminate innovation

P Došenovič Bonča, SLO

Documentation, archiving and interoperability: Evidence for value-based decision making about POCUS

Track B4: WINFOCUS MEETS THE BALKANS

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WINFOCUS Board of Directors member

"Ultrasound is not harmful, only decisions based on it could be!"

EXPERIENCES AND NEEDS IN POCUS: CROATIA

Thirty years ago prof. dr. Mirko Gjurašin the head of the Department of Emergency and Intensive Care Medicine, Universtiy Hospital Zagreb, had a vision that ultrasound can be useful in hands of intensivists. At the beginning of the year 1986 an ultrasound device was available for ICU physicians. In that time young residents Dubravka Bosnić, Marijan Merkler, Marino Kvarantan and Radovan Radonić started training in ultrasound with a lot of enthusiasm. Interuniversity Ian Donald course in abdominal ultrasound provides a good theoretical basis. Consultations with radiologists, gastroenterologists and between each other helped to enhance our skills. Patients follow up and insight into complementary imaging findings provides a feed back to balance reliability of our findings. ICU was running routinely by experienced ICU physicians, in that time based on algorythms not counting on ultrasound. Our first affirmations as young ICU physicians was based on the contributions at the bedside by using ultrasound. Maturing as clinicians and ultrasonographers, we were privileged by complete introduction into clinical data of our patients, so the ultrasound findings were easily interpreted in the context of the clinical picture. Ultrasound naturally becomes an extension of physical examination and important part of clinical decision making process. Little by little our findings, marked as "orientational", become more and more reliable.

After some education abroad Marino Kvarantan introduced interventional ultrasound in our routine (1,2).

Our first experience was presented on International Symposium on Intensive Care Medicine held in Bled, in 1993 (2,3). We have shown that bedside ultrasound was performed in 43% of our ICU patients and in a half of them provided important medical information which often influenced on diagnostic and therapeutic plan. Our congress publication appeared in the same time when Daniel Lichtenstein published his famous publication in the journal Intensive Care Medicine about ultrasound usage by intensivists (4). This paper was important to us because we were not conscious that ultrasound usage by intensivist was not a common practice in that time. This publication also provides us some legitimacy due to similar pioneers work.

Self-made computer program in 10 years recorded 14405 reports performed by our intensivists. Out of them 9052 (62%) were for patients from emergency department, 1816 (13%) were for patients in the intenisve care unit examined at the bedside, and 3537 (25%) were the other patients. In 42% of cases useful information contributing in understanding of the patients condition was achieved, in 34% of cases not important pathology was found, and in 24% ultrasound finding was normal. Program fastens reporting and provides retrievable database. PC XT with a hard disk of today funny 20 MB capacity served for that purpose. The program was demonstrated on the First Congress on Ultrasound Diagnostics in Crikvenica, in the year 1994 (5). Analyisis of archieved data was presented on Symposium on Intensive Care Medicine and on the Summer School on Intensive Care Medicine, held on Brijuni Islands in 2008. Particularly we have recognised usefulness of ultrasound in our patients with sepsis where interventions under the ultrasound guidance can be helpfull (6,7).

Another important nucleus in the introduction of point of care ultrasound performed by intensivists in Croatia was in Rijeka. Anesthesiologist Alan Šustić and his coworkers did a lot of pioneer job in this filed. The most important original scientific contribution of this group was in the field of airway management facilitated by ultrasound (8,9,10,11). Alan Šustić contributed to the publication of the famous supplement of the journal Critical Care Medicine, published in May 2007, dedicated entirely to the point of care ultrasound (12).

In the year 2007 Radovan Radonić met the WINFOCUS leaders and was supported to start with USLS-BL1 courses in Zagreb.

Our first course was in May 2008. It runs regularly twice a year. Course is always excellently marked by participants. More than 500 participants attended the course until now. Also, thanks to WINFOCUS activities, our spectrum of ultrasound applications included into the basic ultrasound skills widened significantly.

Facultative subject „Ultrasound as a stethoscope" is included in the curriculum on the 6th year of the School of medicine University of Zagreb.

The speciality of Emergency medicine was recently introduced in Croatia. Point of care ultrasound is included into the curriculum. Theoretical part is included into the Postgraduate study on emergency medicine.

Point of care ultrasound performed by an attending physician is recognised in Croatia as a field of ultrasound. The confirmation of this is inclusion of the section „Ultrasound in emergency and intensive care medicine" into the Joint Congress of Croatian and Slovenian National Ultrasound Societies held in Maribor in 2013 and Split 2015.

By our oppinion, despite a relativly high number of doctors who attedned our USLS-BL1 course, point of care ultrasound still is not used enough broadly and enough extensively in Croatia as expected. Ultrasound is present in some intenisive care units, but not in all and not in all possible applications. Enthusiasm after the USLS-BL1 course is only partly realised in everday practice. In the first time it seamed that the ultrasound devices were the limiting factors. Today in many units and departments the lack of self confident ultrasongraphers who mastered the field, and spread the phylosophy of visual medicine seems to be the most important limiting factor. Residents in emergency medicine have recognised the usefulness of point of care ultrasound and we can see them as a critical mass of enthusiasts and a force in the near future which will establish this method as a routine in all emergency departments and other hospital departments in Croatia. Interest for the introduction of the point of care ultrasound in the prehospital setting is rising, but still is not realised.

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Track C: POCUS FROM HEAD TO TOES

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"Why waste time and resources when you have POCUS?"

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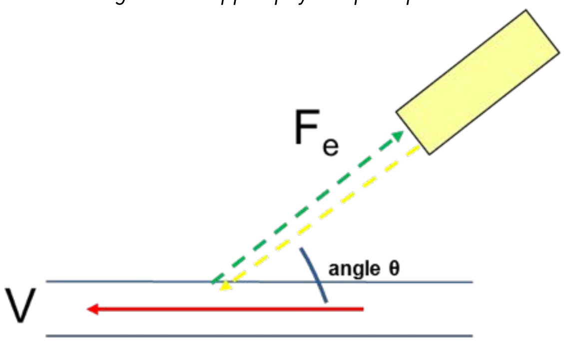
POCUS OF THE EYES

Dr. Philippe PÈS, MD

TRANSCRANIAL DOPPLER IN EMERGENCY AND CRITICAL CARE MEDICINE

Trans-cranial Doppler (TCD) is a technique described more than 30 years ago (1). No radiating and non-invasive, TCD can be repeated at will. It allows, through ultrasound, to evaluate the velocity of blood elements - especially red blood cells - in cerebral arteries. Indeed, when the distance between the ultrasonic probe and a mobile element varies over time, a frequency shift occurs (Doppler frequency) between the ultrasound emitted by the probe and that reflected by the mobile element. Doppler frequency is directly related to the speed of the mobile element calculated by the ultrasound apparatus according to the formula $\Delta.F = (2.Fv) / (C.\cos\theta)$ ($\Delta.F$ is the Doppler frequency, F the frequency of emitted ultrasound, v the velocity of the target, C the average speed of ultrasound in soft tissue and θ the angle of the incident beam relative to the path of the target) [**Error! Reference source not found.**].

Figure 1 – Doppler physical principle



All the cerebral arteries can be explored by TCD. However, in emergency and critical care conditions, the choice will be made on the middle cerebral artery (MCA) as responsible for over 60% of ipsilateral cerebral blood flow [**Error! Reference source not found.**] & [**Error! Reference source not found.**]. In addition, its path, oriented towards temporal bone, makes it easily accessible via the temporal acoustic window with the help of a low frequency probe, with a narrow beam and footprint: the Phased Array probe, so-called cardiac probe [**Error! Reference source not found.**]. The technical achievement and learning have been codified to make the exam as simple as possible, rapid and reproducible. It allows for intracranial flow velocities (systolic velocity (Vs), reflecting systolic blood pressure (SBP), mean velocity (Vm), reflection of cerebral blood flow and diastolic velocity (Vd), reflecting arterial resistances) and calculating the pulsatility index (PI), independent of the angle θ [**Error! Reference source not found.**]. Still, there are a number of cases where the TCD will be difficult or impossible to achieve (women of advanced age, Asians), while other situations can lead to changes in velocities (hypocapnia, anemia, bradycardia) making the interpretation difficult.

Figure 2 - Willis Polygon & MCA

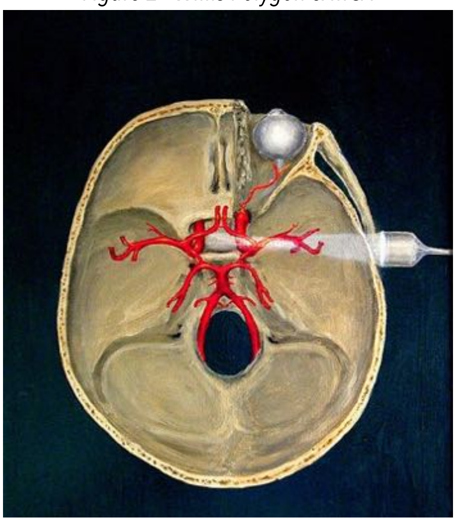


Figure 3 – Bones windows for TCD

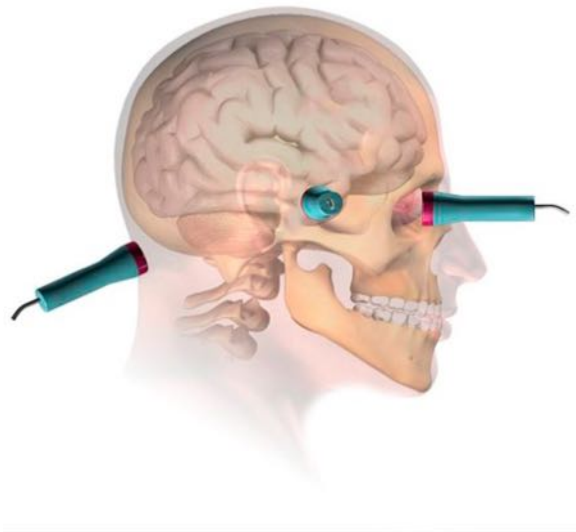
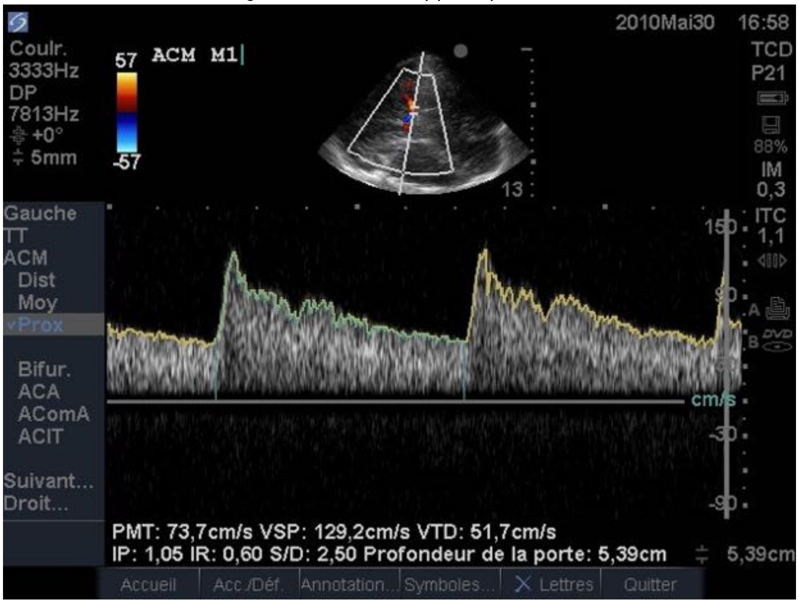


Figure 4 – Vascularization around the brain stem

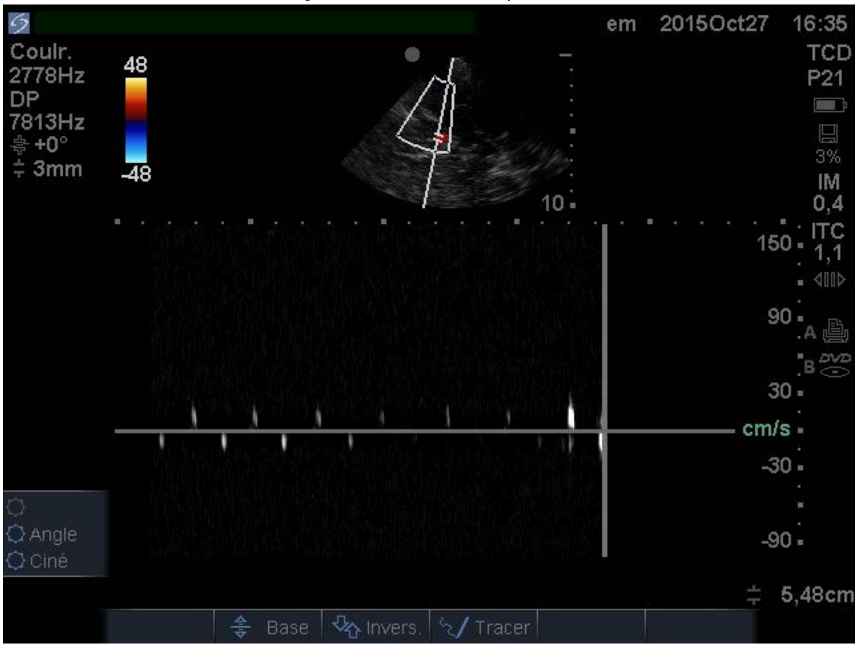
Figure 5 – Normal Doppler Spectrum



Thus, TCD directly assesses the speed of movement of red blood cells in cerebral arteries, but also, indirectly, cerebral blood flow (CBF). This is especially useful in case of imparment of cerebral arterial automation. Intrinsic motility of arterial wall is one of DSC regulators, kipping it constant for variations of SBP from 50 to 150 mmHg. Even in case of peripheral arterial hypotension, without any brain damage, the DSC is preserved (2-3). Conversely, in case of brain disease affecting arterial automation, velocity of cerebral blood flow is impaired. A vasospasm secondary to subarachnoid hemorrhage is detected in resuscitation room by an increase of mean velocity over 150 cm/s, at best coupled with carotid flow velocity (Lindegaard index). An important extrinsic compression as increased intracranial pressure secondary to severe cranial injury, will result in a decrease in Vd and an increase in IP. Normal values (Vd > 30 cm/s and IP < 1.2), intermediate (Vd between 20 and 30 cm/s and IP between 1.2 and 1.4) and abnormal (Vd < 20 cm/s and IP > 1.4) were determined to stratify the risk of post-traumatic cerebral ischemia, closely monitor patients and to establish, if necessary, an anti-edema therapy, including in prehospital phase (5-6). In extreme cases, the TCD can early detect the absence of cerebral blood flow by an oscillating flow (or reverse flow) [**Error! Reference source not found.** & **Error! Reference source not found.**]. It is potentially reversible in acute context (head injury), but much more rarely, if ever, in a chronic context, then precursor to cerebral death (7). Finally, other diseases could in future benefit from the TCD in clinical practice (prevention and risk stratification of stroke in sickle cell disease, management of febrile seizures and status epilepticus in children, acute encephalitis and meningitis) or specific diagnostics (persistent foramen ovale by detecting a cerebral right-left shunt). The use of ultrasonic contrast agents could increase the sensitivity of the TCD.

Figure 6 - Reverse Flow

Figure 7 - Neal-like Sharp Peak



Thus, TCD is a tool for screening, sorting, and monitoring. Learning, while being simple, requires longer than for other indications of clinical ultrasound practice. Nevertheless, accessibility and total safety should lead to its widespread use.

Like any clinical ultrasound examination of the patient in critical condition, TCD must be taken into account in the overall medical reasoning by combining it with the history, the circumstances of management and the clinical examination.

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ROLE OF ULTRASOUND IN THE AIRWAY MANAGEMENT OF CRITICALLY ILL PATIENTS

Ultrasound imaging of upper airway offers a number of attractive advantages compared with competitive imaging techniques or endoscopy in critically ill patients. It is widely available, portable, repeatable, relatively inexpensive, pain-free and safe. In this lecture I present the main potential applications of ultrasonography in the airway management. The role of ultrasound in endotracheal tube placement management, including preintubation assessment, verification of tube position, double-lumen intubation and extubation outcome, are explained. Also, the ultrasound-guided percutaneous tracheostomy, as well as the role of ultrasound in laryngeal mask airway and upper airway anesthesia is presented.

POCUS - Take home points:

- Ultrasonography can be an useful tool in airway management, including preintubation assessment, verification of ETT position, predicting of extubation failure, and for determining the proper size of ETT and left-sided DLT.
- Ultrasonography is an useful and exact supporting method for PDT which could be an alternative to endoscopy in avoiding potentially serious complication of "blind" PDT in difficult cases.

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LUNG ULTRASOUND I – BASIC SONOGRAPHIC PATTERNS

Abstract
Acute respiratory failure is one of the most distressing situations for the patient . Fast and accurate diagnosis leads to effective treatment and patient relief. Critically ill patients present in conditions that frequently delay normal diagnostic workout and consequently compromise outcome. Point of care lung ultrasound is diagnostic tool for rapid diagnosis at the bedside, thus meeting the priority objective of time saving. Basic lung ultrasonography is an extension of physical examination, easy to perform, simple to learn, and has excellent clinical utility for the emergency and many others medical teams. The basic principles of the lung ultrasound are presented.
Key words: A-lines, B-lines, lung sliding, pneumothorax, interstitial syndrome, pleural effusion, lung consolidation

Introduction

Acute respiratory failure is one of the most distressing situations for the patient (and doctor) and also an obstacle in diagnostic procedures. But only an early insight in etiology of the medical condition leads to successful treatment and rapid release of the patient distress. Early diagnosis is a key for effective treatment and decreases mortality and the need for mechanical ventilation and other intensive means of treatment. The underlying causes for respiratory distress are numerous, of course, but the most helpful finding in everyday practice is presence/absence of cardiac failure.

History of disease, clinical examination and bedside radiography, a familiar procedures for more than one century, are strong tools but not precise enough and can be misleading in critically ill (1). The most problematic patients are those with preexisting lung or cardiac conditions. Precise evaluation with CT is time consuming and linked to patient transfer, problematic when the patient's critical condition precludes transfer from protected environments (emergency department, intensive care unit, operating theatre). **In a distressed patient, a bedside non-invasive method is desirable.** The ECG is helpful, but the results of laboratory test such as natriuretic peptide are usually received after the beginning of treatment. A step forward in 90-is was the introduction of echocardiographic exam in critically ill but the echocardiographic machines were problematically big and shock sensitive. Considerable training is needed to perform an echocardiographic exam and such experts are not always readily available. Technological development has led to smaller size and endurance of the echo machines and opened new possibilities of use, even outside the hospital.

Much easier to perform and simple to learn (steep learning curve) is point of care (bedside, focused) lung ultrasonography method with higher sensitivity and specificity than chest X-ray in most lung diseases and has also a good diagnostic efficacy when compared with more sophisticated diagnostic methods (2). For decades it was commonly believed that lungs represented only an obstacle for an echocardiographic exam of thorax. This common prejudice was certainly the reason for slower acceptance of this useful knowledge. The following short text will explain how lung ultrasonography (LUS) in a simple way helps to exclude common pathologies such as pneumothorax, pleural fluid and pulmonary edema as a cause for respiratory distress.

The nomenclature used in text is supported by International evidence-based recommendations for point-of-care lung ultrasound (2).

Technical aspects

Any of the usual probes can be used for emergency LUS, but there are some recommendations. A range of frequencies (4 to 10MHz) can be used to visualize the lungs. High frequencies are useful to look at the periphery of the lung (pleura, subpleural space) with a high resolution as in looking for lung sliding and other signs of pneumothorax, as well as studying lung B-lines. Lower frequencies help with the imaging of deep lung tissues as in looking at consolidation and pleural effusion. Hence a liner (vascular) probe is used for the assessment of pneumothorax, while the convex (curved) ultrasound probe is used for consolidation and pleural effusion (3).
In the supine position, the anterior and lateral lung areas can be easily scanned, but the patient may have to be turned to a lateral decubitus position for scanning posteriorly. Six regions, delineated by the anterior and posterior axillary lines should be systematically examined: upper and lower parts of the anterior, lateral and posterior chest wall (2, 3) (fig. 1).

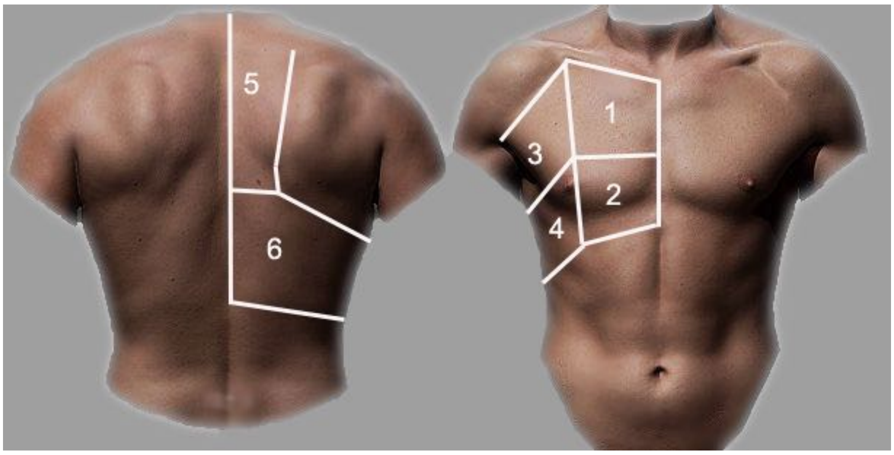

Figure 1. Chest areas to be examined: 1- upper anterior, 2 – lower anterior, 3 – upper lateral, 4 – lower lateral, 5 – upper posterior, 6 – lower posterior area.

Ultrasonography of normal lungs

The findings of LUS relate to the ratio of air to fluid within the lung. The air (and bones) has high acoustic impedance (high attenuation, badly penetrable for sound), much greater than that of other tissues. As lung parenchyma is normally filled with air, the lung is not visible as a structural entity with ultrasonography. But when the lung properties are changed by a disease processes, ultrasound findings change in a specific pattern of artifacts.

In a normal LUS exam we recognize the acoustic shadow under the ribs and between the two rib shadows we normally see a horizontal intense line (whiter line, hyperechoic line) approximately 0.5 cm deeper to the origin of the **rib shadows**. It is a **pleural line**, the interface of the visceral and parietal pleural surfaces (fig. 2). Normally, the two pleural surfaces move across each other during the respiratory cycle. This results in the US finding of **lung sliding**, which is seen as movement of a single pleural line in synchrony with the respiratory cycle. Normal aerated lung has a characteristic pattern of air artifact named A-lines. **A-lines** are horizontally orientated lines seen deep to the pleural line (fig. 2). They represent reverberation artifacts (interface of common tissues with air cause complete reflection of the ultrasound beam and its repetetive echoes) (1, 2, 3). (https://www.youtube.com/watch?v=FuKyRnoGB2k)

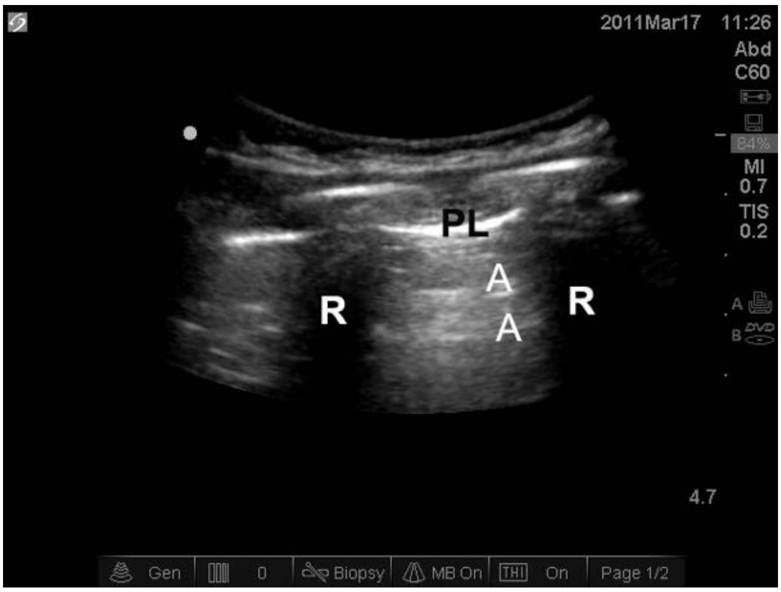

Figure 2. Ultrasonography of normal lungs. R – the acoustic shadow under the ribs, PL – pleural line, the line of lung sliding, A – A-lines.

Pneumothorax

Lung ultrasound is extremely useful in the bedside diagnosis of pneumothorax. Start the exam in the least gravitationally dependent areas. In pneumothorax A-lines are present (like in fig.2), but there is absence of lung sliding, presence of lung point, absence of B-lines, absence of lung pulse. In extreme emergency, absence of sliding and lung pulse allows safe diagnosis. Because of the air entering in-between the two pleuras, thus excluding their interface, there is **no lung sliding**. Sometimes this effect can be caused by other pathologies (atelectasis, one side intubation, pleural adhesion, certain ventilation modes, pulmonary fibrosis, large consolidations…). The **lung point**, which is the sonographic demonstration of the point on the chest wall where the pleural layers adhere again, represents the limit of the pneumothorax extension and allows estimation of its volume. This sonographic sign is highly accurate in ruling-in pneumothorax. The presence of **B-line** (as B-lines originate from the visceral pleura) excludes pneumothorax. The **lung pulse** refers to the rhythmic movement of the pleura in synchrony with the cardiac rhythm. It is a result of cardiac vibrations being transmitted to the lung pleura and detected at the pleural line when there is absent lung sliding but no pneumothorax (1, 2, 3, 4). (https://www.youtube.com/watch?v=FuKyRnoGB2k)
LUS in supine patient is more accurate than chest radiography (2, 4).

Interstitial syndrome

In cardiogenic (or noncardiogenic – ARDS, interstitial pneumonia or pneumonitis, pulmonary fibrosis) pulmonary edema there is an increase of the lung intercellular fluid and resulting thickening of the interlobular septa. Microreflections of ultrasound beam in thickened interlobular septa causes the appearance of the **B-lines**. B-lines are laser-like vertical artifacts that arise from the visceral pleura (fig. 3). They are well defined, do not fade and move with lung sliding. Multiple bilateral B-lines (tree or more B-lines in 2 or more regions bilaterally) indicate the presence of interstitial syndrome. In cardiogenic edema we find B-lines diffusely over both lungs. Only one side B-lines ('focal interstitial syndrome') are found in patients with other diseases (pneumonia, contusion...). Rapid anterior two-region scan is sufficient in emergencies (1, 2, 3, 5).
(https://www.youtube.com/watch?v=UwN-IQqnpb4)

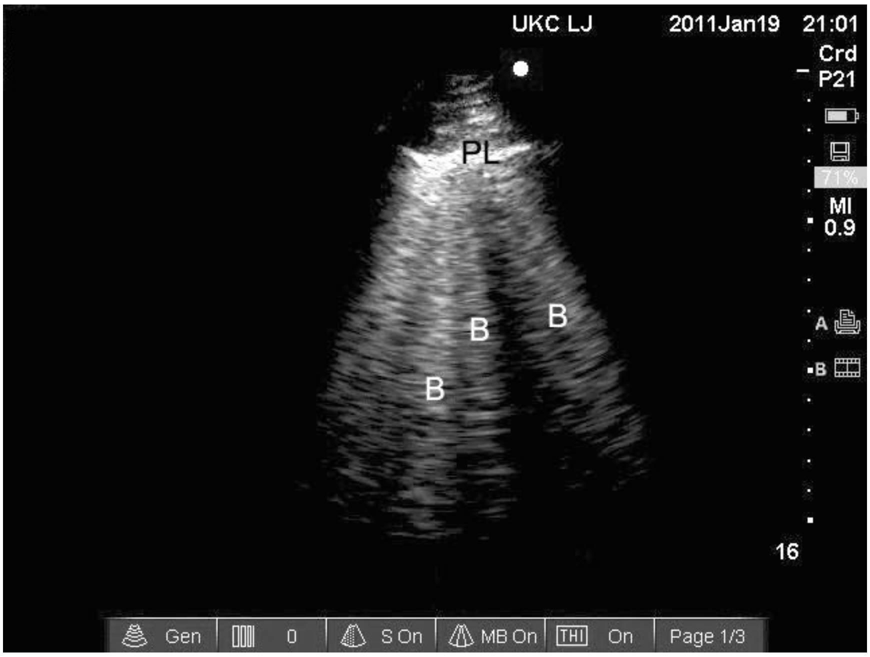

Figure 3. Interstitial syndrome. A patient with pulmonary edema. PL – pleural line. B – B-lines. B-lines arise from the pleural line.

Pleural effusion and lung consolidation

The utility of ultrasonography for the diagnosis of **pleural effusion** is well established.

Ultrasound can detect pleural effusions as small as 3-5 milliliters. Fibrin strands may be present and seen floating in the effusion or connected to each other in a lattice like pattern. LUS is helpful in performing diagnostic or therapeutic punction. In patients with substantial pleural effusion there is normally found some lung consolidation. The consolidated lung resembles liver US (fig. 4, 5) (1, 2, 3). **Lung consolidation:** subpleural echo-poor region or one with tissue-like texture. LUS does not rule out consolidations that do not reach the pleura, it can differentiate consolidations due to pulmonary embolism, pneumonia or atelectasis (2, 5). (https://www.youtube.com/watch?v=UwN-lQqnpb4)

Conclusion

Lung ultrasound is a part of clinical exam, a tool for rapid diagnosis at the bedside in patients with acute respiratory failure. It is much easier to perform than echocardiography and simple to learn.

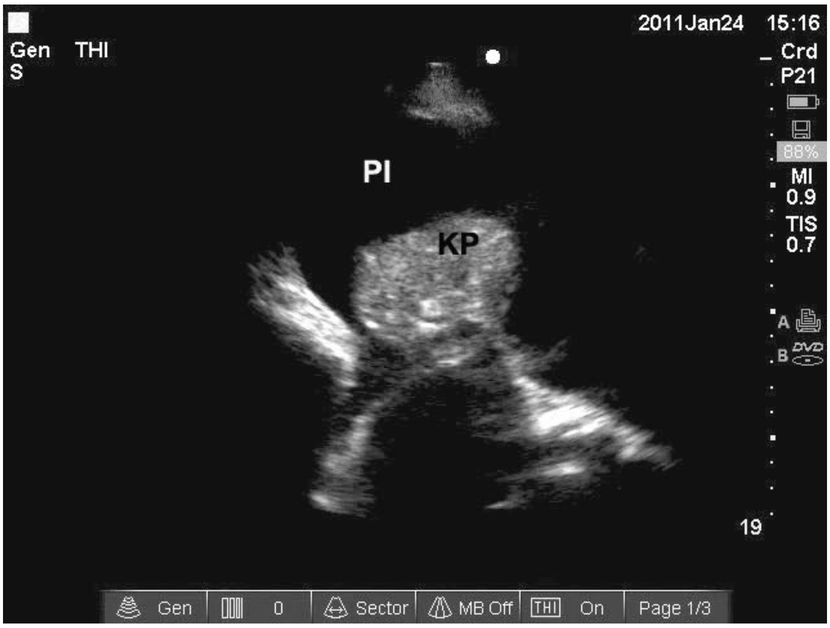

Figure 4. LUS in a patient with pleural effusion and consolidated lung. PI – pleural effusion, KP – consolidatet lung.

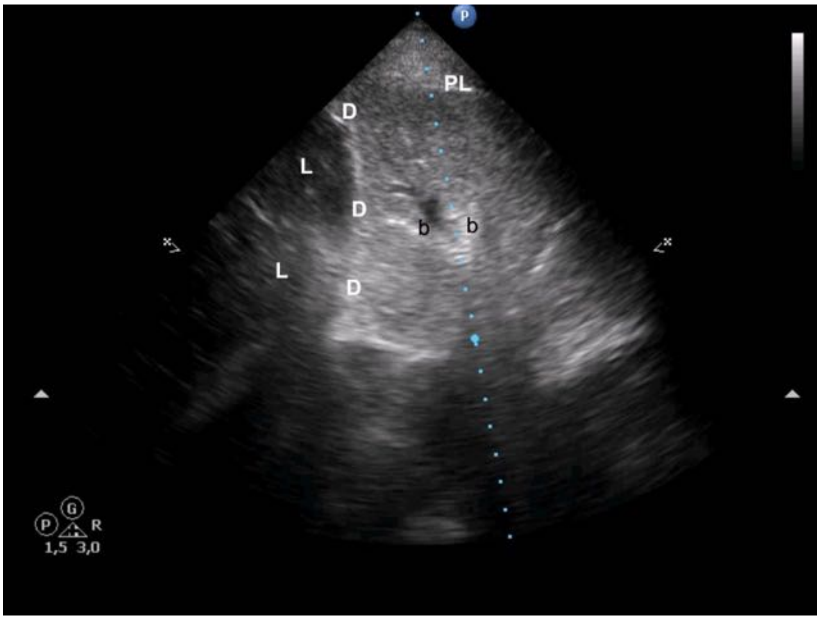

Figure 5. LUS in a patient with right lung atelectasis. D – diaphragm, L – liver, PL – pleural line, b – bronchogram.

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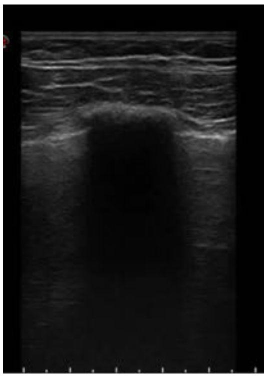
LUNG ULTRASOUND II – DISEASES OF THE PLEURA

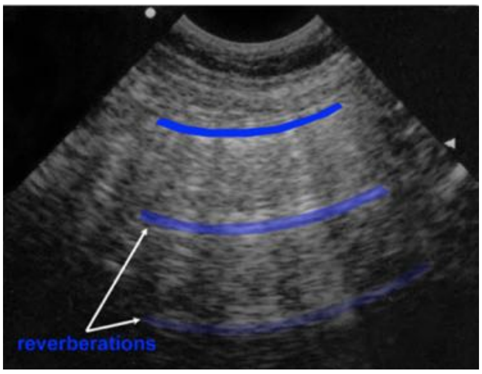
Technical competences: general

Objectives:
- Acquire basic principles of ultrasound and interactions with tissues
- Learn about different probes, features and basic components
- Get familiar with different types of artifacts and their causes
- Find out about different display modes (A-mode, B-mode, M-mode, Dopller)

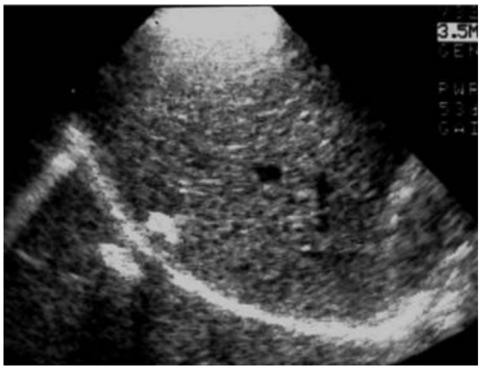
Main Messages:
- The transducer emits an ultrasound wave that interacts with tissues and interfaces and receives back the signals (reflection) and processes the image that appears on the screen.
- Physical properties of beams, tissues and interfaces, together with the distance of the innsonated objects from the probe, determine different echo return and processing.
- Shadowing, reverberation and mirror effect are the most important ultrasound artifacts for the study of the chest.



1. Shadowing



2. Reverberation



3. Mirror image

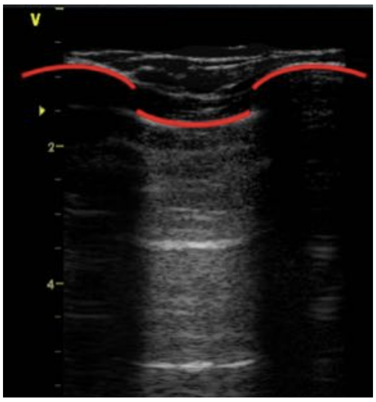
- Interface between surfaces with highly different reflection properties determines the reverberation phenomenon.
- Penetration of the beam is better with low frequency and resolution is better with high frequency transducer.
- M-mode is a single directional beam allowing better spatial and temporal resolution; B-dimensional allows 2D reconstruction.

2. Technical competences: lung application

Objectives:
- Become aware of lung ultrasound limitations
- Learn about chest areas
- Know how to hold and postition the probe on the chest
- Get familiar with main anatomic landmarks

Main Messages:
- Even if ultrasound does not pass through air or bone, alveolar air and the bones of the thoracic cage are not absolute limitations to the usefulness of lung ultrasound.
- We can differentiate three sonographic basic patterns: the normally aerated lung (mirror pattern), the slight increase of fluid and loss of air (interstitial B-lines pattern), the complete loss of air (consolidated pattern).

- Lung ultrasound is a surface imaging technique that does not allow visualization of deep lesions.
- The two main anatomic landmarks of lung ultrasound are the intercostal visualization of the pleural line (the "Bat sign") (*4.*) and the diaphragm.



4. The "Bat sign"

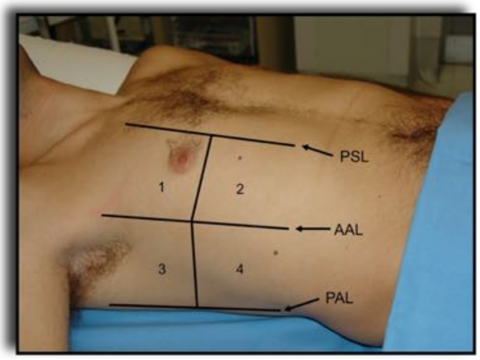
Interstitial Syndrome

Objectives:

- Be aware of the definition of interstitial syndrome
- Acquire a method to evaluate the presence of an intertitial symdrome
- Identify a positive scan and a poistive examination
- Distinguish between focal and diffuse interstitial syndrome (with definition, criteria and clinical implications)

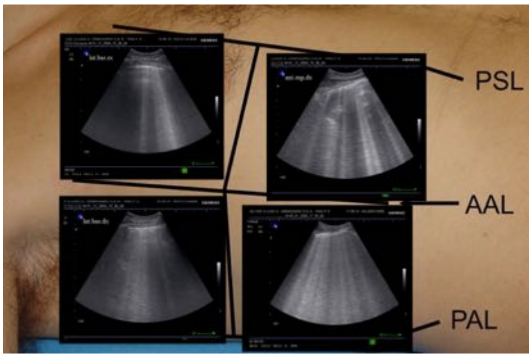
Main Messages:

- The interstitial syndrome is detected in pulmonary conditions that have in common a loss of air content and an increase in interstitial fluids (edema, fibrosis, cellularity).
- The technique consists in scanning 8 antero-lateral thoracic areas by longitudinal and oblique scans (*5.*).



5. Antero-leteral toracic areas

- The main objectives of the technique are the recognition of B-lines, the diagnosis of a positive scan and the diagnosis of a positive examination.
- A positive scan shows at least three B-lines in the longitudinal view.
- The diagnosis of interstitial syndrome can be focal (in normal lung or surrounding isolated consolidations) or diffuse (in edema of any cause, fibrosis, interstitial pneumonia).
- The diagnosis of diffuse interstitial syndrome can be done when at least two chest areas per side are positive for multiple B-lines, performing the examination in 4 antero-lateral chest areas per side (*6.*).
- In the critically ill, it is enough examining the anterior chest: predominance of B-lines on both sides allows diagnosis of diffuse interstitial syndrome (*7.*).



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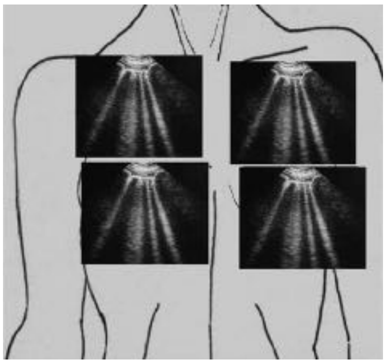

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6. *Diffuse interstitial syndrome (at least 2 positive scan per side)*
7. *Diagnosis of diffuse interstitial syndrome in the critically ill*

Pneumothorax

Objectives:

- Discover the sonographic signs of pneumothorax
- Learn the techique to search for a pneumothorax in stable patients
- Learn the techique to search for a pneumothorax in cardiac arrest/unstable patients
- Be aware of pitfalls during the evaluation of a apneumothorax

Main Messages:

- Air in the pleural space cannot be ultra-sounded, but lung ultrasound is sensitive to the effect of it.
- Three sonographic signs have high negative predictive value: lung sliding, B-lines, lung pulse (*8.*).
- The only sonographic sign with very high positive predictive power is the lung point.
- The scanning technique for a pneumothorax consists in searching for the lung sliding in the anterior-inferior chest bilaterally (in the most dependent chest areas), then moving the probe laterally to search for the lung point (*9.*).
- Lung ultrasound is more sensitive than chest X-ray for the diagnosis of pneumothorax and shows similar high specificity.
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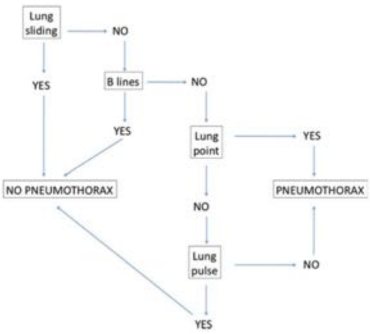
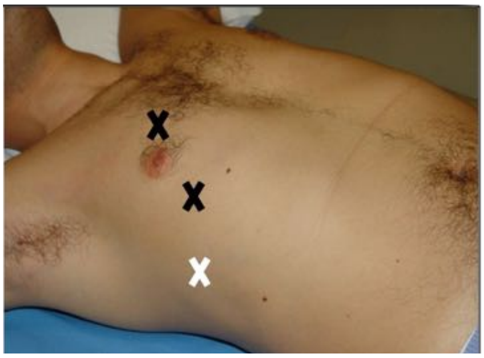


8. Flow chart on diagnosing pneumothorax.



9. Scanning technique for pneumothorax

- In cardiac arrest/unstable patient lung ultrasound for pneumothorax is not only recommended, but needful.
- In cardiac arrest/unstable patient absence of all the three basic sonographic signs, lung sliding, lung pulse and B-lines, in the anterior-inferior chest is enough to diagnose pneumothorax without the need to search for a lung point.
- Subcutaneous emphysema represents one possible source of diagnostic error. However, sonographic detection of subcutaneous emphysema in a chest trauma patient is an indirect sign of pneumothorax.

Pleural effusion

Objectives:

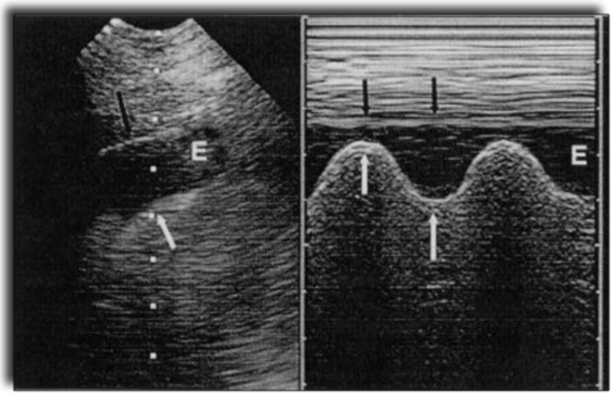
- Be aware of the sonographic signs of a pleural effusion
- Become able to differentiate pleural effusions

- Know how lung ultrasound behaves in comaparison to chest radiography and CT scan

Main Messages:

- The two basic sonographic signs of pleural effusion are: a space between parietal and visceral pleura (*10.*) and the "sinusoid sign" (*11.*).
- Internal echoes detected inside the sonographic space of an effusion suggest an exudate or hemorrhage.
- Lung ultrasound (for detection) is more accurate than chest radiography and as accurate as CT scan.
- Lung ultrasound is more accurate than chest radiography in distinguishing between effusion and consolidation.

10.



11.

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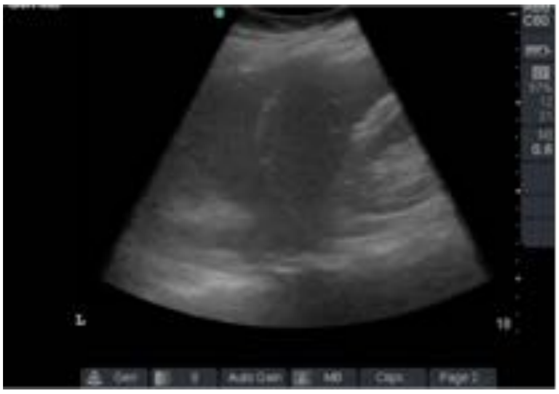
LUNG ULTRASOUND III – DISEASES OF PARENCHYMA

Lung ultrasound has evolved over the last decade as research has increasingly detailed a scientific and evidence based approach to using this important diagnostic tool. Importantly - we now have more evidence on how to differentiate between the different causes of lung consolidation (pneumonia, tumor, infarction) both by refining our interpretation of lung ultrasound artifacts and by using a more integrated multi-organ ultrasound approach. We will review these distinctions and some of the more recent literature supporting these techniques.

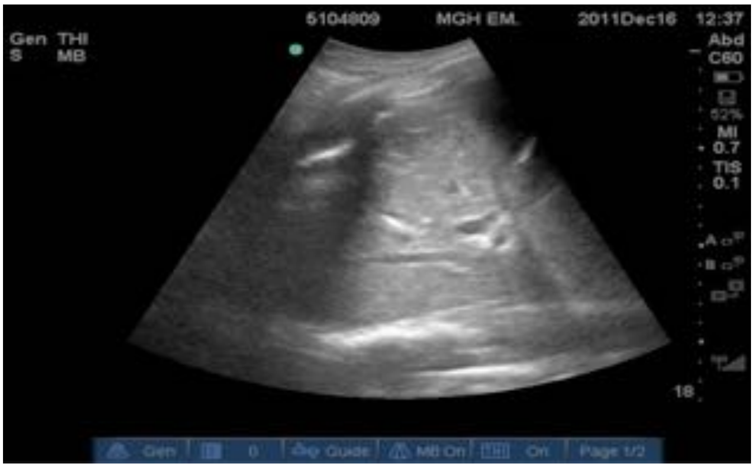
Lung ultrasound and parenchymal disease - What are we looking for?

#1 - Is there consolidation and are the edges smooth and compressed or rough and shredded/irregular?



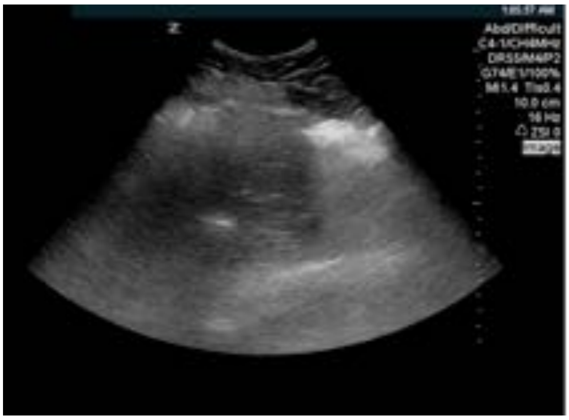
If smooth (picture on the left) - consolidation is much more likely to be compressive.
If rough (picture on the right) - then consolidation is much more likely to be infectious or inflammatory.

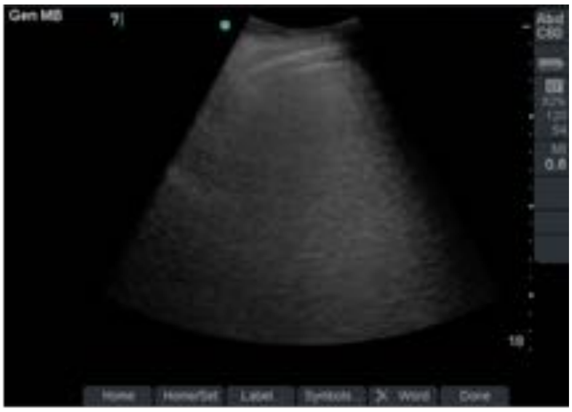
#2 - Are the bronchograms dynamic or static?



This used to be thought to be helpful in distinguishing atelectasis from pneumonia. However, we know pneumonia can cause plugged bronchi and thus static air bronchograms so this finding is less helpful than hoped.

#3 - If there are blines are they 1. present with an irregular and bumpy pleural line/sub pleural consolidations or 2. are they coming off a thin and crisp pleural line?





If blines are grouped with an irregular and bumpy pleural line and/or sub pleural consolidations (picture on the left) - the interstitial syndrome is much more likely to be inflammatory or infectious
If blines are coming off a thin and crisp pleural line (picture on the right) the interstitial syndrome is much more likely to be hydrostatic and a pressure problem i.e. heart failure.

#4 - When do I start antibiotics?

This is the million dollar question.

In my mind blines alone are not enough. Some might say you need to see a consolidation as viral pneumonias can cause blines, irregular pleural lines and sub pleural consolidations. MOST importantly is to integrate your findings with the differential you have for the patient in front of you. There is no pathognomonic finding for bacterial lung disease

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"Can you see the doctor scan with such a portable device? It's the start of a revolution that we've never seen in life.

Why is this lady turning blue? What is the cause of patient shock? All of my doubts are in the past and now we can ROCK!!"

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DIAPHRAGM

When to perform diaphragm ultrasound? What are the techniques to image the diaphragm? How to interpret the findings?

Indications

Diaphragm dysfunction in an underdiagnosed cause of dyspnea and should always be considered in the differential diagnosis of unexplained dyspnea. Diaphragmatic weakness or paralysis can involve either one or both hemidiaphragms (1).

Causes of dysfunction can be classified according to level of impairment: brain (multiple sclerosis, stroke, Arnold-Chiari malformation), spinal cord (quadriplegia, amyotrophic lateral sclerosis, poliomyelitis, spinal muscular atrophy, syringomyelia), vagus or phrenic nerves (Guillain-Barré syndrome, tumor compression, neuralgic neuropathy, critical-illness polyneuropathy, CIDP, Charcot-Marie-Tooth disease), neuromuscular junction (myasthenia gravis, Lambert-Eaton syndrome, botulism, organophosphates, drugs), muscle (dystrophies, myositis, acid maltase deficiency, glucocorticoids, disuse atrophy) and lungs (COPD, asthma) (1).

Indications to perform diaphragm ultrasound are: 1) unexplained dyspnea or exercise limitation; 2) reduced vital capacity on pulmonary function tests; 3) mechanical ventilation weaning failure; and 4) incidental radiographic elevation (1).

Additionally, in trauma scenarios, there are case reports of traumatic diaphragm ruptured diagnosed by ultrasound, but the accuracy of the method is still unknown (2-6).

Techniques

Two approaches are available to evaluate the diaphragm function through ultrasound examination: in 1969, Cohen described the measurement of diaphragm excursion (7); and, in 1989, Wait developed a technique to measure diaphragm thickness based on M-mode ultrasonography (8).

The diaphragm excursion can be measured using a phased-array probe, placed immediately below the right or left costal margin in the mid-clavicular line, or in the right or left anterior axillary line and is directed medially, cephalad and dorsally, so that the ultrasound beam reaches perpendicularly the posterior third of the corresponding hemi-diaphragm. The two-dimensional (2D) mode is initially used to obtain the best approach and select the exploration line; the M-mode is then used to display the motion of the anatomical structures along the selected line – **Fig. 1** (9).

The technique to evaluate diaphragmatic thickness is performed in the zone of apposition of the diaphragm to the rib cage. The zone of apposition is the area of the chest wall where the abdominal contents reach the lower rib cage. In this area, the diaphragm is observed as a structure made of three distinct layers: a non-echogenic central layer bordered by two echogenic layers, the peritoneum and the diaphragmatic pleura. To obtain adequate images of diaphragmatic thickness in B and M-Mode, a linear high-frequency probe is placed in the mid-axillary line, at the 8th or 9th intercostal space, with the marker pointed to cephalic region of the patient. The thickness can be measured during quiet spontaneous breathing or during a maximal inspiratory and expiratory effort – **Fig. 2** (9).

How to interpret the images?

In a patient with dyspnea ➔ Gottesman et al. demonstrated a especificity of 100% to diagnose diaphragm dysfunction with a thickening fraction (TF) ≤ 20%, calculated as $(Thick_{MAX} - Thick_{MIN}) / Thick_{MIN}$ (10).

In a patient on mechanical ventilation ➔ the value of diaphragm ultrasonography relies both on prediction of weaning success and follow-up of ventilator-induced diaphragm dysfunction (VIDD). Patients with excursion of 11 mm or less, there is 83% of specificity for prediction of weaning failure (11); an excursion ≥ 25 mm has 100% of sensitivity to predict a good outcome; a TF, when ≥ 30%, has sensitivity of 88% and specificity of 71% (12) and, when ≥ 36%, sensitivity of 82% and specificity of 88% for weaning success (13). In follow-up pilot studies, Grosu et al. demonstrated an end-expiratory thickness reduction of 6% per day on mechanical ventilation (14), and Mariani demonstrated an average of 4 days of VIDD resolution after the first spontaneous breathing trial (15). We recommend a multi-organ approach, as described by Mayo et al. in a comprehensive review of cardiac, diaphragm, pleural and lung ultrasound during weaning process (16).

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INFERIOR VENA CAVA

What are the techniques to image the IVC? How to interpret the findings? Are there differences between patients in mechanical ventilation and with negative pressure ventilation? What is the relationship between the IVC and a sheep?

Technique (1)

To obtain a reliable image of IVC, start with a 2D short-axis view of IVC and aorta (**Fig. 1**), then rotate the probe to a long-axis view, tilting it to focus the region where IVC enters the right atrium, just after an hepatic vein reaches the IVC (**Fig. 2**). Although there is some variation in the literature about the right spot to consider the diameter, I recommend you to use 2-2.5 cm before the right atrium, adjacent to the hepatic vein. Make sure you use the same spot when performing serial measurements.

You can move to the next step (*interpretation*) right now. But before, you can choose to obtain an M-Mode image, especially if you are concerned about the dynamic variations of the IVC during a respiratory cycle (**Fig. 3**). It's a nice way to assess fluid responsiveness in selected patients, as we will see further.

How to interpret the IVC ultrasound?

It's important to recognize the physiological aspects that influence the IVC, in order to run off the binary (and poor) thought "empty cava" equals "hypovolemia" equals "give fluids!" First, you must remember that, to remain open, this collapsible vessel requires a distending pressure greater than the critical pressure producing collapse, i.e. its closing pressure. Regarding IVC, the distending pressures are the **mean systemic filling pressure** and the **right atrial pressure** (RAP), influenced by **pleural pressure**, while the **intra-abdominal pressure** represents the closing pressure. In a healthy volunteer, you can assume a linear relationship between IVC diameter and RAP, except in situations when IVC is fully collapsed or distended (2).

With these parameters in mind, you can understand the potential usefulness and limitations of IVC ultrasound to assist the decision of administer fluids to our patients. Let's move to the evidence.

Is IVC ultrasound a good surrogate for RAP measurement?

This may be a good starting question, as RAP have been considered a surrogate for end-diastolic right ventricle volume, except for patients with right ventricular dysfunction, obstructive shock or tricuspid regurgitation. In spontaneous breathing (SB) shocked patients, there's good correlation between an end-expiratory IVC of 9 mm or less and a low RAP (3-5). In controlled mechanical ventilation (MV), an IVC of 12 mm or less correlates with RAP $\leq$ 10 mmHg (6) and, when 25 mm or more, there's moderate correlation with RAP $\geq$ 15 mmHg (7). Unfortunately, as you can observe, there's an important grey zone in these values. Even considering the respiratory variation (IVCRV), calculated by the formula $(IVC_{inspiration} - IVC_{expiration})/IVC_{expiration}$, probably you'll still have doubt: in SB patients, IVCRV < 16% means high RAP and > 72%, probably we have low RAP (5); in MV patients, IVC variation < 10% means high RAP, i.e. hypervolemia, RV dysfunction, cardiac tamponade, tricuspid regurgitation (7).

What about fluid responsiveness?

The best scenario to consider IVC variability for prediction of fluid responsiveness is with controlled MV patients and with a tidal volume (Vt) of 8 mL/kg of predicted body weight. In these cases, a variation of 18% has both sensitivity and specificity of 90% (8). "But wait, I work in an Emergency Room and I don't see many of these patients!" Well, I'm a critical care physician and me neither; my ventilated patients are on PSV (majority) or with a low tidal volume. Maybe for an anesthesiologist, it could be interesting data. In SB patients, however, the evidence is poorer: a variation of less that 15% means lack of fluid responsiveness (9), but we don't have a cutoff with good specificity to predict good response to fluids.

"If the IVC is full, I never administer fluids!"

There's rationale with this statement, but, unfortunately, so far we can't find strong evidence supporting it. If you are confident about the prediction of high RAP based on your measurement, you'll be probably right withholding fluid. We know that a high RAP is predictive of pulmonary edema, for experimental studies on sheep (10); strategies aiming low RAP have better outcomes on lung injury patients (11,12); and specialists recommend using it as a "stopping rule" (13). On the other side, a collapsed IVC isn't a "green light" to administer fluids, especially in patients with intra-abdominal hypertension (14).

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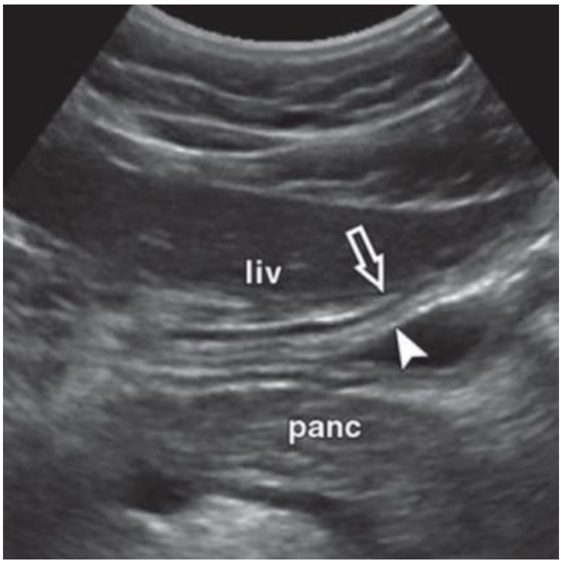
BOWEL

Normal bowels: normal gut signature

- Normal bowels have physiologic lamellation of bowel wall, with five alternating concentric hyperechoic and hypoechoic bands. Innermost hyperechoic layer (arrowheads) is mucosal surface, followed by hypoechoic muscularis mucosa, hyperechoic submucosa, hypoechoic muscularis propria, and outermost hyperechoic serosal surface (arrows). Muscle is usually hypoechoic and fat is usually hyperechoic, but disease states can alter these normal appearances.
- This pattern allows the sonographer or radiologist to distinguish bowel from adjacent structures, and disruption of the pattern aids the diagnosis of bowel pathology.
- Normal bowel pattern: normal gas pattern, normal mucus patter, and normal fluid pattern.



Abnormal bowels

A diseased bowel is generally easier to image with ultrasound than normal healthy bowel, because it is usually accompanied with following helpers.

- Decreased Motility
- Thickened walls
- Fluid-filled and distended lumen
- Echogenic adjacent mesenteric fat (inflammation)
- Free fluid

Common bowel diseases in acute abdomen

- Bowel perforation (pneumoperitoneum)
- Acute appendicitis
- Diverticulitis

- Intussusception
- Small bowel obstruction
- Colitis

SAFER Lasso approach for bowel; normal

	Normal Sono-anatomy
Size	Thickness < 4 mm, SB diameter < 2.5 cm, appendix diameter < 6 mm
Air	Normal intraluminal air with dirty shadowing or reverberation (normal gas pattern).
Fluid	Normal fluid pattern
Echogenicity	Normal Gut signature (high-low-high-low-high)
Regional lesion	No stone, mass, shape change (disruption of multi-lamellated pattern) Dynamics: Normal peristalsis, easily compressible

SAFER Lasso approach for bowel; abnormal

	Pathologic findings
Size	Wall thickening: concentric or eccentric Dilated fluid-filled SB > 25mm: SBO Appendicitits: noncompressible distended appendix > 6 mm
Air	Trapped: within-Emphysematous intestinalis
Fluid	Within: fluid filled loops - ileus Surrounding: free fluid around loops – high grade obstruction
Echogenicity	Loss of normal gut signature (layering)
Regional lesion	Intra-luminal - appendicolith Extra-luminal - echogenic mesenteric fat cake, bowel-in-bowel, diverticulitis, LNs, epiploic appendagitis, mass Dynamics: increased or impaired peristalsis, lack of normal compressibility, increased vascularity in wall and adjacent mesentery

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ACUTE SCROTAL ULTRASOUND

Normal anatomy

The Testicles have an ovoid shape with a mild homogeneous glandular echogenicity. Normal length of 3 - 5 cm, Width 2 - 4 cm and anteroposterior diameter of 3-4 cm.
Scrotal wall : formed by several layers of tissue (skin, darthos, external spermatic fascia , cremaster muscle, internal spermatic fascia , a thin layer of fatty tissue and vaginal Tunica (scrotum) and visceral (testicle) tunic.Thickness 2 to 5 mm .
Tunica vaginalis: is displayed as a thin echogenic line that surrounds the testicles.
There is usually a small amount of anechoic fluid between the layers of the tunica vaginalis.

Epididymis: have tree parts : head, body and tail.
Head: upper and lateral to testicle. Echogenicity similar to testicle. Thickness 10 mm
Body: posterolateral to the testis. It looks thinner than the head and more echogenic.
Tail: at the lower pole of the testis. Not usually seen.

Spermatic Cord: Located in the upper pole of the scrotum.It is seen as an echogenic band .
It contains arterial and venous vessels and spermatic duct.

Vascularization: Scrotal wall : pudendal arteries
Testicular: They arrive by the cord.

- Testicular artery : branch of the Aorta
- Deferential Artery: branch of the bladder
- Cremasteric Artery : branch of the inferior epigastric .

Testicular artery enters the scrotum and is divided into one or more capsular arteries on the posterior aspect of the testis .

Technical Approach

Linear probe of 7.5 to 10 MHz .
Ask the patient to hold the penis against the abdomen.
Make longitudinal and transversal sections of the testicles. Compare both of them. Epididymis and spermatic cord.Tunics and scrotal content (hydrocele).

Pathological findings

Acute Scrotum
Pain, Hyperemia and testicular swelling
The most frequent cause of testicular pain is Epididymitis

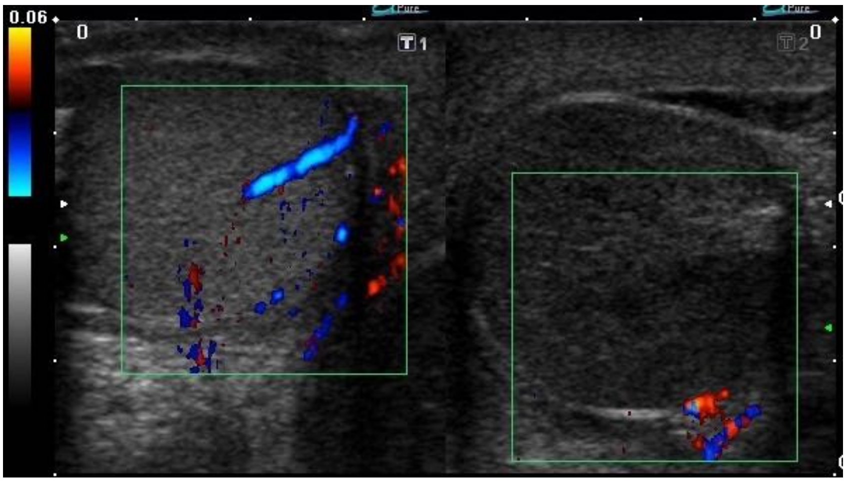
Orchitis and Epididymitis
Enlarge with decrease echogenicity of the Epididymis
and very heterogeneous.

Orchitis associated diffuse or focal (next epididymis), hypoechoic testis.
Hydrocele (liquid collection in the albuginea tunica)
Thickening of the scrotal tunics .
Abscesses : Necrotic area without blood flow but with increased flow in the adjacent. Cystic areas, secondary infarctions (cannot be distinguished easily from a torsion)
Doppler: Epididymis with increased flow, hyperemic testicle.
Differential diagnosis: testicular torsion, INCREASE FLOW (COMPARED TO THE CONTRALATERAL)
If it not solved with AB, Beware! Check if there is a hidden tumor.

Testicular Torsion

Testicular torsion refers to the torsion of the spermatic cord structures and subsequent loss of the blood supply to the ipsilateral testicle.The testicle is attached to the wall by its free edge , where the visceral tunic retracts to parietal .
Cremaster contraction rises and rotates the testicle on its pedicle more than normal , obstructing the flow and giving pain.
In 60 % of cases the torsion is preceded by trauma, physical activity or sex.
Torsion occurs when the testicle rotates between 90° and 180°, compromising blood flow to and from the testicle. Complete torsion usually occurs when the testicle twists 360° or more; incomplete or partial torsion may occur with less degrees of rotation.
The twisting of the testicle causes venous occlusion and engorgement as well as arterial ischemia and infarction of the testicle.
Pain in the lower abdomen , which migrates into the scrotum.Nausea. Vomiting.
Testis transverse location.Edema and erythema of the scrotal skin.

Testicular necrosis depends on the degree and duration of the torsion.
Necrosis of the testicle 20% after 6 hours, 80% after 12h and 100% after 24h



Early Phase (4-6 h): normal echogenicity with possible size increase of testicle. Normal wall thickness. Possible reactive hydrocele.
Doppler decrease blood flow. If the torsion is complete the flow is absent.
Required optimal setting of the doppler paramaters (amplitude and PRF) for slow flows especially in the case of children.
Venous flow is initially lost because of easily collapsible vessel walls and lower pressure system
Meticulous Doppler comparison of the two testes is mandatoryTestis and epididymis increase in size. Hypoechoic .coarsely heterogeneous testicular parenchyma with anechoic areas (edema , necrosis and hemorrhage)
Reactive hydrocele .Increasing the thickness of scrotal tunics .Spermatic cord twisted and thickened .
During the first 4 hours ultrasound can be normal.Always compared to the contralateral .

After 6-8 Hs: enlargement of the affected testis and increased or heterogeneous echogenicity, reactive small hydrocele. No color flow signals

Torsion of the testicular Appendix

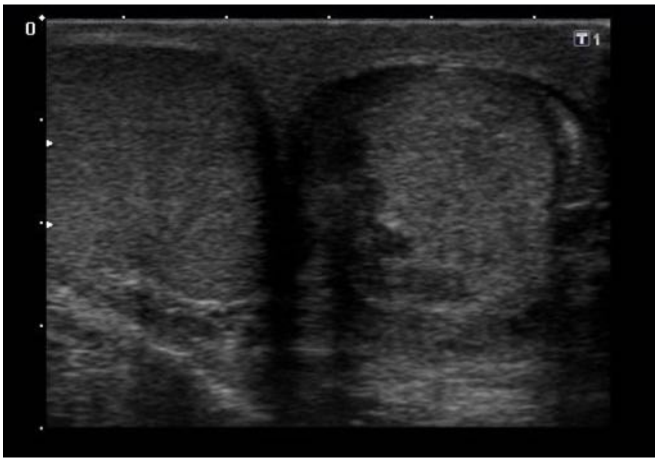
Is the major cause of an acute scrotum in pediatric patients. Symptoms are similar to testicular torsion or epididymitis.

Clinical : Typical mush , small , mobile, round at the upper pole of the scrotum.

Ultrasonography : the identification of a testicular appendage larger than 5.6 mm is suggestive of torsion, round , hyperechogenic mass with hypo- or anechoic center (ring image), adjacent to the testicles.

Testis normal vascularization.

Testicular Trauma



We have to search: Contour abnormality of the testis,

Disruption of the tunica albuginea (discontinuity echogenic band surrounding the testicle),

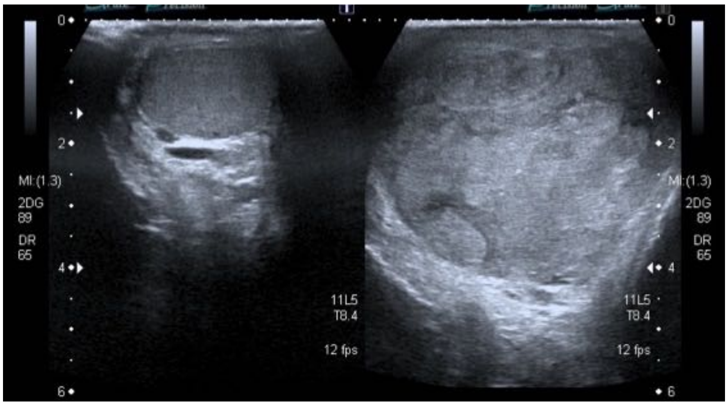
Direct visualization of a fracture line (Linear hypoechoic band that extends across the testicular parenchyma and represents a break in the normal testicular architecture. The overall contour remains smooth, as the testicular shape and the tunica albuginea are maintained),

Presence of hematocele (Blood in the tunica vaginalis: like hematoma, it's acutely echogenic and become more complex and more hypoechoic with age),

Intra-or extra testicular hematoma,

Heterogeneous appearance of the testis (heterogeneous parenchyma with or without localized anechoic intra or peritesticular areas or hypoechoic areas),

Hyperemia of the epididymis



Tips, tricks and pitfalls

- Always compare, volume, echogenicity, texture, shape of both testes and epididymides
- Use the doppler, but make sure that it has a correct setting

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POINT-OF-CARE ULTRASONOGRAPHY IN GYNECOLOGY AND OBSTETRICS

Introduction

In the last thirty years ultrasound technology has experienced extraordinary improvement not only in ultrasound as a physical phenomena but also in terms of a data acqusition and data manipulation. Gynecology and obstetrics was among the first medical fields that embraced ultrasound in diagnostics and therapy and rapid adoption continues even today in breaktrough technologies such as 3D ultrasound. Parallel with these advancements there is a growing need on the other side of the spectrum - to use mobile ultrasound technology in bedside manner by less experienced sonographers in order to easily and more readily detect common disorders. These tendencies are present for some time in other field of medicine as well. For example, in cardiology interesting concepts such as "Ultrasound as a stethoscope" were introduced. Appearance of rather powerful handheld ultrasound devices on the market has stimulated research in this area.
The purpose of this article is to describe ultrasound fundamentals and common pathology that can be diagnosed with handheld devices even in hands of less experienced user. Ultrasound pictures of described states are presented at the end of the article (picture 1, 2, 3, 4).

GYNAECOLOGY

In order for ultrasound scan to be informative sonographer needs basic knowledge of anatomy and planes in which these organs are evaluated.

Uterus - normal findings

Gynecologists prefer vaginal over abdominal approach for its better visualisation and higher resolution of a observed area. However from a point of care ultrasonography only abdominal scan is feasible. For greater success in visualisation full bladder is recommended. Two most useful planes for uterus evaluation are longitudinal and transferse plane. In longitudinal plane we can see the uterus behind the bladder as a mild echogenic, homogeneous pear-shape structure with hyperechogenic line in the middle of it. This line represents the endometrium. Cranial part of the structure represents the corpus and lower part the cervix of the uterus. Caudaly from cervix and around the bladder we can see the vagina as a tubular structure outlined with three hyperechogenic lines (outer lines are borders of the vagina and middle line is the line, where anterior and posterior wall of the vagina touch on each other). Presence of fluid in the vagina or cavum uteri can be easily detected with ultrasound and can provide diagnosis of hematocolpos and hematometra (presence of blood in uterus or vagina). In cases of primary amenorrhea and abdominal pain, this ultrasound picture can rise the suspicion of imperforate hymen.

Uterus - pathological findings

Pathological development of the uterus
US detection of uterus development abnormalities usually requires high technology equipment and experienced sonographer in the field of gynecology. Rare cases when they can be easily detected are presence of hematocolpos or pregnancy. In these cases fluid in the extended cavum of uterus makes septum visible. Visualisation of two uterus can raise suspicion of uterus didelphys. However, it is a rare condition. "Catsign" in fundal area of the uterus in transverse plane indicate the presence of uterus arcuatus or septal uterus.

Myomas
Myomas are benign tumors of the uterus that arise from the myometrium. It can be responsible for pelvic pain, abnormal vaginal hemorrhage, dysmenorrhea, infertility, abortion or preterm birth. They are usually oval with echogenicity depending on type of tissue more prevalent in the tumor (connective tissue is more hypechogenic then myometrium tissue). Bigger ones are more easily detected, because they usually deform the shape of the uterus or make it bigger than normal. In some rare cases they can be even larger than the rest of the uterus. Symptoms often correlate with the position of myoma in the uterus (subserosal - near the surface of the uterus, intramural - inside the myometrium submucosal - near the endometrium; cervix, isthmus or corpus of uteri).

Adenomyosis
In adenomyosis endometrial tissue is found not only in endometrium but also inside the myometrium. By ultrasonography it is characterized by larger number of small hypoechogenic cysts inside of the myometrium. Myometrium is usually thickened, which consequently makes uterus bigger. Ultrasonographically it can resemble myoma.

Endometrial polyps and hyperplasia
In postmenopausal women endometrial hyperplasia or thick endometrium is associated with endometrial carcinoma. Larger number of cysts in thick endometrium is additional suspicious sign and requires further evaluation. Endometrial polyps are endometrial proliferations that extend into the uterine cavity. On ultrasound examination they are easier to detect by thicker endometrium with irregular outline or with presence of fluid in the uterine cavum.

Hematometra or pyometra
One of the easier markers to detect on ultrasound examination is fluid in the uterine cavum, which should be further evaluated and put in context of accompanying clinical signs.

IUD
If very bright somewhat thicker hyperechogenic line is seen inside of endometrium, then this can be a confirmation of IUD. Detailed evaluation of its position in uterus can be a challenge during transabdominal approach.

Ovaries and tubes - normal findings

Very often it is hard to visualise ovaries with transabdominal approach. That is the reason that for these structures gynecologist use more often than not transvaginal probe. In detection of these structures somewhat helpful could be transverse plane at the level of uterine fundus. Laterally from fundus are ovaries that are usually oval in shape with small hypoechogenic cysts that represent follicles. Fluid either in Douglas space or in ovarian cysts makes visualization of ovaries easier to notice and to evaluate. Another useful landmarks for orientation and search for ovaries are full bladder and nearby great vessels. In healthy women tubes are not usually seen even with transvaginal approach. Pathological changes like accumulation of fluid makes the tubes visible with ultrasound.

Ovaries and tubes - pathological findings

Cysts
The bigger the cyst the easier it is to diagnose them, especially with lower quality ultrasound and transabdominal approach. All cysts can be categorized in six different categories in accordance with their ultrasonographic features – Unilocular cysts, multilocular cyst, unilocular solid cyst, multilocular solid cyst, solid cyst and uncategorizable lesions. General rule is that the more complex cyst is, the higher is the risk for malignancy. Irregular cyst walls, intracystic papillation or extensive vascularisation detected by Doppler ultrasound are additional features more frequently present in malignant tumor.

Teratomas
These are the most frequent ovarian tumors in reproductive life of the women. They contain very different tissues such as follicles, hair or even teeth. They are filled with seborrheal tissue. Typically on ultrasound they have oval shape with not so clear borders form the rest of the surrounding tissues. These unilocular cysts are usually filled with sonographically very heteroechogenic content.

Endometrioma

Endometrioma arises from endometrial implants on ovary or other surrounding tissues. They frequently appear in shape of unilocular cyst with content that produces mild and homogeneous echoes. We usually find them in premenopausal women.

OBSTETRICS

Basic concepts

From a standpoint of POCUS and its focus on transabdominal approach, pregnant women are easier to evaluate then gynecological patients, because the majority of ultrasound examinations are done over woman's belly and only smaller portion in the beginning of pregnancy is done with transvaginal approach. Each ultrasound examination through pregnancy has specific goals that are correlated with different gestational age. For its different goals we could categorize ultrasound examinations in pregnancy in prenatal, intrapartal and postpartal.

Prenatal ultrasound

First trimester - normal findings

Last menstrual period can help us in calculating the gestational age and the expected date of delivery by using Naegele formula. We can arrive at expected date of delivery by adding number 7 to days, subtract number 3 from months and add number one to years of a date of last menstrual period. With transabdominal examination, it is helpful to have a full bladder, which pushes the uterus outside the pelvis, provides echogenic medium for better visualisation and moves the gut out the way of the direction of the ultrasound waves. Midline sagittal section directly above the symphysis enables fast orientation, visualisation of uterus ant its content.

Gestational sac

First, we have to find gestational sac inside the uterus, more specifically in the endometrium. With abdominal probe we usually see it at about 6th weeks of pregnancy. It looks like oval hypoechogenic formation with echogenic brighter ring around it. Frequently it can be found in fundal area, asymmetrically positioned in the uterus. Noticing these features are important for confirmation of a intrauterine pregnancy and exclusion of the extrauterine one. Gestational sac on average grows 1 mm in diameter per day. Baby's heart beats are seen around 6 to 8 weeks. Measuring the diameter of gestational sac can help in confirmation of intrauterine pregnancy, calculation of gestational age and the diagnosis of abortion.

Yolk sac

Yolk sac is another important structure to recognize in gestational sac near the embryo. It is ring-like hypoechogenic structure. On average it is a 3 mm in diameter with maximal diameter of 6 mm at 10th gestational week. Irregular wall or bigger size of the yolk sac can predict in some cases bad outcome of a pregnancy (abortion).

Measuring crown-rump-length (CRL)

In the first trimester CRL measurement represents the most reliable indicator of gestational age. Once determined in this way, expected date of delivery should not be changed later in pregnancy even if discordance is present.

Twins

One of the most important tasks of first trimester ultrasound is to determine the chorionicity of the twins. There are three possibilities – dichorionic diamniotic, dichorionic monoamniotic and monochorionic monoamniotic twins. Twins from two zygotes are only dichorionic, but twins from one zygote can have all three forms, depending on how soon was the zygote division. Ultrasound sign for chorionicity is found at the point where septum leaves the placenta. So called "lambda sign" describes the triangular shape of this origin of the septum from placenta (dichorionic) and T sign (monochorionic). Based on these signs different types of twins have different management later in the pregnancy.

First trimester - pathological findings

GEU, Blighted ovum, missed abortion, incomplete and complete abortion

Not seeing the gestational sac with transabdominal ultrasound even after 8th weeks of pregnancy, should make us think about the possibility of pregnancy outside the uterus (the most frequent place is tube). Beta HCG levels help us in differential diagnosis of extrauterine pregnancy, earlier then expected pregnancy or complete abortion. Blighted ovum refers to empty gestational sac without fetus. Fetus without heart activity is found in missed abortion. In all these cases, information about the last menstrual period is of outmost importance.

Hydrops foetalis

Hydrops foetalis describes the accumulation of fluid in at least two fetal cavities. The most common locations are skin edema, ascites, pleural and pericardial accumulation of the fluid. Hydrops foetalis is often found while measuring nuchal translucency in first trimester, but it can be also found in subsequent examinations.

Second and third trimester - normal findings

In second trimester the focus is on evaluation of fetal growth and fetal anatomy. Ultrasound could be very helpful in determining the position of the baby. From 18th to 24th weeks every pregnant women has ultrasound examination where we measure the baby's bipariatal diameter (BPD), head circumference (HC), abdominal circumference (AC) and femur length (FL). Based on these measurements, the estimate of the fetal weight can be calculated. Reference curves for each of these measurements can tell us if baby is growing properly. Detailed examinations of the structures of the baby's head, face, heart, abdomen and extremities can show us if the fetal development is normal. Useful markers for orientation for general impression about fetal anatomy is cavum septi pellucidi, lateral ventricles and small brains in the head, stomach in the upper abdomen, bladder in the lower abdomen, one bone in proximal extremity (hand and leg), and two bones in distal extremity. During this period we also evaluate the placenta, the umbilical cord and the amniotic fluid. For placenta it is important to determine its position in relation to the inner cervical ostium (placenta previa). It is also important that baby has enough amniotic fluid around him (deepest pocket is bigger then 3 cm). In the third trimester we are interested in determining the position of the baby, its growth (measurement mentioned above), volume of amniotic fluid, location of the placenta.

Intrapartum ultrasound

At the beginning of the labor and during the delivery it is very useful to acquire information about the fetal position and weight, amount of the amniotic fluid and the position of the placenta. For twins it is very useful to evaluate the position of the each fetus in uterus and their relationship to each other. At this time, it is possible with ultrasound examination to evaluate if there are any obstacles to the normal delivery such as myoma, ovarial cyst or large abnormalities of the fetus. This is especially important in cases where pregnant women did not have any prenatal care or there is no written data to confirm that the pregnancy went normally. In terms of intrapartal hemorrhage ultrasound can determine if this hemorrhage is a consequence of the abruption of the placenta. Ultrasound examination can determine if pathological CTG is a consequence of fetal heart arrhythmia or hypoxia (tachycardia or bradycardia). Ultrasound can be used to exclude umbilical cord prolapse. In expulsion phase of the delivery, when fetal head is low, we can use ultrasound to confirm the dorsooccipito position of the fetal head.

Postpartum ultrasound

In postpartal period ultrasound can help us in determining the position of the placenta, and the presence of the residua in the uterus. It can help us in controlling the instrument during curettage.

Conclusion

The obstetrics and gynecology are medical fields where ultrasonography have found large and successful application. With development of handheld devices and wider acceptance of concept point-of-care ultrasonography across the medicine, this new approach will find its role even in the field of obstetrics and gynecology.

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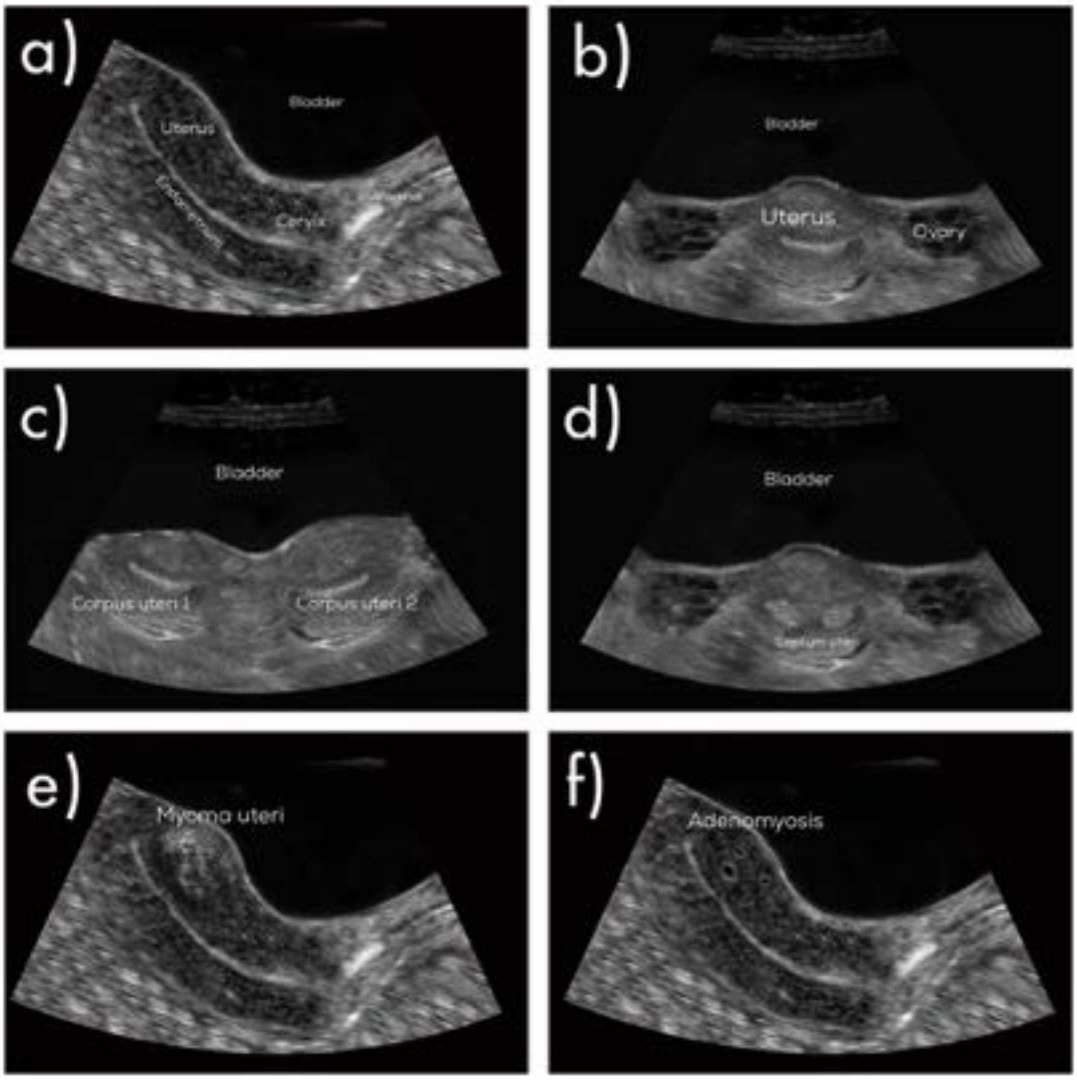
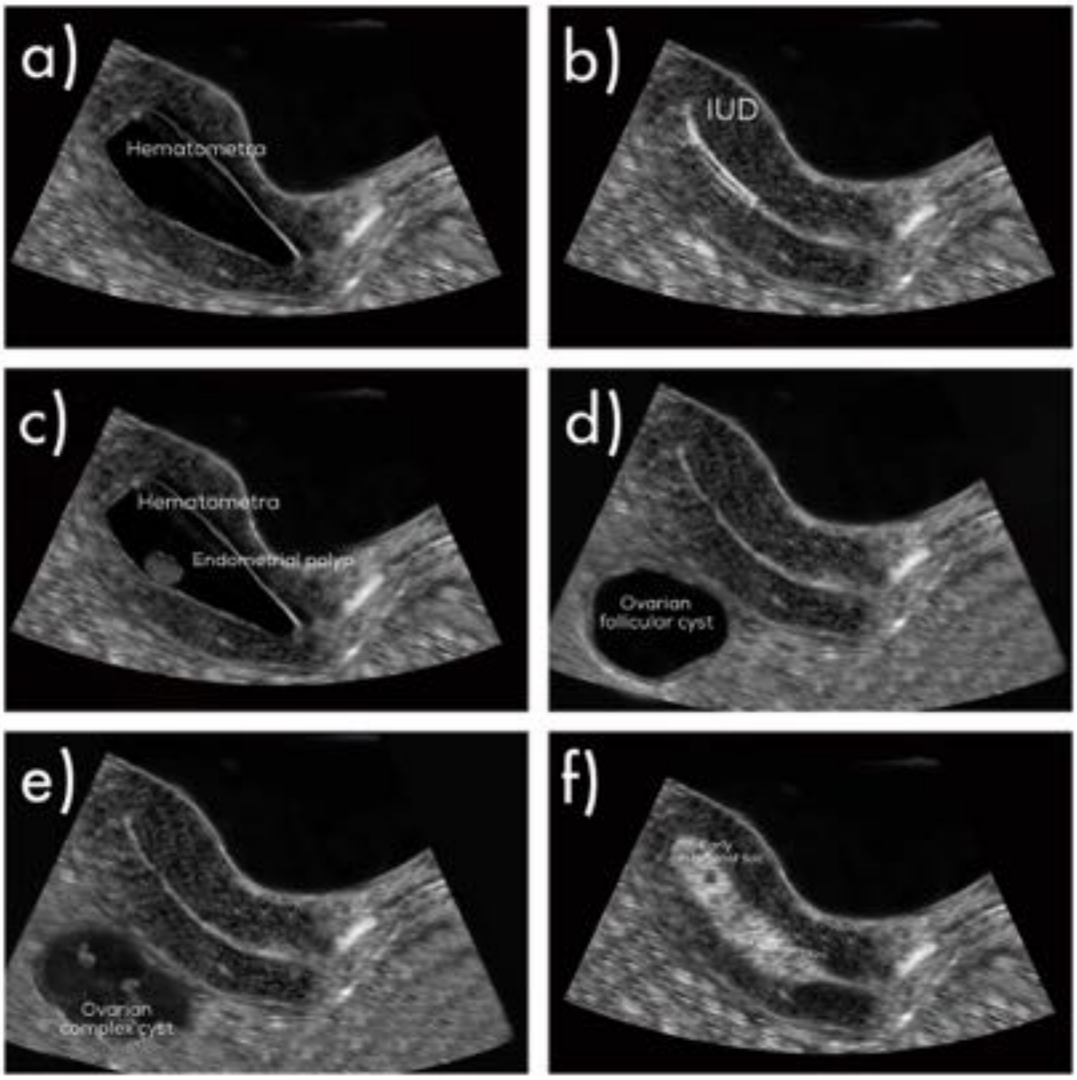
Pictures

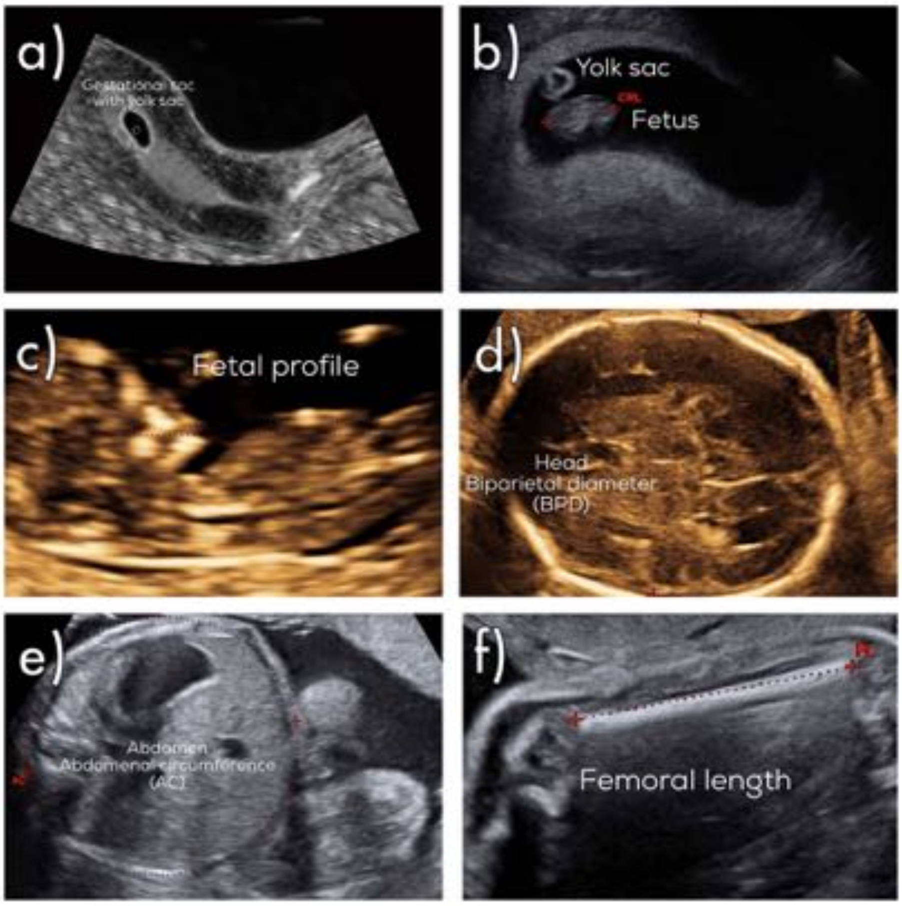
Picture 1: a) transabdominal sagittal section of the uterus, b) transabdominal transverse section of the uterus and ovaries, c) transabdominal transverse section of the uterus didelphys, d) transabominal transverse section of the uterus subseptus, e) transabdominal sagittal section of the uterus with intramural myoma, f) transabdominal sagittal section of the uterus with adenomyosis.



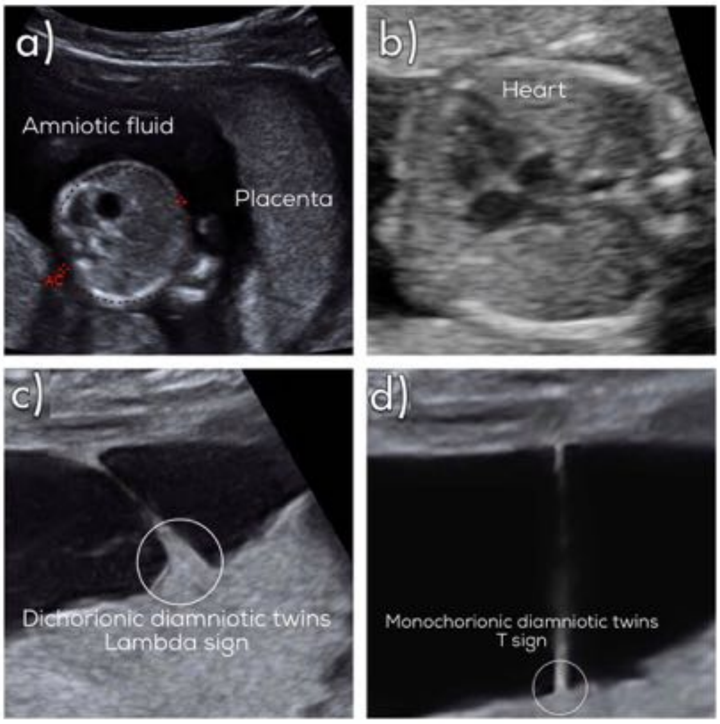
Picture 2: a) transabdominal sagittal section of the uterus with hematometra, b) transabdominal transverse section of the uterus and IUD (intrauterine device – contraception), c) transabdominal sagittal section of the uterus with hematometra and endometrial polyp, d) transabdominal transverse section of the uterus and ovarian simple follicular cyst, e) transabdominal transverse section of the uterus and ovarian complex follicular cyst, f) transabdominal sagittal section of the uterus with gestational sac (very early pregnancy).



Picture 3: a) transabdominal sagittal section of the uterus with gestational sac and yolk sac in very early pregnancy, b) gestational sac with fetus and yolk sac in 7th week of pregnancy, c) Fetal profile in 13th week of pregnancy, d) fetal head – measurement of biparietal diameter in 24th week of pregnancy, e) fetal abdomen – measurement of abdominal circumference in 24th week of pregnancy, f) fetal femur – measurement of fetal length in 24th week of pregnancy.



Picture 4: a) evaluation of the amount of amniotic fluid and location of placenta, b) fetal heart – four chambers, c) lambda sign in dichorionic diamniotic twins, d) T sign in monochorionic diamniotic twins.



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MSK I - BONE

(*This lecture will just concentrate on the usage of diagnostic capability of ultrasound in emergency and critical care*)

Why use ultrasound?

High accuracy /sensitivity/specificity

- Compared with radiography, EP US is an accurate diagnostic test to rule in or rule out extremity fractures. The diagnostic accuracy for history and physical examination are inconclusive [1].
- Emergency physicians can accurately evaluate long bone fractures in the ED using POCUS. In particular, long bone fractures can be excluded with a high degree of confidence [2].
- Ultrasound scans by minimally trained clinicians may be used to rule out a long-bone fracture in patients with a medium to low probability of fracture [3].
- Clinicians with focused ultrasound training were able to diagnose fractures using point-of-care ultrasound with a high specificity rate [4].
- Point-of-care ultrasonography is highly sensitive for elbow fractures, and a negative ultrasonographic result may reduce the need for radiographs in children with elbow injuries [5].
- Ultrasound imaging performed by emergency sonologists showed excellent sensitivity and specificity in the diagnosis of hand fractures [6].
- Extremity ultrasound can be performed quickly and accurately by nonphysician personnel with excellent accuracy [7].
- Sonography reveals more fractures than radiography and will reveal fractures in most patients presenting with suspected rib fracture [8].
- Early ultrasonography is more accurate than clinical and radiologic evaluation at detecting rib and sternal fractures [9].

Faster Diagnosis and time-saving

- Non-life-threatening skeletal injuries are often kept waiting for hours for treatment because radiographic examination is delayed. Bedside ultrasound has the potential to be a quick, noninvasive alternative for identifying bone fractures in the ED setting [10].

Portability

- Can be done as a bedside examination
- Repeatable

Avoid multiple check X-Ray / Decrease radiation

- Ultrasound is comparable to X-ray for the detection of fractures. Ultrasound should be the first imaging method in children with trauma and nonspecific clinical signs or indistinct location of pain, followed by X-ray exams of the predefined region [11].
- Bedside ultrasound performed by pediatric emergency medicine physicians is a reliable and convenient method of diagnosing forearm fractures in children. It is also useful in guiding the reduction of these fractures [12].

- Useful in ultrasound-guided fracture reduction of pediatric forearm fractures in the ED [13].

Practicality (undeserved /disaster /austere /remote setting)

- Use of clinician-performed point-of-care ultrasound to diagnose fractures is not only feasible in traditional healthcare settings, but also in underserved or remote settings
- The increasing availability of lightweight, robust, user-friendly, and low-cost portable ultrasound equipment is particularly suited for use in the physically and temporally challenging environment of a multiple casualty incident (MCI) [14].
- Ultrasound by an experienced clinician in the austere environment can be performed accurately and can possibly prevent unnecessary evacuations for suspected fractures requiring radiographic verification [15].

Technique

Probe selection

- High frequency linear probe (7.5 -15 Mhz), except for deep structures e.g neck of femur or vertebral bone (may require low frequency probe).

Views

- Longitudinal
  - scan along entire bone from between proximal and distal suspected fractutre site /tenderness [Fig. 1].
  - note haematoma , depth of soft tissue and cortex
- Transverse
  - turn 90 degrees at site of disruption [Fig. 2] and [Video 1].

Normal anatomy

- Bone is a bright reflector
- Normal cortex is smooth and uninterrupted

Focused questions

- Is there an interruption in the bony cortex and surrounding haemotoma / soft tissue injury [Fig. 1-3] and [Video 1-2]?
- Can a degree of angulation or displacement be assessed?

Fig 1: A longitudinal scan showing a clavicle fracture seen as cortex discontinuity / interupted (arrow) with surrounding haematoma.

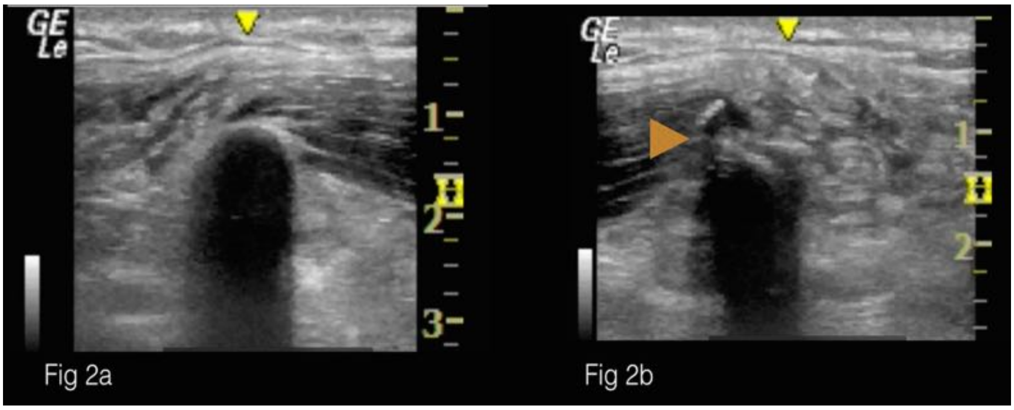

Fig 2a: Tranverse scan of clavicle bone showing a normal smooth and uninterupted cortex. **Fig 2b**: Tranverse scan showing a fracture clavicle with surrounding haematoma.

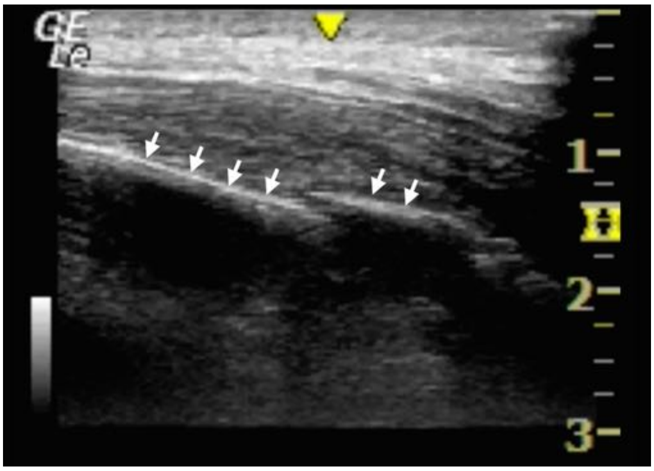

Fig 3: Skull fracture as indicated by cortex discontuinity.

Pathology /Non-trauma application

Many types of pathology can be identified as cortical irregularities including Hill-Sachs disease, osteolytic lesions, exostoses, and osteophytes.

Ultrasound can effectively assess the extraosseous component of malignant and aggressive benign lesions and those tumours arising from the surface of the bone (Periosteal reaction, cortical destruction, pathological fracture, matrix mineralization, fluid-fluid levels and involvement of the neurovascular bundle) [16].

How to improve image quality?

Water bath technique

- The water bath replaces the need for ultrasound gel or contact between the ultrasound transducer and the patient's skin, thus eliminating discomfort. [17].

Pearls and Pitfalls

- Bone is too superficial or site TTP - Use standoff pad or water bath
- Can't find a break - Use your physical exam to guide position of probe
- Strange anatomy -Look at the contralateral side
- Pathologies wherein tendons pull a portion of cortical bone away from the bone surface, such as Osgood-Schlatter disease and avulsion fractures, are often well depicted with ultrasound.

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Video

Video 1: Tranverse scan of clavicle showing cortex discontuinity and surrounding haematoma.

Video 2: Scan showing a skull fracture with interuptted cortex.

Aleksandar BILIĆ, MD

REGIONAL ANESTHESIA

For the past decade regional anaesthesia has gained popularity mainly as a result of the use of ultrasound. It has made the technique not only safer, but also much more interesting. So far, vast majority of regional nerve blocks have been reserved for use only in operating theatres for elective procedures. However, its use should not be limited to procedural pain only, because it is also a very useful tool in the treatment of urgent, accident pain. If we look at things from the patient's point of view, regional block is very effective and we should learn how to safely implement regional anaesthesia as soon as possible. If you are an emergency doctor, you must ask yourself a lot of questions about the matter. I will only present the basic ones.

Why should we use regional anaesthesia in emergencies?

Because it is an excellent way of helping a patient in pain, without affecting his mind with opiates and anaesthetics. Therefore, we should consider the use of a block only in conscious patients. Anaesthetists use blocks for postoperative pain, performing them in sedation or under general anaesthesia, but it seems logical that the approach should be different for emergencies.

Where should we perform the blocks?

If we concentrate on regional anaesthesia for emergency medicine, we should consider two options. The first is the performance of regional blocks in the field, and second is in Emergency departments. Indeed, there are some blocks that have to be performed in hospital only, namely neuro-axial blocks (epidural, paravertebral, spinal). However, most of peripheral nerve blocs can also be performed in the field, provided that there is a trained person fully equipped for that action there.

Which basic blocks should I learn?

Probably, the basic blocks, we should learn, are peripheral blocks of extremities. They are easy to perform and do not have a very steep learning curve. Ultrasound guided nerve blocks of the upper extremities affect the nerves of brachial plexus. It can be blocked in several locations. Most popular are:

- Scalenus nerve block
- Supraclavicular block.

Both cover almost the entire arm. If we need, we can also use radial, ulnar, or median nerve block.

Basic blocks for the lower extremities are:

- Sciatic nerve block (proximal – gluteal or subgluteal region, and distal – popliteal),
- Femoral nerve block,
- Adductor canal block.

The sciatic mainly covers the posterior aspect of the leg, and the femoral mainly the anterior. Adductor canal covers the anterior aspect of the leg, and it is only a sensory block, which makes it even more interesting.

There are also some blocks that could well be used in the field for broken ribs – the so called intercostal blocks. They do carry the risk of pneumothorax, but given proper training in ultrasound (FAST), one should be able to perform them safely.

Which are the possible side effects of regional anaesthesia?

We worry about:

- Allergies – rare, but possible
- Systemic toxicity – tachycardia, cramps, seizures, loss of conciseness, respiratory arrest, cardiac arrest – follow "lipid rescue protocol"
- Patient refusal
- Nerve damage

- Compartment syndrome

What is "lipid rescue protocol"?

We follow this protocol when we have obvious local anaesthetic toxicity with respiratory or cardiac arrest. It includes giving lipid infusions to patient.

How do we start with regional anesthesia?

Organised courses – cadaver workshops – are the best way to start. They are organised by ESRA (European society for regional anaesthesia) in Europe, or ASRA in America. At the moment. Vast majority of regional anaesthesia is performed by anaesthetists. Therefore, there must be somebody among them willing to help you learn. There are 12 centres of excellence in Europe. You can have a "hands on" guided lessons there. It is not wise to start on your own without supervision, so it is recommended that your first blocks are well planned.

In summary, regional anaesthesia should have a future in Emergency medicine. All we need to do is filtrate suitable conditions, and learn how to do it.

Track D1: FREE TOPICS

Track D2: POCUS IN PEDIATRIC CARE

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Dr. Doniger is currently the Co-Director of Pediatric Emergency Ultrasound and the Program Director of the Pediatric Emergency Medicine Fellowship program at New York Methodist Hospital in Brooklyn, NY. Following her training in Pediatrics and Pediatric Emergency Medicine, she was the first to complete an additional Emergency Ultrasound Fellowship in 2008.
Since that time, Dr. Doniger has authored and co-authored numerous book chapters, articles and other publications on point-of-care ultrasound. She edited the first textbook "Pediatric Emergency and Critical Care Ultrasound", and has lectured on national and international levels. She is currently the American College of Emergency Physicians (ACEP) Pediatric Ultrasound Subcommittee Chair. She also serves on the Board of Directors of WINFOCUS and is in charge of organizing pediatric point-of-care ultrasound education throughout Latin America.

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PEDIATRIC POCUS: WHERE WE'VE BEEN … WHERE WE'RE GOING

Emergency Ultrasound, or bedside ultrasound, or point-of-care ultrasound (POCUS) began in the adult Emergency Department (ED) in the 1980's. Only in the past 10 years has ultrasound become prevalent in Pediatric Emergency Medicine. Some reasons in the past have included the lack of machines, money, and trained personnel. Now there is an exponentially growing group of fellowship-trained pediatric point-of-care ultrasound experts and interest is increasing worldwide. The first textbook for Pediatric POCUS was published in 2014 (1).

What makes pediatric POCUS so different from adult POCUS? Initially, we started with borrowing from the "adult applications". These include some of the "basic 6" initially presented by the American College of Emergency Physicians (ACEP): E-FAST, cardiac, etc. The first, rather basic "pediatric-specific" applications included the evaluation of bladder volume prior to catheterizations (2). This was followed by the evaluation of the Inferior Vena Cava (IVC) as a measure of hydration status. Unfortunately, studies for the IVC have not been able to be validated in children (3).

More recently, we have moved beyond the "borrowed" adult applications or the "basic" pediatric applications and have developed some important core applications, specific to the practice of PEM. These applications are often referred to as "The Pediatric Abdomen" and include appendicitis (4,5), intussusception (6), and pyloric stenosis.

Now that we are developing a critical mass of pediatric POCUS experts and its use is increasing, what are the emerging applications? Lung ultrasound has been shown to be accurate in diagnosing pneumathoraces. But lung ultrasound has become so much more, and can rapidly and accurately identify pleural effusions and consolidations (7). The uses for lung ultrasound will continue to expand, and lung ultrasound will likely serve as one of the "core" important applications for children in the near future.

In addition to the already-established applications in the literature, there are additional applications that are likely to continue to evolve. While there is currently a paucity of literature regarding these topics, they serve as potential applications unique to our pediatric patients.

The "head and neck" encompasses several applications including: endotracheal tube placement (8), the identification of esophageal foreign bodies (9), and neck masses. In particular, the use of POCUS for neck masses can easily distinguish between an enlarged lymph node, and abscess, or congenital abnormalities (i.e. thyroglossal duct cysts, branchial cleft cysts, etc.).

Ocular ultrasound is another application that may serve as an important one for children in the future. Especially since ophthalmic examinations in children are inherently much more difficult to perform, POCUS can provide a wealth of information quickly at the beside. While the use of POCUS for globe rupture has been controversial in the past, a recent study showed that with a careful examination, the application of the transducer on the eye does not increase the intraocular pressure, in healthy volunteers (10). Extreme care must be taken when using POCUS for this use. Additional emerging applications, are to use POCUS in order to identify retina hemorrhages in the situations of non-accidental trauma (11).

These are only a sampling of a few of the applications. Many pediatric POCUS experts believe that bowel ultrasound will continue to develop, and will become increasingly useful for the clinician, well beyond the traditional applications of the "Pediatric Abdomen". Recently, a novel POCUS application was studied, in diagnosing constipation in pediatric patients (12). POCUS can also be utilized in several tropical infectious diseases, such as malaria, dengue, and intestinal parasites (i.e. Ascariasis) (13). There are specific courses on the use of POCUS in Tropical Infectious Diseases (in Lima, Peru January 2017 cherndon@augusta.edu).

So now that POCUS has become more prevalent in the practice of Pediatric Emergency Medicine, we need to ensure that clinicians are properly trained in these applications. Previously, a significant roadblock was the lack of pediatric-specific guidelines. In 2015, these guidelines jointly endorsed by the AAP, ACEP and WINFOCUS were published. This document largely focused on specifying two pathways that a clinician may obtain training: a training-based pathway (i.e. PEM fellowships, US fellowships) and a practice-based pathway (14).

In addition, there are growing resources for training for the clinician. WINFOCUS provides comprehensive 2-day pediatric POCUS courses. There is an additional pathway for "Advanced" certifications www.winfocus.org . A new organization, P2 Network was developed: p2network.com in order to provide an organizational "home" for those trained in pediatric POCUS. There are several committees, including "education" and "research" with several ongoing projects. For those interested in pursuing a dedicated Emergency Ultrasound or Pediatric POCUS fellowship, more information can be found at: eusfellowships.com.

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THE PEDIATRIC E-FAST AND THE TRAUMA INTERNATIONAL CONSENSUS CONFERENCE (ICC)

Trauma is the leading cause of death & disability of children worldwide. Pediatric Emergency Medicine (PEM) is a relatively new field of medicine, few specialists worldwide The management of trauma in children, is derived from ATLS guidelines for adult trauma victims. In this scenario, children are often considered as "small adults," since the essential principles of trauma management are the same. However, in pediatric patients, it is especially important to consider radiation exposure and its subsequent risk for contributing to lifetime cancers. It is for this reason, the management of a pediatric trauma patient should take this into consideration and reduce radiographs and CT scans whenever possible. It is interesting to note, that one Abdomen/pelvis CT scan is equivalent to 500 X-rays.

The Focused Assessment Sonography for Trauma (FAST) was initially developed in 1999 after the First International Consensus Conference on Ultrasound and Trauma was developed to determine whether fluid/blood is present in the abdomen. More recently, the Extended- FAST expanded the FAST examination to include the evaluation of the thorax. The use of the FAST ultrasound examination has largely replaced the need for Diagnostic Peritoneal Lavage (DPL). The yes/no questions that the FAST answers at the bedside are:

1) Is there free fluid/blood in the abdomen?
2) Is there fluid/blood in the pericardium
3) *Is there air or fluid in the thorax?*

The literature in support of the use of the E-FAST for trauma, has largely focused on adult trauma patients (1). The FAST has been shown to have a FAST SN 70%, SP 100%. When combined with the physical examination, the sensitivity for the FAST approaches 100% Unfortunately, there is a paucity of literature with regards to applying the E-FAST to pediatric patient populations (2).

One of the limitations to developing robust studies and literature for the FAST in pediatrics, is that few people are actually using the FAST in pediatric patients. Some of the reasons why this may be, include: the mechanisms are different in pediatric and adult trauma patients, and there are several perpetuated myths in the pediatric surgery and PEM communities.

Since the E-FAST has become the standard in the evaluation of the adult trauma patient, and has evolved since its inception in 1999, the 2nd International Consensus Conference (ICC) on Ultrasound in Trauma was convened in October, 2013. Other International Consensus Conferences included those for lung ultrasound (3), ultrasound-guided vascular access (4), and focused cardiac ultrasound (5). The ICC is comprised of a group of experts, who review all of the literature and Group of experts, review all of the available literature, vote on the strength of particular recommendations. For the 2nd ICC for Ultrasound in Trauma, there have been additional meetings in Belo Horizonte, Brasil and Boston, USA. The group is currently voting on the statements derived from the literature. Ultimately, this will result in updated recommendations for the E-FAST with a potential renaming of the FAST/E-FAST.

For the 2nd ICC for Trauma in Ultrasound, there are particular “Domains” and “Subdomains” which each statement falls under. Some of the major “Domains” Include: background, technique, clinical integration, safety/harm, education/training, secondary survey and future directions. Pediatric POCUS is a subdomain, and currently has 27 statements that are being voting on. Many of the statements fall under the categories of the “Domains”. In the final manuscript, Pediatric POCUS statements will either be integrated throughout, or have its own distinct section. The major statements involve the following topics:

The *technique* for performing the E-FAST in pediatric patients is *essentially* the same as in adult patients, with a few minor exceptions. The views are the same in adult and pediatric patients:
1) Morison’s
2) Splenorenal
3) Suprapubic
4) Subxiphoid (alternative Parasternal Long-axis)
5) Lung (right and left)

Since children are generally smaller and structures are more superficial, it is recommended to decrease the depth to see structures appropriately, it is also advised to use a smaller footprint, higher frequency transducer whenever possible. However, a major different between adult and pre-pubertal children, is that the suprapubic view: the most sensitive region for detecting fluid (6). As a result, consider performing first, perform both the transverse and sagittal views in children.

Another major focus of the pediatric statements, include *decreasing the use of ionizing radiation*, and utilizing an “ultrasound first” approach (7,8,9).

In addition, how we use the E-FAST in children may be different than that of adult trauma patients, since the management relies largely on non-operative management. This is an example of a clinically-integrated approach, in which the clinician doesn’t rely solely on the E-FAST but combines it with the trauma mechanism, physical examination findings, and laboratory results. It has been shown that in combining laboratory results with the E-FAST, the clinician can improve the test characteristics of the E-FAST in children (10). With this algorithm, the clinician can determine wither the child needs a CT scan or radiographs. And the disposition can be determined: the OR, Admit for observation, ER observation, or discharge home.

Other statements involve the future of the use of the E-FAST in pediatric patients. There is potential for serial US examinations to be important in the management of pediatric trauma patients. In addition, the use of contrast-enhanced US may help in the staging of liver and splenic lesions that may further help decrease the use of CT scans. Finally, additional research needs to be performed on the test characteristics of the FAST specifically in pediatric patients and in outcomes.

Finally, several statements focus on pediatric-specific training for the use of the E-FAST in children. This is in-line with the pediatric guidelines that were recently published in 2015 that were jointly endorsed by the AAP, ACEP and WINFOCUS (11).

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PEDIATRIC LUNG ULTRASOUND

Objectives:

Review - How to Thoracic Ultrasound
Lung ultrasound indications and images normal and abnormal
BLUE and FALLS Protocols
Applications in Pediatrics: Bronchiolitis, pneumonia, pneumothorax, Effusion and more
Current Literature and Future Direction

Review Basics – Artifacts

A Lines - The pleural surface acts as an acoustic reflector with resulting distal reverberation artifacts - semi-circular arches at varying distance from the top of the screen

B Lines/Comet Tails - As fluid accumulates in lung artifacts develop from sound waves across air & fluid - Bright laser-like rays from the pleural line to bottom of the screen. Can signify ARDS, pulmonary edema, bronchiolitis, and pneumonia . More than two rays on the screen, in more than two areas of the chest, bilaterally. B-lines can be a normal finding in lung as long as it is fewer than three and they may be termed comet tails or lung rockets.

Thoracic/Lung ultrasound is currently one of the most popular applications of bedside ultrasound. It was found to be more sensitive and specific than chest X-ray for pleural effusion, pulmonary edema, and pneumothorax evaluation. Several studies in the Emergency Department look at lung ultrasound at the bedside and compare it to chest x-ray. They indicate that lung ultrasound has a higher sensitivity than x-ray: CXR 52% while ultrasound had 92%. Although CXR has a high specificity we know that ultrasound is highly specific as well.

Findings on thoracic ultrasound include but are not limited to Pneumothorax, normal aeration patterns, alveolar-interstitial patterns, consolidation, and pleural effusion.

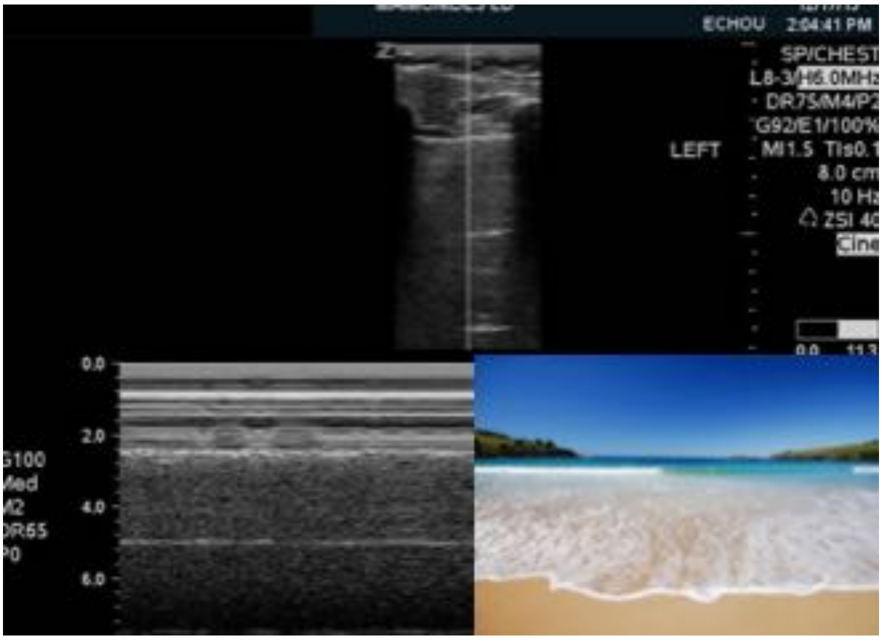
Lung Ultrasound Technique and Probe Selection:

Image acquisition is best with the linear probe but you may use the phased array or curvilinear probe as well.
Using the high frequency linear probe, place the probe on the anterior chest wall at the 3rd-4th intercostal space and midclavicular line.
Place the patient seated or supine with arms abducted as much as possible. Orient the marker towards the head and scan across the intercostal spaces in a longitudinal direction. Ensure the rib shadows are on the lateral edges of the image.

The best approach is a methodical one viewing the anterior chest, mid axilla and posterior chest on both left and right sides. This ensures you cover the entire area. Similar to the blue protocol, which was developed to assess lung in acute respiratory failure, this will assure a more thorough approach to evaluating the lung.

The typical view we see on ultrasound is called the "bat wing sign" two ribs separated by pleural line.

A normal lung should have lung sliding which represents the movement of the parietal and visceral pleura. It is visualized as subtle white shimmering line at the pleural interface synchronous with respiratory cycle. At times you may see A-lines this is a normal reverberation artifact generated by the parietal pleura. You can confirm this using M-mode (which shows motion over time) this image is called the seashore sign. The ocean/waves represent the chest wall and pleura and the shimmering sand represents the normal lung movement.



Absence of lung sliding Indicates the following possibilities:
Apnea, Mainstem intubation, Mainstem obstruction, severe parenchymal lung disease, or Pneumothorax

Pneumothorax:

CXR has a misdiagnosis rate of 30-40%.
Gold standard is CT scan.
LUS in the diagnosis of Pneumothorax has a Sensitivity 95 %, specificity 94%.
On ultrasound there will be no lung sliding. To confirm M mode will show a barcode sign or stratosphere sign.

Another way to determine a pneumothorax is the lung point sign:
it is usually found at the border of partially collapsed lung and pneumothorax. If it is visualized at the anterior chest wall (small ptx) Lateral/Posterior chest wall (large ptx). It is 100% diagnostic/specific for pneumothorax, but low sensitivity (66%)

Power Slide:

Using Power Doppler to pick up subtle flow is highly sensitive. If there is lung sliding present power Doppler with light up the sliding pleural line with color flow.

Lung Pulse Sign:

Rhythmic movement of the pleura in synchrony with cardiac rhythm.
Best viewed in areas of lung adjacent to the heart. It is a result of cardiac vibrations being transmitted to the lung pleura in poorly aerated lung. In a normal well-aerated lung this sign is not present. Must remain steady when performing and decrease patient movement to avoid false positive result.

BLUE and FALLS Protocols:

Some protocols used in the adult emergency department setting include: the bedside lung ultrasound in emergency (BLUE)-protocol for the immediate diagnosis of acute respiratory failure and the fluid administration limited by lung sonography (FALLS)-protocol for the management of acute circulatory failure. These applications require the mastery of 10 signs indicating normal lung surface (bat sign, lung sliding, A-lines), pleural effusions (quad and sinusoid sign), lung consolidations (fractal and tissue-like sign), interstitial syndrome (lung rockets), and pneumothorax (stratosphere sign and the lung point). These signs have been assessed in adults, with diagnostic accuracies ranging from 90% to 100%, allowing consideration of ultrasound as a reasonable bedside gold standard.

The **BLUE protocol** was designed for the main disease; pneumonia, congestive heart failure, COPD, asthma, pulmonary embolism, pneumothorax, with an accuracy 90%.

The **FALLS protocol** sequentially rules out obstructive, then cardiogenic, then hypovolemic shock and expediting the diagnosis of distributive (usually septic) shock.   These protocols have not been well studies in pediatrics but can contribute to clinical evaluation as well.

Other Findings and Pediatric Specific applications:

Artifacts (B-lines), Consolidations/Pneumonia, Pleural effusions Bronchiolitis, In Newborns; RDS, TTN.

B-lines:
Reverberation artifact. Multiple can represent "wet lung"; CHF, ARDS, interstitial lung disease, Bronchiolitis.
Two or less can still be seen in normal lung. More than that is abnormal.

Consolidation:
Studies showed that the ultrasound signs of lung and pleural diseases described in adults are also found in pediatric patients. In suspected pneumonia, lung ultrasound has demonstrated to be no less accurate than CXR. Data suggest that, when there is clinical suspicion of pneumonia, a positive lung ultrasound excludes the need to perform CXR.

On ultrasound Airless lung has tissue density. This is described as hepatization, where lung looks like liver.

Consolidation may not always be pneumonia.
Alveolar consolidation can occur with pneumonia or other alveolar filling process. It can occur with atelectasis from compression (pleural effusion), or resorptive (bronchial obstruction) Bright white - air bronchograms (static vs. dynamic).

Dynamic air bronchograms:
- Air within the bronchi move toward the periphery during inspiration;
- Specificity 94%, positive predictive value 97% for lung consolidation.

Static air bronchograms:
- No respiratory variation;
- Air bubbles trapped within the respiratory circuit.

Pneumonia:
Tissue like sub pleural lung consolidation. Air bronchograms appear scattered, branching pattern they are Dynamic air bronchograms.

Atelectasis is similar echogenicity to the liver. Air bronchograms are static and appear crowded and parallel.

Pleural Effusions:
Appears as an anechoic (black), or hypoechoic compared to the liver.
Area surrounded by typical anatomic boundaries - inside of the chest wall, the diaphragm, and the surface of the lung. May see echogenic material within (septations, cellular debris, etc..).

Spine sign - persistence of spine shadow. This occurs because the effusion consists of fluid, which acts a better medium for the ultrasound beams to penetrate thus allowing us to visualize the entire spine, which was once blocked due to the air filled lung.

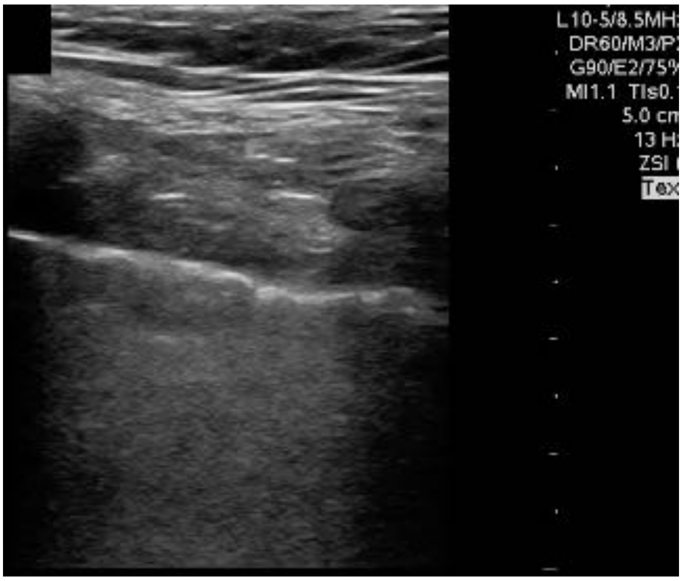
Quad sign - is static sign of Pleural effusion
Sinusoid - is a dynamic sign of Pleural effusion using M mode

LUS is superior to supine CXR in diagnosis of pleural effusion. Evidenced by the Quad sign or the Sinusoid sign with a Specificity of 97% when compared to the gold standard of thoracentesis and Sensitivity and specificity of 93% when compared to CT scan. Extension of the spinal stripe is very sensitive as well.
Ultrasound guided Thoracentesis: decrease complication rate, is easy to learn, real time evaluation of the pleural space, improves yield and should be standard of care.

Pediatric Specific:

Bronchiolitis:

Clinical diagnosis that consists of wheezing, cough, fever, tachypnea, retractions, hypoxia. +/- response to albuterol, steroids, nebs, there is no consensus. So How can we risk stratify? Does Ultrasound help. X-rays are not very helpful in the diagnosis. On ultrasound we can visualize B-line, sub-pleural consolidations, and lumpy bumpy irregular pleura and sometimes effusions.



The irregular pleura can be due to chronic changes and a diseased lung (ie. Pneumonia, ARDS, bronchilotis.) A study in 2011 in Journal of pediatrics, found that ultrasound is much more sensitive in bronchiolitis than cxr. They found that the combination of B-lines, lumpy bumpy pleura and sub-pleural consolidations could indicate disease severity. CXR could potentially miss these findings. Although having one or the other findings did not seem as specific, having all three did indicate a more severe disease and longer hospital course.

A study we conducted at my institution at New York Methodist Hospital last year looked at the number of B-lines and if this indicated disease severity. The number of B-lines did not make a difference but we did confirm that having all three of the findings correlated with a more serve disease course, longer hospital stay, and repeat ultrasound showed resolution of these B-lines.

The wheezing Child – a study in the EM Journal 2015
Study looked at children with respiratory tract infections and wheeze
A positive LUS seems to help distinguish between clinical syndromes by ruling in pneumonia and ruling out asthma.
B-lines were seen in 80%, consolidation in 64%, pleural abnormalities in 23%. The proportion of positive LUS, along with their diagnostic accuracy; had a sensitivity (95% CI), specificity (95% CI). Thus possibly eliminating the need for cxr.

Future of pediatric Lung Ultrasound

Could Lung Ultrasound be used as a point-of-care tool, to guide diagnosis and disposition in children with wheeze. Lung ultrasound to replace CXR in diagnosing pneumonia in children?!

International Consensus Conference on Lung Ultrasound (ICC-LUS) provide evidence-based recommendations on "point-of-care" LUS with a promise of update every four years or whenever there is major change in evidence.

Recommendations provide unified approach and language for six major areas of LUS (terminology, technology, technique, clinical outcomes, cost effectiveness, and future research).

Summary:

View at least 3 areas on each side
Repeatable
Quick and simple to perform
Multiple ways to confirm lung sliding

May pick up findings that x-ray will miss
Similar findings in children to adults.
Highly specific

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"POCUS saves lives every day. NOT using it is doing your patients a disservice. NOT teaching it is doing your students a disservice."

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PEDIATRIC POCUS IN RESUSCITATION AND SHOCK

Objectives:

- To adapt the RUSH exam for pediatric patients
- To recognize the usefulness of POCUS during resuscitation and shock in Airway, Breathing, Circulation

Background: Shock

"Acute syndrome that occurs because of cardiovascular dysfunction and the inability of the circulatory system to provide adequate oxygen and nutrients to meet the metabolic demands of vital organs."

Background: Types of Shock

1. Hypovolemic: Hemorrhage or loss of other body fluids
2. Cardiogenic: Pump failure
3. Distributive: Sepsis, anaphylaxis, or neurogenic causes
4. Obstructive: Pericardial tamponade, large pulmonary embolus, or tension pneumothorax

RUSH (rapid ultrasound in shock and hypotension) Exam

- Incorporates traditional elements of bedside ultrasound that focus on patient anatomy with newer techniques that allow real-time interpretation of patient physiology
- Noninvasive
- Improves the accuracy of the initial diagnosis and care plan of a patient in shock
- Provide a means for continued hemodynamic monitoring as treatment is rendered
- In the past, ultrasound was used primarily to assess anatomy and pathology, but its ability to assess critical physiology has become increasingly apparent

Step 1 The Pump ~ Cardiac

1. Pericardial effusion
2. Cardiac tamponade
3. LV contractility --> cardiogenic pump failure
4. Rt vent strain --> PE
5. RV dilation (same or bigger than LV) --> PE

Step 2 The Tank: Fullness~ Vascular/Abdomen

6. Evaluate vascular volume
   Inferior vena cava
   Jugular Vein

7. Evaluate extravascular volume
   Intestinal

IVC

8. IVC-to-aorta ratio of less <0.8 = Volume depletion
9. IVC that collapses more than 50% is concerning for hypovolemia
10. IVC with little respiratory variation and plethoric = concern for right-sided heart overload, strain or hypervolemia
11. Poor LV function in the setting of an enlarged, non-collapsible IVC is highly suggestive of cardiogenic shock.

Step 2 The Tank: Leakiness ~ Thoracic/Abdomen

15. Extravasation of fluid into the thoracic and/or abdominal/pelvic body compartments
16. E-Fast:
    pleural fluid
    abdominal fluid/air
17. Bowel obstruction
    Window box abdomen
    Look for ringed mass (intuss)
    Lack of peristalsis
    Dilated thick bowel
    Free fluid

Step 2 The Tank: Compromise

18. Lung
    a. Pneumothorax
       Barcode sign
    b. Pneumonia
       B lines indicates pulmonary edema and tank overload
       Tissular appearance of lung
       Pleural effusion
19. > 3 B-lines within a single lung interspaceare pathologic and c/w pulmonary edema
20. Adult studies show that B-lines facilitate the diagnosis of pulmonary edema from heart failure

Step 3 The Pipes

21. Femoral and popliteal DVT
22. indirect PE evidence

Step 1 The Pump

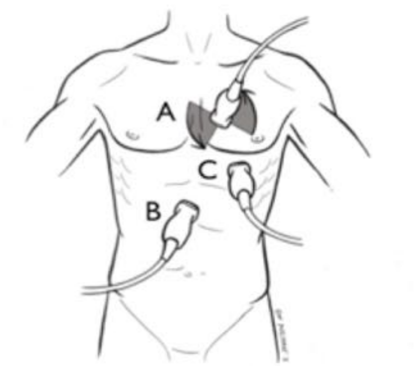

Figure 1. Evaluation of the Pump
A. Parasternal views (long/short axis)
B. Subxiphoid view
C. Apical view

Step 2 The Tank: Fullness

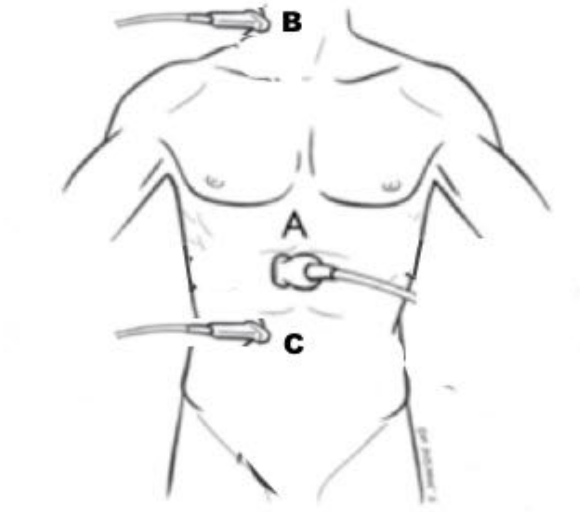

Figure 2. Evaluation of the Tank
A. Inferior vena cava (long axis)
B. Jugular vein
C. Intestinal

Step 2 The Tank Leakiness

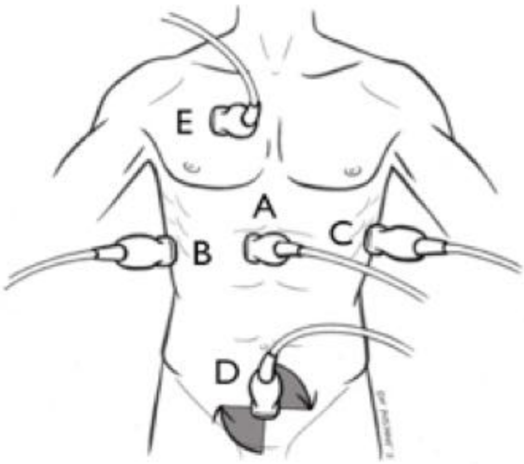

Figure 2. Evaluation of the Tank
A. Inferior vena cava (long axis)
B. FAST (right upper quadrant, add pleural view)
C. FAST (left upper quadrant, add pleural view)
D. FAST (pelvis)
E. Pneumothorax
FAST = focused assessment with sonography in trauma

Step 2 The Tank Leakiness

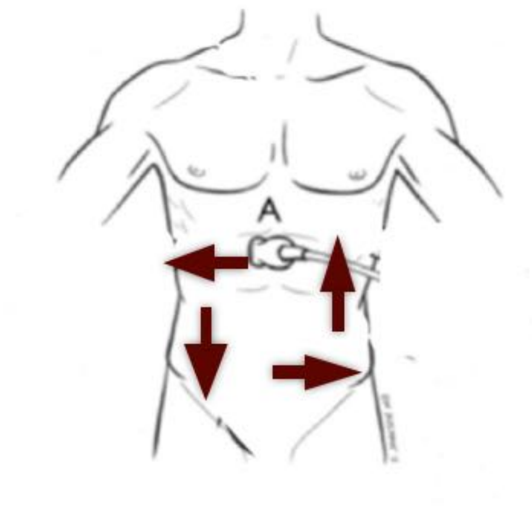

Figure 2. Evaluation of the Tank
A. Bowel obstruction

Step 2 The Tank: Compromise

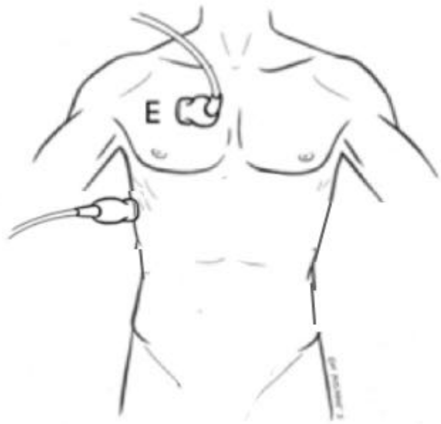

Figure 2. Evaluation of the Tank
E. Pneumothorax/Pneumonia

Step 3 The Pipes

Figure 1. Evaluation of the Pipes

5. Femoral DVT
6. Popliteal DVT

DVT = deep vein thrombosis

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"POCUS saves lives every day. NOT using it is doing your patients a disservice. NOT teaching it is doing your students a disservice."

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THE PEDIATRIC ABDOMEN: APPENDICITIS, PYLORIC STENOSIS, INTUSSUSCEPTION, BOWEL

Objectives:

Recognize the sonographic appearance of common pediatric abdominal disorders: Appendicitis/Intussusception/Pyloric Stenosis/Bowel.

Probe selection for all these studies is the high frequency linear probe.

Appendicitis

Background

- Blind ended tubular structure originating from the cecum
- Usually lies over-top the psoas muscle & external iliac vessels
- Normal appendix can be difficult to visualize by US
- US is specific (85-98%) but not sensitive for appendicitis

Anatomy

- The base of the appendix attaches to the postero-medial wall of the cecum, just inferior to the end of the ileum
- The tip can be found in a retrocecal, pelvic, subcecal, pre/postileal, or right pericolic position

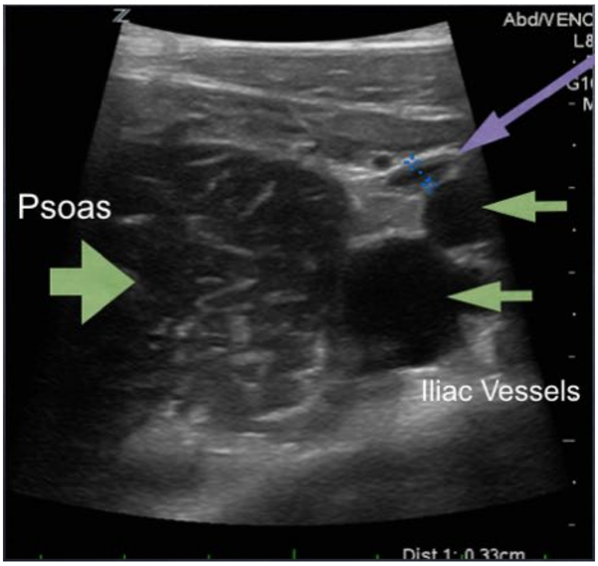
Scanning Protocol

1. Where does it hurt?
2. Graded compression: Gentle pressure to push away bowel loops
3. Start at the level of the colon by umbilicus
4. Localize psoas muscle and move laterally to curvature of abdominal muscles
5. Localize large bowel (cecum), no active peristalsis
6. Follow lateral margin caudad
7. Sweep medially to localize psoas and iliac vein and artery
8. Look for appendix overlying these structures
9. Color doppler to assess hyperemia and inflammation
10. Complete exam from the pelvis to the iliac vessels to the inferior aspect of the liver

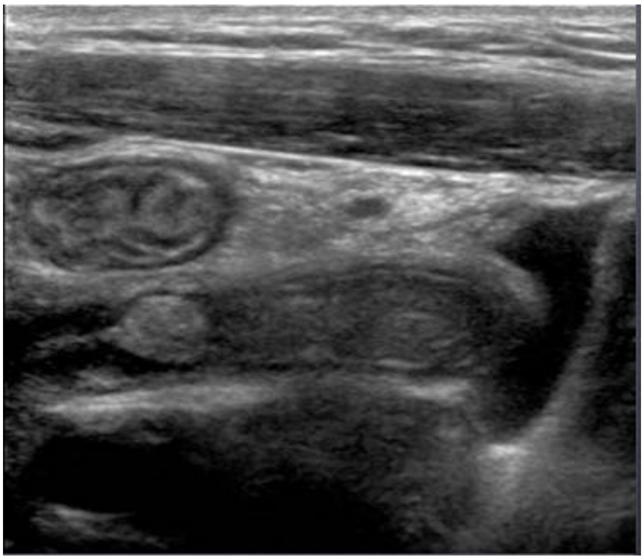
Characteristics

- Blind-ended tubular structure
- Non-compressible*
- No peristalsis
- Measures >6 mm in diameter*
- Target appearance

- Appendicolith
- Surrounding fluid or abscess
  *most sensitive signs



normal appendix


dilated appendix with free fluid at tip

False negatives
- Cannot find it
  Gas filled
  Location
- Tip appendicitis
- Perforated/gangrenous
- Massively enlarged

False positives
- Dilated fallopian tube
- IBD
- Peri-appendicitis
- Resolving appendicitis

Intussusception

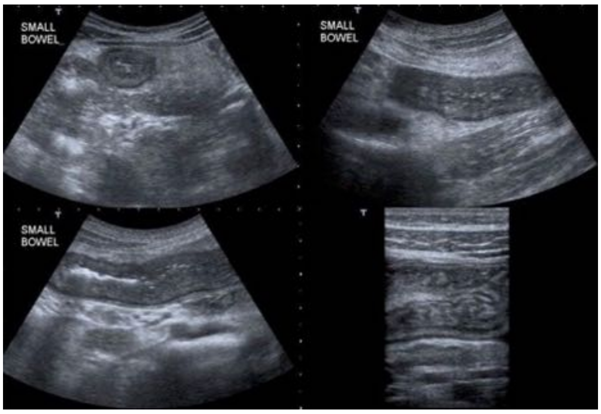
Background
Invagination of segment of bowel (intussusceptum), usually terminal ileum, into another segment of bowel (intussuscipens), usually cecum.

Anatomy:
- Most commonly found in right lower or upper quadrant at illeo-cecal valve.
- Multiple layers (concentric rings) of bowel with hypoechoic rim (muscularis) and central echogenicity (mucosa and submucosa).
- With increasing bowel edema, mucosal and submucosal layers are obliterated resulting in fewer layers and therefore fewer rings

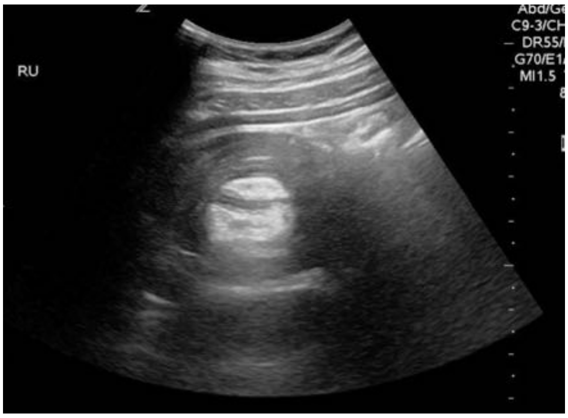
Scanning Protocol
1. Graded compression to push away bowel gas
2. Follow colon from right to left
3. 10 total images:
   2 images each quadrant:
   Transverse/Sagittal
   1 sagittal image each flank

Characteristics

- Sonography said to have a sensitivity of 100%
- In transverse has target or donut appearance
- In longitudinal has pseudokidney appearance
- Decreased color flow suggests a high likelihood of bowel ischemia
- Mean lesion diameter: Ileocolic: 2.63cm, Small bowel: 1.42cm
- Ileocolic intuss are larger. Small bowel intuss usually self resolve



normal bowel



intussusception

Mimics on sono

- Psoas Muscle
- Polypoid AVM of the colon
- Spine/intervertebral disc
- Massively thickened/perforated appendicitis/Phlegmon
- Liver Abscess
- Eosinophilic Gastroenteritis

Pitfalls not visualizing entire bowel because of patient compliance or too much gas.

Pyloric stenosis

Background

- Most common intestinal obstruction in infancy, 2-4 per 1000 live births
- 4:1 Male : Female ratio, 30% first born male
- Secondary to hypertrophy and hyperplasia of muscular layers of the pylorus
- Leads to narrowing of the gastric antrum and lengthening the pyloric canal

Indications for scan

- Age: Average 3 weeks (1-18 wks)
- Non bilious vomiting (70% projectile)
- Intermittent or with each feed, hungry after vomiting, can be progressive as muscle hypertrophies
- Signs of dehydration/malnutrition, poor weight gain, weight loss, decreased urinary output, lethargy, shock
- Hypochloremic, hypokalemic, metabolic

Anatomy

- The pylorus is contiguous with the stomach, lying to the right of the midline
- Cylindrical structure with echogenic pyloric canal surrounded by hypoechoic muscular layer
- Visualized as a mass in direct connection with the stomach in longitudinal plane
- Transverse view target appearance (hypoechoic muscle surrounding the central echogenic mucosa)

Scanning Technique

1. Graded compression to push away bowel gas
2. Feed baby while scanning
3. Place pt in right lateral decubitus position, allows fluid in the stomach to distend the antrum and pyloric region
4. Attempt to soothe infant, ↓ bowel gas
5. Use stomach, liver and gall bladder as landmarks
6. Start at the stomach and look for fluid entering
7. Trace the stomach to its end, near the midline of the patient
8. Pylorus should come into view as stomach distends
9. High incidence of renal abnormalities with HPS (UPJ obstruction, renal agenisis, horseshoe kidney)

Characteristics:

- Sonography said to have sensitivity of 90-96%
- Muscular Wall Thickness ≥ 3-3.5 mm measured from top of wall to where canal starts
- Pyloric canal length ≥ 1.2-1.7 cm measured from start to end of canal
- No peristalsis of pylorus
- No or little movement of stomach contents to duodenum

normal pylorus

pyloric stenosis

Pitfalls

- Psuedo-thickening of the pyloric muscle (False Positive)
  - Tangential (off mid-line) orientation
  - Gastric decompression
- Non-visualized posteriorly displaced pylorus (False Negative)
  - Gastric overdistension

Bowel

Background

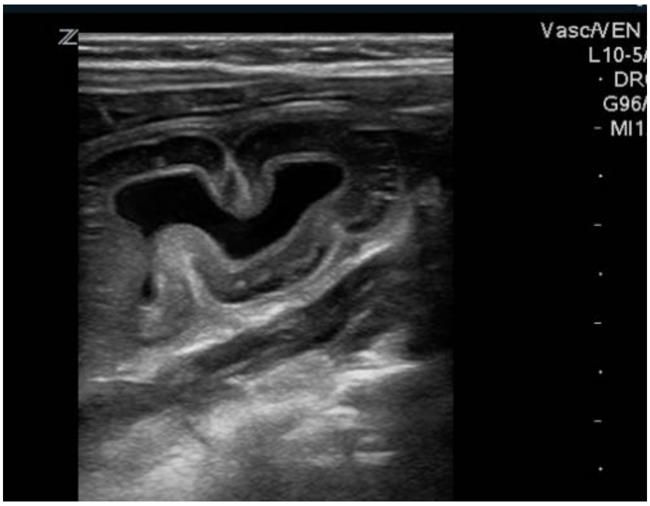
- Usually ignored or impedes other studies
- Small bowel has active peristalsis
- Large intestine has less active peristalsis
- Easily compressible
- Internal: gas or food particles
- Too much gas obscures imaging

Anatomy
- Small Bowel
    - Muscular wall layer <2-3mm
    - Plicae circulares
- Large intestine
    - Muscular wall layer inversely proportional to bowel diameter (<4mm normal)
    - Haustra

Scanning protocol
1. Where does it hurt?
2. Graded compression: Gentle pressure to push away bowel loops
3. Isolate colon and follow
4. Isolate small bowel and follow
5. Lawn mower technique

Characteristics of obstruction
- Fluid filled bowel loops w hyperechoic spots
- >2.5cm in diameter (SBO)
- Abnormal peristalsis
    - To and Fro / bounce back
    - Absent
- Free air
- Increased bowel wall perfusion via Doppler = infectious/inflammatory
- Decresed bowel wall perfusion via Doppler = ischemia
- Intraperitoneal free fluid
- Thickened wall


obstruction


thick loops

Pitfalls
- Proper assessment of peristalsis
- Not recognizing dilated thickened bowel
- Not looking for FF in usual places
- Mistaking free air for bowel gas
- Remember to use Doppler
- Correlate with Abdominal X-ray if performed

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Track D3: POCUS IN NURSING CARE AND ELSEWHERE

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"Ordinary men look at new things with old eyes. The creative man observes the old things with new eyes (Gian Piero Bona)."

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THORACIC ULTRASOUND FOR CONFIRMATION OF CORRECT LUNG EXCLUSION BEFORE ONE LUNG VENTILATION IN THORACIC SURGERY

Abstract:

Fiber optic bronchoscopy is the standard technique to assess correct double lumen endotracheal tubes positioning before lung exclusion for one lung ventilation. However, it requires a trained specialized anesthesiologist, and is often resources consuming. Aim of this study, purposed by a nurse, is to compare it with thoracic ultrasound performed by anesthetic nurses in terms of sensibility, specificity and cost-effectiveness.

We designed a case-control, cross-over, blinded study in which, after patients intubation, correct lung exclusion was assed both via standard bronchoscopy, performed by a specialist anesthesiologist, and thoracic ultrasound performed by a trained anesthetic nurse. A continuos cohort of adult patients undergoing thoracic surgery on one lung ventilation, after intubation with a double lumen endotracheal tube, subsequently underwent traditional fiber optic bronchoscopy followed by thoracic ultrasound to assess correct lung exclusion.
The two techniques resulted to be equally sensitive and specific. Thoracic ultrasound was associated to a significantly quicker execution than fiber optic bronchoscopy. Time of execution, together with the fact that ultrasound was performed by a nurse, the costs of materials and its sterilization, had a significant economic impact, with a net saving of 37.2±5.4 Euros per case.

Conclusion:
Even though fiber optic bronchoscopy remais the gold standard in checking optimal double lumen endotracheal tube positioning, thoracic ultrasound is a specific, sensitive and cost-effective method to quickly obtain a functional assessment that it is working properly, through identification of correct lung exclusion.

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Background

Double lumen endotracheal tubes (DLET) are commonly employed in many thoracic surgical procedures, as well as in different procedures involving a surgical acess to the thoracic surgical access to the thoracic cavity, such as esophageal surgery and orthopedic surgery of the thoracic spine. Moreover, in the intensive care setting, DLET allows for the isolation of an affected lung, or a differential ventilation of the two lungs (1-3). Different models of DLET have been developed, the most diffused being Carlens, White and Robertshaw tubes, whatever the model DLET are generally inserted using the same technique, i.e. under direct laringoscopy as for any other endotracheal tube, with the longer bronchial lumen curved anteriorly, once passed through the laryngeal inlet they are blindly rotated by 70-90 degree, in order for the bronchial lumen to correctly fi tinto the corresponding main bronchus. Left sided DLET are more commonly employed than their counterpart right sided DLET, being specifically indicated in the aesthesiologic setting just to allow specific surgical procedures, such as significant left sided lung resections, or left pneumonectomies. This because right sided DLET carry the significant risk of excluding the right upper lobe bronchus, with consequent possible intraoperative atelectasis and hypoxia (2,3).

Correct positioning of DLET is vital, being a wrong positioning and consequent incomplete lung exclusion direct or indirect cause of significant morbidity and mortality in the thoracic surgical population, accounting for up to 30% of perioperative deaths in specific subpopulations, such as esophageal surgery patients. Because of the importance of confirming DLET positioning and correct lung exclusion, the elective method currently recommended is by auscultation followed by a double check with fiber optic bronchoscopy (1-3).

Fiber optic bronchoscopy however is costly, considering both personnel costs and costs of materials. First of all, it is generally performed by a fully trained anesthesiologist, secondarily the cost of the bronchoscopes themselves, and of their sterilization required after each procedure are not neglibile as well. Moreover in anesthesiology departments with important case loads of thoracic surgery, the time needed to sterilize every single bronchoscope after any procedure makes the requirement for multiple bronchoscopes mandatory. Moreover the more procedures are performed with each bronchoscope, the more sterilization processes it must undergo, the sterilization processes significantly shorten the bronchoscope life, inevitably causing different degrees of damage to the optic fibers (2,3).

Thoracic ultrasound is an expanding field of emergency and intensive care medicine. It allows for prompt detection of life threatening conditions, such as hemothorax or pneumothorax and has been shown to be extremely helpful in a quick differential diagnosis of the critical patient in case of acute respiratory distress (4-6). In particular, thoracic ultrasound has been shown to have an extremely high sensivity and specificity in the detection of pneumothorax, outperforming the plain chest radiogram in the emergency setting (4-15). The ultrasonographic diagnosis of pneumothorax is based on the detection of the absence of two specific echografic signs, the first being the so-called "sliding sign", given by the ultrasound image of the hyperechoic visceral pleura sheath sliding on the parietal pleura sheath in normal aerated and ventilated lungs, the second being the so-called "seashore sign", obtained when M-mode modality is used to detect pleural movement across a given section of the lung (15).

Nurse ultrasound has being increasingly expanding in Switzerland the las years, particularly in the emergency setting. Many protocols including image acquisition by specifically trained nurses have been successfully implemented in many centers and multiple settings, including the so-called extended FASt, both in the emergency room and out of hospital. These protocols include thoracic ultrasound for the exclusion of pneumothorax and hemothorax. In this context, for the acquisition of standardized images in specific protocols, nurse ultrasound can be as effective as ultrasound performed by medical doctors and of course competitive in terms of timing, specificity, sensitivity, and cost-effectiveness.

Material and methods

After local ethical committee approval and oral patients consent, a cross-over, case-control, blinded, prospective study, has been conducted on a continuous cohort of adult patients undergoing thoracic surgery under single lung ventilation, the only exclusion criteria being patient refusal and difficult airways impeding the use o a DLET.

After anesthesia induction, left Robertshaw DLET insertion and start of positive pressure ventilation through a Bain circuit, the consultant anesthesiologist checked the correct tube positioning via fiber optic bronchoscope (Karl Storz & Co, Germany). Left DLET was considered correctly positioned when the upper margin of the bronchial cuff protruding from the left main bronchus was visualized through the bronchoscope inserted in the tracheal lumen of the tube. Once bronchoscopy was concluded, a specifically trained anaesthetic nurse performed a thoracic ultrasound with a 8 MHz linear probe (LogicQ, GE, USA), in both the lower quadrants of patient thorax, in order to identify the presence or absence of the sliding sign in B-mode at the level of the diaphragm, in the costal-phrenic groove. Left DLET was considered correctly positioned when after bronchial lumen occlusion, the sliding sing was lost on the left side, while persisting on the opposite side, and also when switched to the M-mode, the seashore sign turned into a stratosphere sign on the left side.

The consultant and the nurse were blinded to each other result and wrote their evaluation of proper left DLET positioning on a separate piece of paper. Evaluations could just be resumed in three alternative judgments, either "correct position", "wrong position", or "inconclusive exam". The two evaluations were subsequentely compared and, in case of either discrepancy between judgments or one of the techniques judged as inconclusive, the two techniques were further repeated until consensus was obtained. Procedural time for both procedures was calculated starting either from fiber optic bronchoscope insertion in the tracheal lumen of the DLET or from probe positioning on patient's thorax and until the evaluation was written down.

A poweer calculation with regard to sensitivity was performed as a non-inferiority test. Sample size required per group was calculated to be of 51 patients for a significance level of 5% and a power of 90%. Data were collected anonymously in an electronic data-base.

The economic assessment of the two procedures has been performed as a cost-minimization analysis. In both cases the point of view adopted for the economic analysis is the one of the hospital administration. A top-down technique was used to estimate the costs related to working time professionals spent in the processes, while micro-costing was adopted to address costs related to drugs and devices employed in the two groups. Indirect fix costs (material and resources required for operation and anesthesia), inhospital management related costs and postoperative management related costs were assumed to be unaffected by the procedures.

The economic analysis took instead into account costs directly related to the performance of the two techniques: personal costs, costs of materials, and costs of the sterilization process. All costs are expressed in Euros.

Unpaired t-test was used for parametric data null hypothesis testing, while Mann-Whitney U-tes was applied to non parametric data. A p value <0.05 was considered statistically significative (95% confidence interval). Results are given as mean (m) ± standard deviation (SD) for normally distributed parameters or median (M) and relative interquartile range (IQR) for non normally distributed parameters. Statistical analysis was performed using SPSS (IBM, USA) and Numbers '09 2.1 version (Apple Inc, USA) softwares.

Results

A total of 51 patients were included over a period of 5 months. Patients were ASA grade I to III, adults, mean age was 62.6 ±11.95 years, gender ratio (male:female) was 29:22. No patient was excluded from the study.

The two techniques resulted to be equally sensitive and specific with regard to correct left DLET positioning, giving the same result in all buto ne patients, in whom fiber optic bronchoscopy confirmed correct left DLET position while thoracic ultrasound resulted inconclusive since a clear sliding sign imaging was not possible because of a poor acoustic window. This difference in specificity being not statistically significant (p=0.308). Sensibility was the same with the two techniquest (p=1.000). Whit regard to mean procedural time, ultrasound was associated to a significantly quicker execution than fiber optic bronchoscopy (2.08 ±0.5 min vs 7.70 ±4.2 min, p<0.05). Time of execution together with the fact that ultrasound was performed by a nurse compared with a specialist anesthesiologist, had a significant economic impact, being ultrasound associated with a net saving of 5.2 ±0.4 Euros per patient treated (p<0.05).This difference was further increased when costs linked to standard cleaning and sterilization procedures where taken into account, leading to a further saving of 23.3 ±5.3 Euros in favor of ultrasound (p<0.05).

Finally, when cost of material was taken into account, calculating amortizations of devices used, a further saving of 8.7 ±2.4 Euros was highlighted in favor of ultrasound (p<0.05). Ultrasound was thus significantly associated to a net saving in global costs. These costs include both personnel costs and costs of material and equipment, accounting for a total of 37.2 ±5.4 Euros per case, which in this case-series translated in a global reduction in hospital costs of 7810,72 ±52.7 Euros.

Discussion

To our knowledge this is the first study targeting the use of thoracic ultrasound to assess correct lung exclusion before one lung ventilation for thoracic surgery. This technique is now well established in many settings, mainly for a rapid diagnosis in the emergencies and traumas. Its steep learning curve and straightforwardness quickly favored its spread not only to different specialties but also to other healthcare professionals, such as nurses and paramedics. This also because of a clear trend in industry, which reduced ultrasound machines costs and improved their performances, widening their possible applications.

According to our result, the use of thoracic ultrasound to assess correct one lung ventilation after DLET intubation could be as specific and sensible as fiber optic bronchoscopy, but more costeffective, particularly when performed by a properly trained nurse. In our opinion, fiber optic bronchoscopy could hardly be completely substituted by thoracic ultrasound for this particular application, since direct vision of DLET position maintain some specific advantages. For example, it can assess optimal position of bronchial lumen cuff in relation to the carena or correct positioning of the right upper lobe bronchus opening in right DLET. However thoracic ultrasound could eventually be considered as a first method to assess correct lung exclusion after left DLET positioning, keeping fiber optic bronchoscopy as a rescue technique in case a further assessment is required, in case of doubts or complications.

Conclusion

Even though fiber optic bronchoscopy remains the gold standard in checking optimal double lumen endotracheal tube positioning, thoracic ultrasound is a specific, sensitive and cost-effective method to quickly obtain a functional assessment that it is working properly, through identification of correct lung exclusion.

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Thoracic ultrasound for confirmation of correct lung exclusion before one lung ventilation in thoracic surgery.
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Conflicts of interest: none of the Authors has a conflict of interests.
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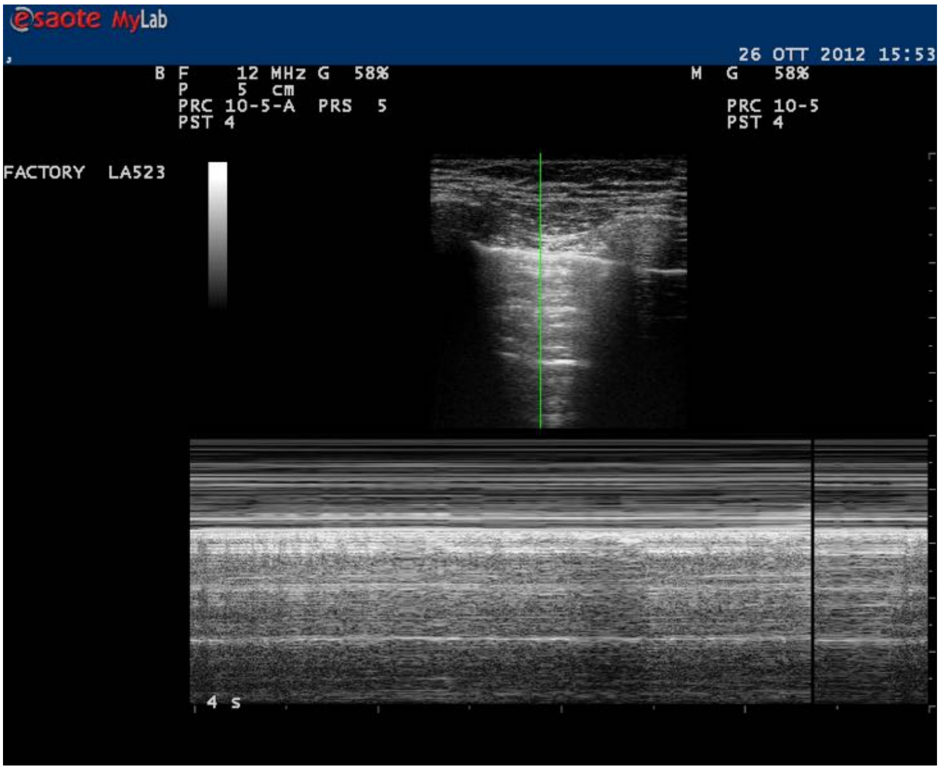
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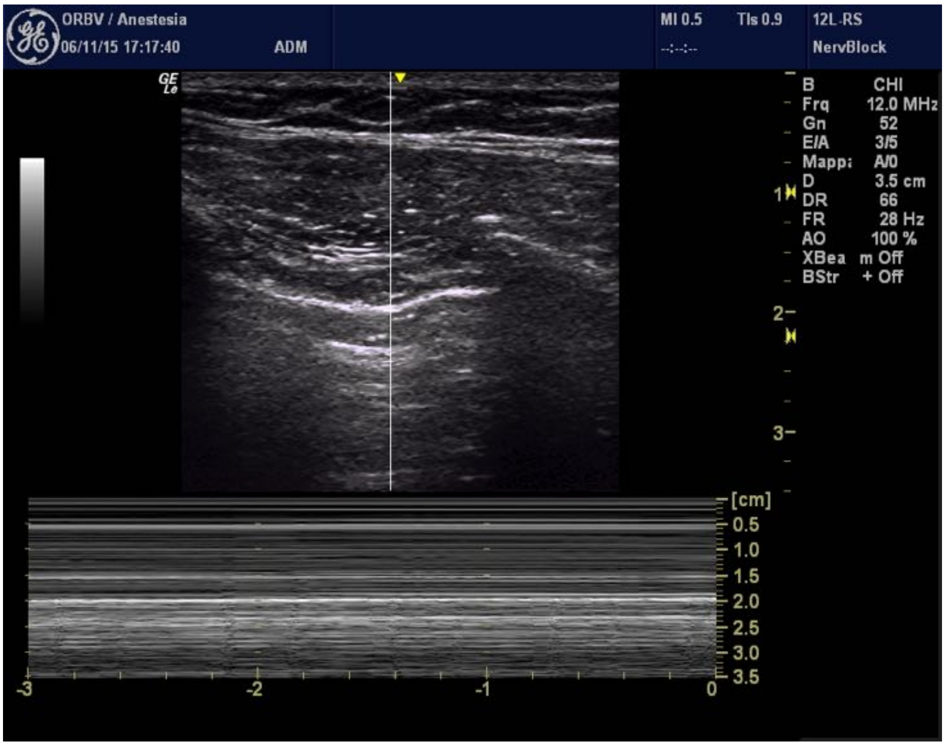
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PROTOCOLIZED CARE TO REDUCE HYPOTENSION AFTER SPINAL ANESTHESIA (ProCHRYSA RANDOMIZED TRIAL): STATISTICAL PLAN

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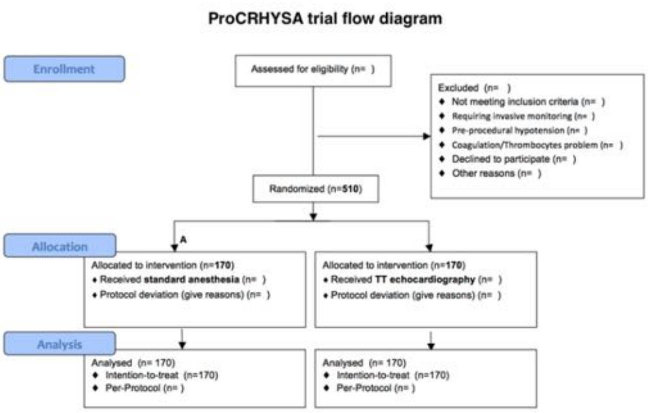
Background

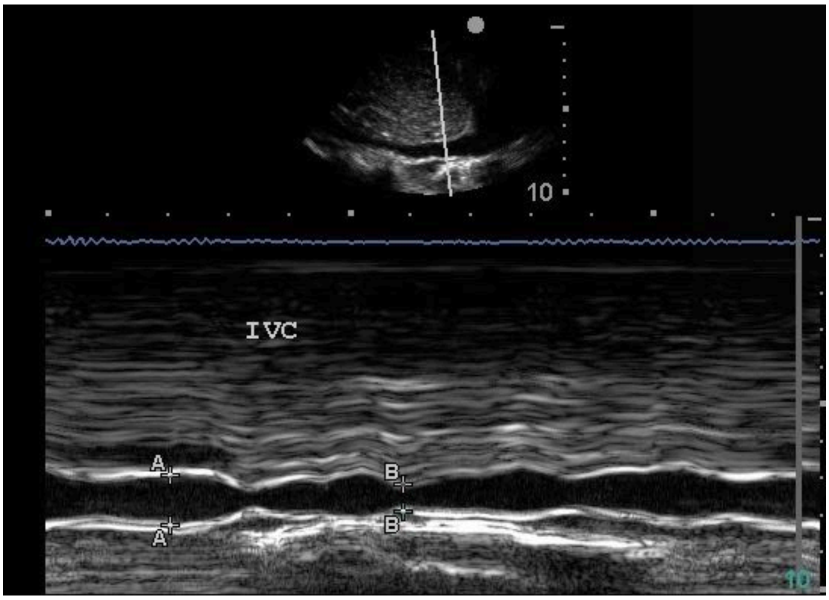
Spinal anesthesia is a regional anesthesia technique widely employed in clinical practice. The common side effects consist in a reduction of systemic vascular resistances, with systemic hypotension. To prevent this complication, blind administration of fluids is commonly used. This is accomplished on an empirical basis, carrying risk of possible volume overload. Vena cava ultrasound has been shown to be an effective method to assess fluid responsiveness in critical care patients, however this method has never been studied in a non-critical population. Aim of this study is to assess the efficacy of vena cava ultrasound guided titrated volume repletion in preventing spinal anesthesia induced hypotension in an elective surgical population.

Methods

We designed a randomized, case-control, prospective trial comparing standard practice to ultrasound guided vena cava fluid repletion before spinal anesthesia for elective surgery. After written informed consent, we randomized ASA 1 to 3 patients into two groups: the first received no preliminary volume repletion, according to standard local practice, while the second was assessed with vena cava echography before spinal anesthesia. Patients found to be responsive to fluids were given subsequent boluses of 500 ml crystalloids before proceeding to spinal anesthesia and reassessed afterward until found euvolemic. Non-invasive arterial pressure was periodically measured in any patient after spinal anesthesia until discharge to recovery room and the significant hypotension rate was subsequently calculated in the two groups.



Significant hypotension was defined according to international guidelines as fall in systolic arterial blood pressure more than 50 mmHg or 25% from baseline value, an absolute value of systolic pressure less than 80 mmHg, an absolute value of mean pressure less than 60 mmHg, a reduction in mean arterial pressure more than 30% from baseline value and/or clinical symptoms of inadequate perfusion[i]. Exclusion criteria were considered contraindication to spinal anesthesia, patient's refusal or lack of protocol adherence. Data are given as percentage of significant hypotension, p value (p) and confidence intervals (CI). Power calculation was preliminary performed, identifying a sample size of 150 patients per group (95% confidence level).



Results

A total of 64 patients were recruited in a 5 month period. 16 patients did not meet inclusion criteria and were excluded. 19 patients randomized to the cases group were subsequently excluded because of protocol adherence issues (poor echographic windows did not consent adequate vena cava diameter measurement). Post-spinal significant hypotension rate was 66% in control group (N=32) and 45% in the group whose preventive volume repletion was guided through vena cava ultrasound (N=32), this difference being statistically significant (p=0,043 CI=95%).

Conclusions

Vena cava ultrasound assessment is an effective method to assess fluid responsiveness also in non-critical patient who underwent preoperative fasting before elective surgery and can be routinely employed for guiding titrated and tailored preoperative volume repletion in order to reduce risk of significant hypotension after spinal anesthesia.