MAYO CLINIC

Pediatric Perioperative POCUS
Yay! Ultrasound!

Devon Aganga, M.D.
Pediatric Anesthesia and Critical Care Medicine
Mayo Clinic
Minnesota Society of Anesthesiologists
November 18th 2017

Disclosures

- Absolutely nothing to Disclose

Mayo Clinic Children's Center

Objectives

- Define POC ultrasound
- Procedural POC ultrasound
- Diagnostic POC ultrasound
  - Cardiac POCUS
  - Lung POCUS
  - Gastric POCUS

Mayo Clinic Children's Center

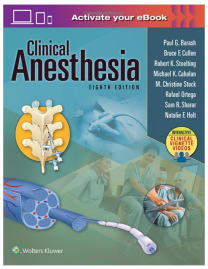
What is POCUS?

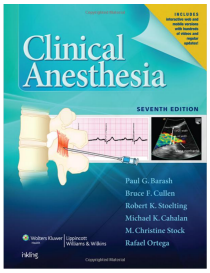
- Defined as ultrasonography brought to the patient and performed by the provider in real time to answer specific questions
- Allows findings to be directly correlated with presenting signs and symptoms
- Easily repeatable if the patient condition changes
- Used by various specialties
- Can be divided into procedural and diagnostic applications

Table 1. Selected Applications of Point-of-Care Ultrasonography, According to Medical Specialty.[a]

Specialty	Ultrasound Applications
Anesthesia	Guidance for vascular access, regional anesthesia, intraoperative monitoring of fluid status and cardiac function
Cardiology	Echocardiography, intracardiac assessment
Critical care medicine	Procedural guidance, pulmonary assessment, focused echocardiography
Dermatology	Assessment of skin lesions and tumors
Emergency medicine	FAST, focused emergency assessment, procedural guidance
Endocrinology and endocrine surgery	Assessment of thyroid and parathyroid, procedural guidance
General surgery	Ultrasonography of the breast, procedural guidance, intraoperative assessment
Gynecology	Assessment of cervix, uterus, and adnexa; procedural guidance
Obstetrics and maternal–fetal medicine	Assessment of pregnancy, detection of fetal abnormalities, procedural guidance
Neonatology	Cranial and pulmonary assessments
Nephrology	Vascular access for dialysis
Neurology	Transcranial Doppler, peripheral-nerve evaluation
Ophthalmology	Corneal and retinal assessment
Orthopedic surgery	Musculoskeletal applications
Otolaryngology	Assessment of thyroid, parathyroid, and neck masses; procedural guidance
Pediatrics	Assessment of bladder, procedural guidance
Pulmonary medicine	Transthoracic pulmonary assessment, endobronchial assessment, procedural guidance
Radiology and interventional radiology	Ultrasonography taken to the patient with interpretation at the bedside, procedural guidance
Rheumatology	Monitoring of synovitis, procedural guidance
Trauma surgery	FAST, procedural guidance
Urology	Renal, bladder, and prostate assessment; procedural guidance
Vascular surgery	Carotid, arterial, and venous assessment; procedural assessment

N Engl J Med 2011;364:749-57.





Procedural POCUS: Vascular Access

- Select a high frequency transducer with a small foot print
- IJ most frequently used site in neonates and small infants
- Ideally, external diameter of catheter should not exceed 1/3rd of diameter of the vein.
- Neonates and small infants rarely have deep arm veins > 2 mm

Elbarbary et al. Pediatric Ultrasound-Guided Vascular Access. Lumb, Philip and Karaiktsos, Dimitrios. Critical Care Ultrasound. Elsevier, Philadelphia, PA. 2015.

Mayo Clinic Children's Center

Procedural POCUS: Vascular Access

Randomized Controlled Trial of Ultrasound-Guided Peripheral Intravenous Catheter Placement Versus Traditional Techniques in Difficult-Access Pediatric Patients

Stephanie J. Doniger, MD, RDMS,†‡ Paul Ishimine, MD,†‡ John Christian Fox, MD, RDMS,‖ and John T. Kanegaye, MD†‡*

Shorter times to cannulation (p=0.001)
Fewer attempts (p=0.004)
Fewer needle redirections (p<0.0001)
N=50; POCUS:25; standard:29

Pediatric Anesthesia

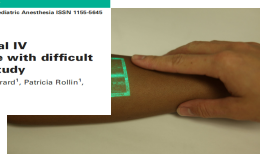
Pediatric Anesthesia ISSN 1155-5645

ORIGINAL ARTICLE

Ultrasound guidance allows faster peripheral IV cannulation in children under 3 years of age with difficult venous access: a prospective randomized study

Mehdi Benkhadra[1], Mathieu Collignon[1], Isabelle Fournel[2], Christian Oeuvrard[1], Patricia Rollin[1], Murielle Perrin[1], François Volot[1] & Claude Girard[1]

1 Department of Anesthesiology and Intensive Care, University Hospital Bocage, Dijon, France
2 Department of Epidemiology and Infection Control, University Hospital Bocage, Dijon, France



Shorter times to cannulation (p<0.001)
Fewer attempts (p=0.004)
N=40; POCUS:20; standard:20

Both studies used real time ultrasound visualization

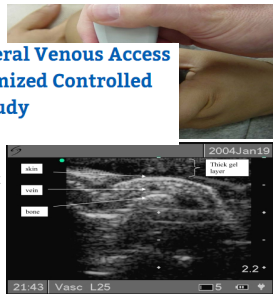
Mayo Clinic Children's Center

POCUS: Vascular Access

WestJEM Integrating Emergency Care with Population Health

Ultrasound-Assisted Peripheral Venous Access in Young Children: A Randomized Controlled Trial and Pilot Feasibility Study

ARTICLES , ORIGINAL RESEARCH



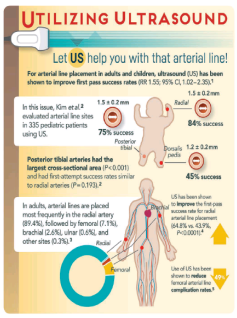
- No statistically or clinically significant differences between POCUS and standard approach
- N=44; POCUS N=23

Static ultrasound technique

Mayo Clinic Children's Center

POCUS: Vascular Access

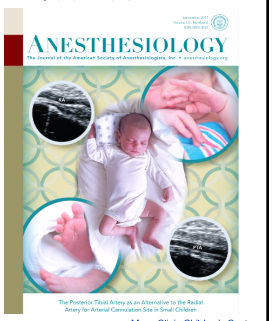
ANESTHESIOLOGY



Posterior Tibial Artery as an Alternative to the Radial Artery for Arterial Cannulation Site in Small Children

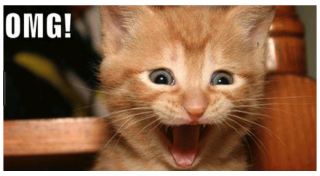
A Randomized Controlled Study

Eun-Hee Kim, M.D., Ji-Hyun Lee, M.D., In-Kyung Song, M.D., Jin-Tae Kim, M.D., Ph.D., Won-Jong Lee, M.D., Hee-Soo Kim, M.D., Ph.D.



Mayo Clinic Children's Center

Diagnostic POCUS in pediatric perioperative and critical care practice?



Mayo Clinic Children's Center

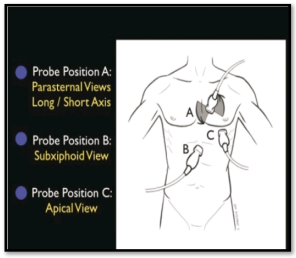
Case

- 3 month old with large VSD just repaired with uncomplicated CPB run, chest closed, 2 chest tubes with moderate bleeding, intubated on vasoactive infusions, no rhythm disturbances, soon becomes profoundly hypotensive, sinus tachycardia and rapid increase in RA pressure after transfer from OR to PICU with noticed decrease in $ETCO_2$. Pt is mottled. Looks awful.
- This kid is in big trouble. Role for POCUS?

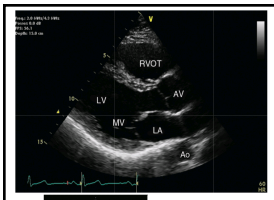
Mayo Clinic Children's Center

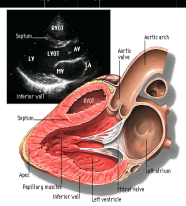
POCUS: Cardiac
Focused Clinical Questions

- What is the patient's cardiac function?
  - Normal
  - Mildly depressed
  - Moderately depressed
  - Severely depressed
- Is there a pericardial effusion? Where?
- What is this patient's volume status?



Mayo Clinic Children's Center





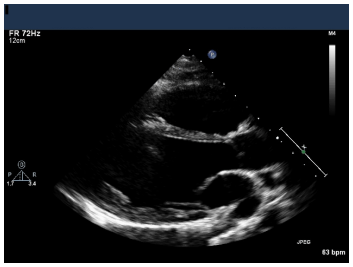
Parasternal Long Axis

USES

- LV size and function
- Pericardial effusion
- Evaluate MV, AoV
- Color Doppler: Screen for regurgitation
- Indicator position: 11 o'clock
- 3rd intercoastal space

Mayo Clinic Children's Center

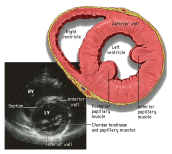
Parasternal Long axis view

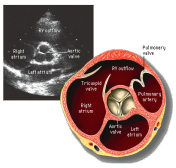


Mayo Clinic Children's Center

Parasternal Short Axis:

rotate 90º clockwise from parasternal long





USE

Midpapillary level:

- Assess LV contractility
- Regional wall motion

Mitral Level

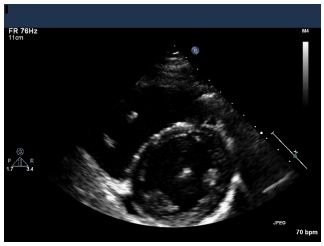
- LV contractility
- mitral valve

Aortic Valve level:

- AV/TV/PV/Atria
- Color Doppler for regurgitation

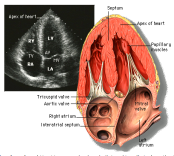
Mayo Clinic Children's Center

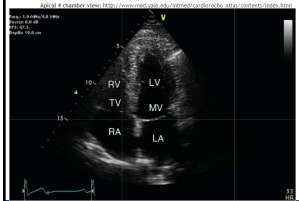
Parasternal Short Axis View



Mayo Clinic Children's Center

Apical 4 chamber view



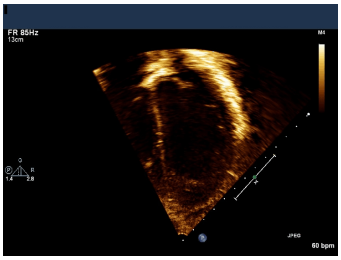


USE

- LV, RV size and contractility
- LV/RV ratio
- Valves – MV, TV
- Indicator position at 3 o' clock position
- Transducer pointed to right scapula

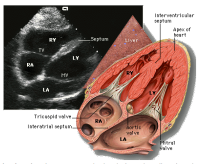
Mayo Clinic Children's Center

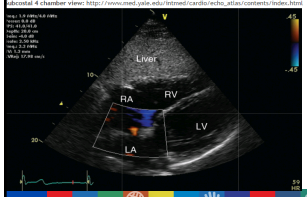
Apical 4 Chamber view



Mayo Clinic Children's Center

Subcoastal View





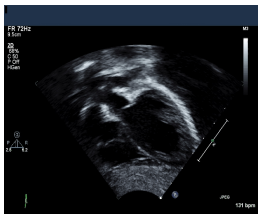
USE

- LV and RV function
- Pericardial Effusion
- IVC examination
- *May be the only available view in patients on mechanical ventilation*
- Accessible during CPR (during pulse checks; do not interrupt resuscitation)

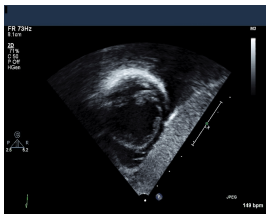
Mayo Clinic Children's Center

Subcostal Views

Subcostal 4 chamber view



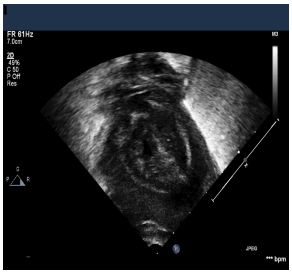
Subcostal short axis view



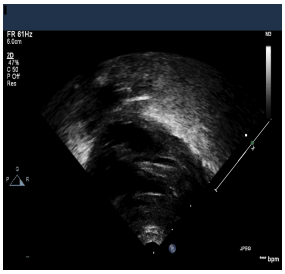
Mayo Clinic Children's Center

Child in ICU with severe hypotension
Pericardial Effusion: Subcoastal View

Pre



Post



Mayo Clinic Children's Center

POCUS: Cardiac

Journal of Cardiothoracic and Vascular Anesthesia ▮ (▮▮▮▮) ▮▮–▮▮▮

Contents lists available at ScienceDirect

ScienceDirect

journal homepage: www.jcvaonline.com

Case Report

Perioperative Point-of-Care Ultrasound in Pediatric Anesthesiology: A Case Series Highlighting Intraoperative Diagnosis of Hemodynamic Instability and Alteration of Management

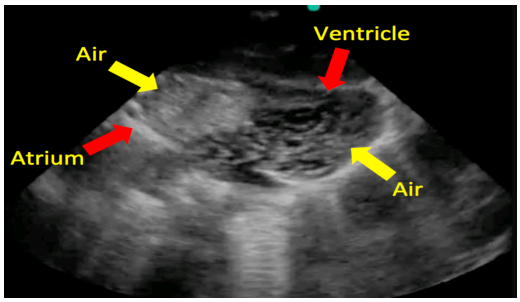
Adam C. Adler, MS, MD, FAAP

Department of Anesthesiology, Perioperative and Pain Medicine, Division of Cardiovascular Anesthesiology, Texas Children's Hospital, Baylor College of Medicine, Houston, TX

Mayo Clinic Children's Center

Adler AC. (2017), http://dx.doi.org/10.1053/j.jvca.2017.04.027

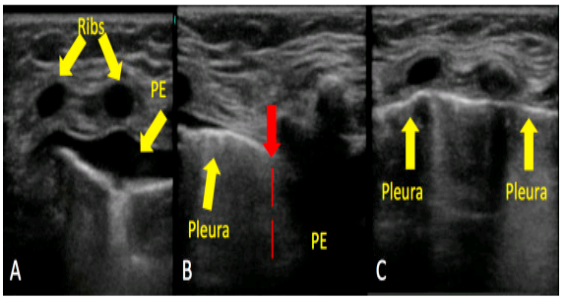
Case 1



Mayo Clinic Children's Center

Adler AC. (2017), http://dx.doi.org/10.1053/j.jvca.2017.04.027

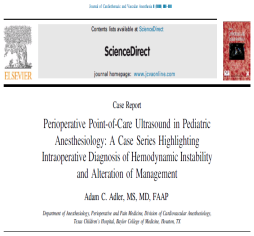
Case 2



Mayo Clinic Children's Center

Adler AC. (2017), http://dx.doi.org/10.1053/j.jvca.2017.04.027

- Perioperative use of POCUS by anesthesiologist
- Changed management for the better
- Can be used in children with congenital heart disease…to answer simple basic questions


ScienceDirect

Case Report

Perioperative Point-of-Care Ultrasound in Pediatric Anesthesiology: A Case Series Highlighting Intraoperative Diagnosis of Hemodynamic Instability and Alteration of Management

Adam C. Adler, MS, MD, FAAP

Mayo Clinic Children's Center

Case

- 3 month old FT baby to undergo one-lung ventilation for Left thoracic surgery. Mask induction, PIV x2, 3.0 cuffed ETT in right mainstem to achieve OLV. Patient positioned Right lateral decubitus. Auscultation confirmed OLV. Vent: 6cc/kg/breath.
- Minutes in, during surgical prep, patient desaturates to mid 60s, higher peak pressures on ventilator, higher ETCO2. In room provider calls for assistance.
- Differential Dx?
- How can POCUS be applied in this situation?

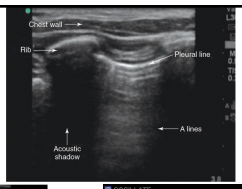
Mayo Clinic Children's Center

POCUS: Lung
Focused Clinical Questions

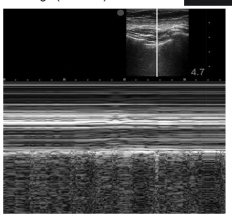
- Is there a pneumothorax?
- Endobronchial intubation?
- Effective lung isolation in One-Lung isolation?
- Pleural Effusion?
- Atelectasis/consolidation/ Pulmonary edema?
- Ideal PEEP looking at RV fill and function?

Mayo Clinic Children's Center

POCUS: Lung

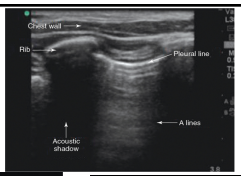


Normal lung:
Seashore sign (m-mode)

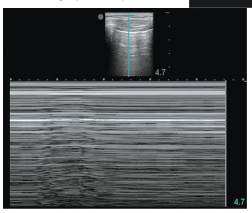


Mayo Clinic Children's Center

POCUS: Lung



Pneumothorax:
Barcode sign (m-mode)



Mayo Clinic Children's Center

Journal of Anaesthesiology Clinical Pharmacology
Review Article

Intraoperative lung ultrasound: A clinicodynamic perspective

Amit Kumar Mittal, Namrata Gupta
Department of Anesthesiology and Critical Care, Rajiv Gandhi Cancer Institute and Research Center, New Delhi, India

Abstract

Table 3: Intraoperative diagnosis of desaturation by LUS

Causes	Lung signs	
	Present	Absent
Pneumothorax	Lung point	Lung sliding, B-lines, lung pulse
Endobronchial intubation	Lung pulse in opposite lung	Lung sliding, lung point both in opposite lung
Bronchospasm	Lung sliding,	Lung pulse, lung point, B-lines
Atelectasis without pleural effusion	Lung sliding, lung pulse	Lung point
Pulmonary edema	B-lines, lung sliding	Lung pulse, lung point
Pulmonary embolism	Lung sliding, A-profile	Lung pulse, lung point, B-lines

Accuracy of Transthoracic Lung Ultrasound for Diagnosing Anesthesia-induced Atelectasis in Children

Cecilia M. Acosta, M.D., Gustavo A. Maidana, M.D., Daniel Jacovitti, M.D., Agustín Belaunzarán, M.D., Silvana Cereceda, M.D., Elizabeth Rae, M.D., Ananda Molina, M.D., Sergio Gonorazky, M.D., Stephan H. Bohm, M.D., Gerardo Tusman, M.D.

ABSTRACT

Background: The aim of this study was to test the accuracy of lung sonography (LUS) to diagnose anesthesia-induced atelectasis in children undergoing magnetic resonance imaging (MRI).

Methods: Fifteen children with American Society of Anesthesiology's physical status classification 1 and aged 1 to 7 yr old were studied. Sevoflurane anesthesia was performed with the patients breathing spontaneously during the study period. After taking the reference lung MRI images, LUS was carried out using a linear probe of 6 to 12 MHz. Atelectasis was documented in MRI and LUS segmenting the chest into 12 similar anatomical regions. Images were analyzed by four blinded radiologists, two for LUS and two for MRI. The level of agreement for the diagnosis of atelectasis among observers was tested using the κ reliability index.

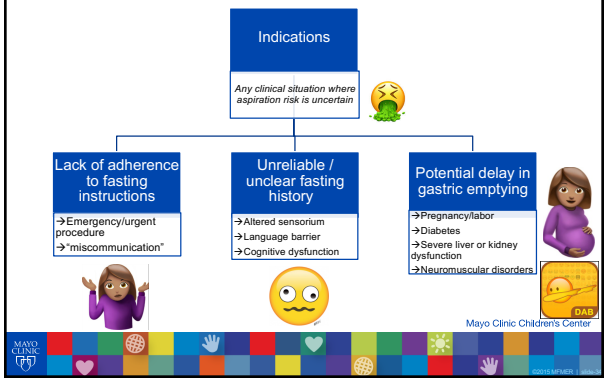
Results: Fourteen patients developed atelectasis mainly in the most dependent parts of the lungs. LUS showed 88% of sensitivity (95% CI, 74 to 96%), 89% of specificity (95% CI, 83 to 94%), and 88% of accuracy (95% CI, 83 to 92%) for the diagnosis of atelectasis taking MRI as reference. The agreement between the two radiologists for diagnosing atelectasis by MRI was very good (κ, 0.87; 95% CI, 0.72 to 1; $P < 0.0001$) as was the agreement between the two radiologists for detecting atelectasis by LUS (κ, 0.90; 95% CI, 0.75 to 1; $P < 0.0001$). MRI and LUS also showed good agreement when data from the four radiologists were pooled and examined together (κ, 0.75; 95% CI, 0.69 to 0.81; $P < 0.0001$).

Conclusion: LUS is an accurate, safe, and simple bedside method for diagnosing anesthesia-induced atelectasis in children.
(Anesthesiology 2014; 120:1370-9)

Case

- 4 year old with developmental delay presents in the morning for Achilles tendon releases. Potentially difficult airway. Mother reports that en route, he may have gotten into a cup of cheerios that his 2 year old brother was eating. Unclear how much or if at all he ate any of the cheerios as his brother may have eaten what was unaccounted for.
- Cancel case? Delay 6 hours? How can POCUS help?

POCUS: Gastric Ultrasound

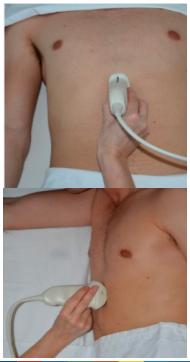


Gastric UltraSound

http://gastricultrasound.org/index.html

Mayo Clinic Children's Center

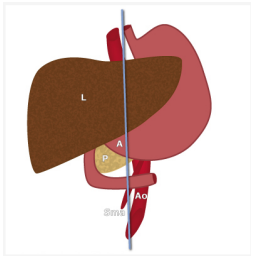
POCUS: Gastric

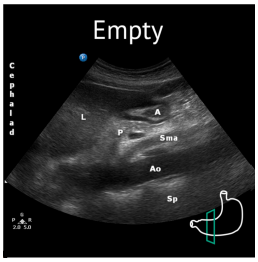


- Abdominal settings
- Curved array low frequency probe (2-5 mHz) or linear high-frequency (5 – 12 mHz) probe in small children
- Patient Position
  - Start in supine position
  - Then position in right lateral decubitus.
  - Must scan in these 2 positions before impression can be made
- Scan in a sagittal plane
- Sweep from patient's right to left of subcostal area
- Identify the gastric antrum

http://gastricultrasound.org/Image%20Acquisition/scanningtechnique.html accessed 11/12/2017

Mayo Clinic Children's Center

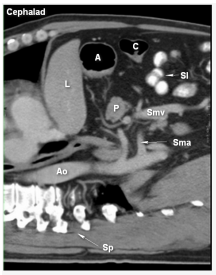




http://gastricultrasound.org/Image%20Acquisition/appliedanatomy.html accessed 11/12/2017

Mayo Clinic Children's Center

POCUS: Gastric applied anatomy



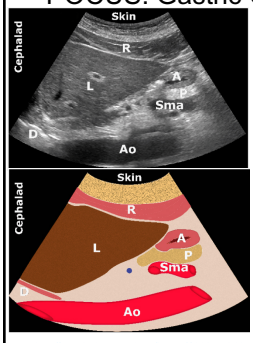
A: antrum; Ao: aorta; C: colon; L: liver; P: pancreas; SI: small intestine; Sma: superior mesenteric artery; Smv: superior mesenteric vein; Sp: spine

- Gastric Antrum
  - Most amendable to US exam
  - Accurately reflects content of entire stomach
  - Hollow viscus with a prominent multi-layer wall
  - Between liver (anteriorly) and pancreas (posteriorly)
  - Is usually located superficially (3-4 cm)
- Landmarks:
  - Left lobe of liver
  - Pancreas
  - Aorta
  - Superior mesenteric artery
  - Superior mesenteric vein

http://gastricultrasound.org/Image%20Acquisition/appliedanatomy.html accessed 11/12/2017

Mayo Clinic Children's Center

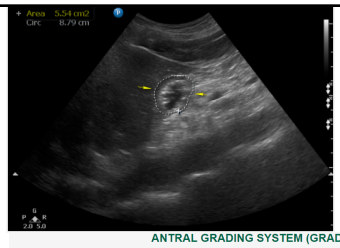
POCUS: Gastric Content types



Grade	Antral Shape	Antral Wall	Content
Empty	Flat & Collapsed OR Round (target shape)	THICK with prominent muscularis propria	None -or- Small amount of hypoechoic content
Clear Fluid	Round, Distended	Thin	hypoechoic
Milk or Suspension	Round, Distended	Thin	hyperechoic
Solid	Round, Distended	Thin	Heterogeneous, particulate +/- mixed with air

http://gastricultrasound.org/Image%20Acquisition/gastriccontent.html accessed 11/12/2017

Mayo Clinic Children's Center



- The cross-sectional area has linear correlation with the gastric volume
- Measure CSA at level of Aorta
- Input CSA measurement into predictive model to assess gastric volume

http://gastricultrasound.org/image%20Acquisition/volumeassessment.html

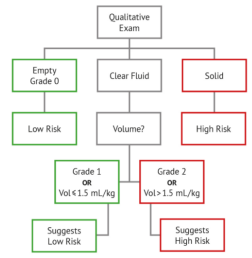
ANTRAL GRADING SYSTEM (GRADES 0 - 2)

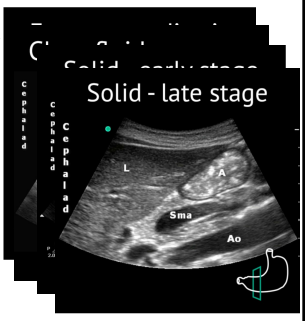
Grade	Antral presentation	Volume implications	Aspiration risk
0	Empty in both supine and RLD position	Minimal	Low risk
1	Empty in supine, clear fluid visible in the RLD	≤ 1.5 mL/kg, compatible with baseline gastric secretions	Low risk
2	Clear fluid visible in both positions	>1.5 mL/kg, likely in excess of baseline gastric secretions	High risk

- Most fasted individuals (> 95 %) present a grade 0 or 1 antrum which correlates with low gastric volume
- A grade 2 antrum is rarely seen in fasted patients and is suggestive of significant gastric volume

Mayo Clinic Children's Center

POCUS: Gastric. Interpretation of findings





Mayo Clinic Children's Center

POCUS Gastric U/S videos

Empty

Clear Fluid

Mayo Clinic Children's Center

POCUS Gastric U/S videos

Solid Early Stage

Solid Late Stage

PAEDIATRICS

Ultrasound assessment of the gastric contents for the guidance of the anaesthetic strategy in infants with hypertrophic pyloric stenosis: a prospective cohort study

A.-C. Gagey[1], M. de Queiroz Siqueira[1], F.-P. Desgranges[1], S. Combet[1], C. Naulin[2], D. Chassard[1,3] and L. Bouvet[1,4,*]

[1]Department of Anaesthesia and Intensive Care, Hospices Civils de Lyon, Femme Mère Enfant Hospital, 59, boulevard Pinel, 69500 Bron, France, [2]Department of Anaesthesia and Intensive Care, Centre Hospitalier de Villefranche-sur-Saône, Plateau d'Ouilly Gleizé, 69655 Villefranche-sur-Saône, France, [3]University of Lyon, Claude Bernard Lyon 1 University, 43 boulevard du 11 Novembre 1918, 69100 Villeurbanne, France, and [4]Inserm, U1032, LabTau, 151, cours Albert Thomas, 69003 Lyon, France

*Corresponding author. E-mail: lionel.bouvet@chu-lyon.fr

- Prospective, Observational study
- Assessed whether US monitoring of the aspiration of stomach contents may be helpful to guide the choice of anesthetic induction technique
- N=34; US of antrum before and after aspiration of gastric contents
- Stomach defined as empty with grade 0 score
- Stomach was empty in 30 of 34 cases
  - 9 before aspiration / 21 after aspiration
- Allowed for safe performance of non-RSI technique in 88% of the infants
- Correlation between antral area (in right lateral decub) and aspirated gastric volume

Learning and Training Resources

- USabcd.org
- Gastricultrasound.org
- SCCM.org
- PedsEM resources

Conclusions

- POCUS is an important tool in the perioperative and critical care settings
- Expanded use in procedural exploits
- Huge potential for diagnostic use in the OR for:
  - Cardiac: tool to rapidly assess CV instability and assess and direct efforts in CPR
  - Lung: tool to help rapidly diagnose hypoxemia etiology perioperatively
  - Gastric: aspiration risk assessment in setting of questionable per os intake

MAYO CLINIC

Questions & Discussion