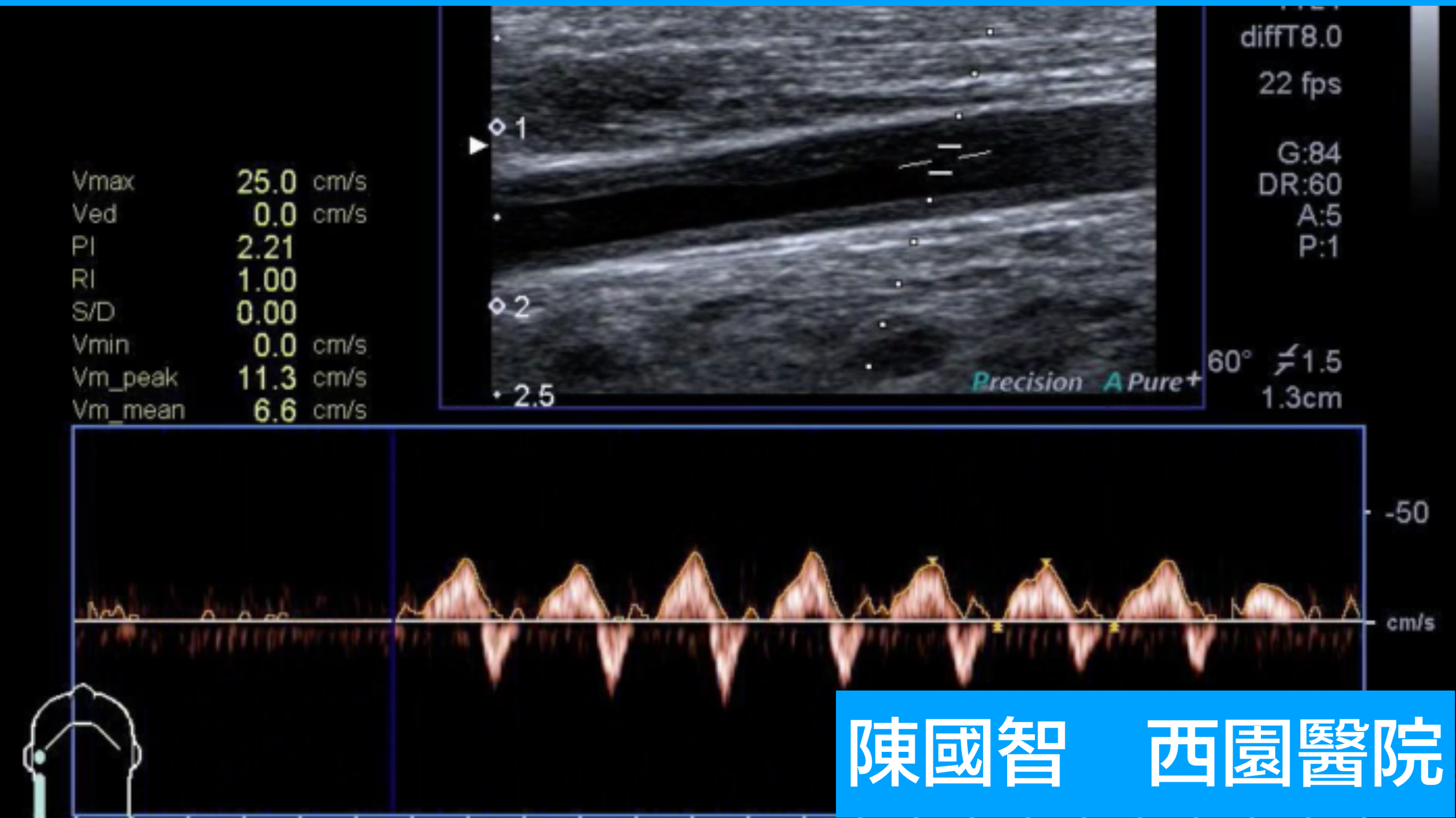
Novel applications for non-hemodynamic monitoring



陳國智　西園醫院

Conflict of Interest

前急診超音波委員會主委
急救加護重症超音波工作坊負責人
WINFOCUS & PERCUSS指導員

JUICE BAR 格主
POCUS Academy 小編

COI

201803
Mindray
Asia-Pacific
US Forum

Conflict of Interest

20180916 CCUS_Basic

POCUS

Point-of-care ultrasound

"ultrasonography brought to the patient and performed by the provider in real time"

Moore, C. L., & Copel, J. A. (2011). NEJM, 364(8), 749 - 757

POCUS

Care

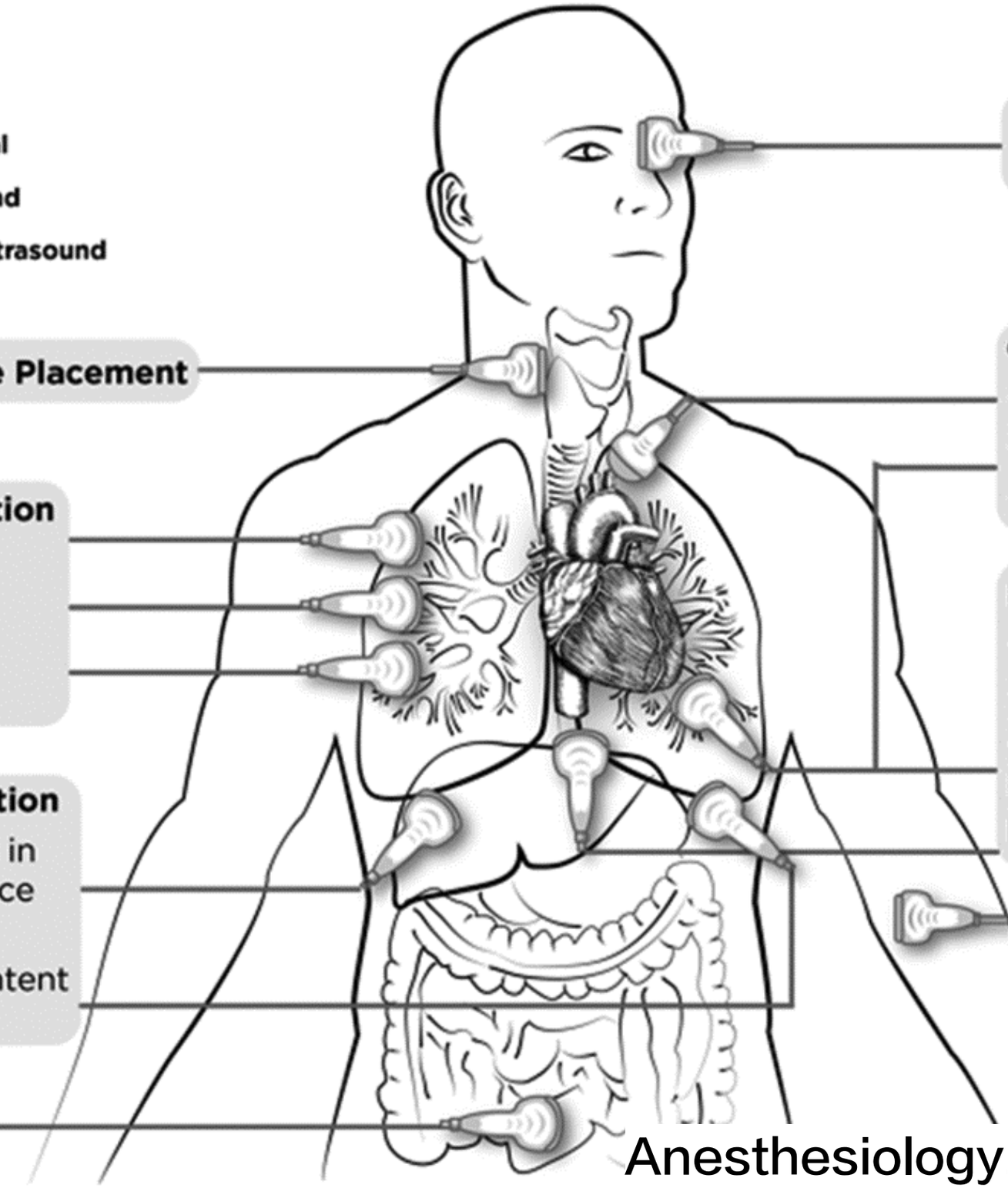
Time

You

F.O.R.E.S.I.G.H.T. Comprehensive Perioperative Ultrasound Examination

Focused
Peri**O**perative
Risk
Evaluation
Sonography
Involving
Gastro-Abdominal
Hemodynamic, and
Trans-Thoracic Ultrasound

Anesthesiologist



ICP Accessment
·Optic sheath diameter

Endotracheal Tube Placement

Cardiac Evaluation
·R/L ventricular function
·Pericardial effusion
·Severe valvular abnormalities

Pulmonary Evaluation
·Pneumothorax
·Pleural effusion
·Severe alveolar interstitial disease

Hemodynamics
·IVC collapsibility
·LV end diastolic area
·Respiratory variation on Doppler flow across LVOT/ peripheral arteries

Abdominal Evaluation
·Evaluate free fluid in interperitoneal space via 3 windows
·Assess gastric content and volume

Vascular Access
·Demonstrate image acquisition of peripheral veins/arteries

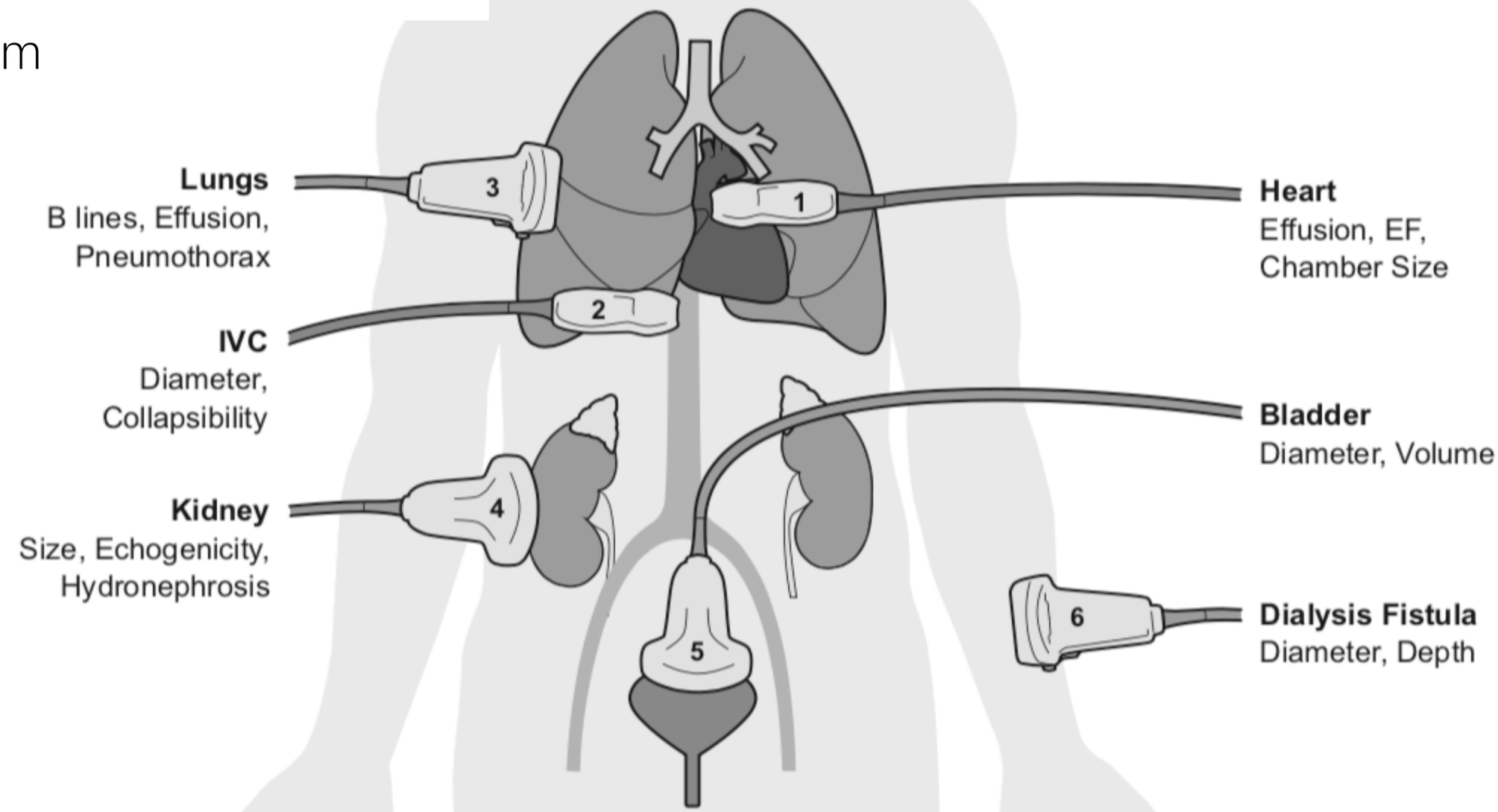
Anesthesiology. 2015 Sep;123(3):670–82

	IMAGE AREA	IMAGE ACQUISITION	PROBE
1	Heart	Parasternal Long Axis (PLAX)	Phased
2	Inferior Vena Cava	Subcostal	Phased
3	Lung	Anterior, Lateral, Posterior	Linear
4	Kidney	Longitudinal, Transverse	Curved
5	Bladder	Suprapubic	Curved
6	Dialysis Fistula	Longitudinal and Transverse	Linear

Nephrologist

Johns Hopkins **Nephrology** fellowship

POCUS curriculum



Semin Dial. 2018 Mar;31(2):154–162

I–AIM

Indication

Acquisition

Interpretation

Making decision

Bahner DP, et al. J Ultrasound Med 2012

Indication

- Respiratory symptoms and/or signs
- Unclear chest radiograph findings
- Monitoring and prognosis

Pretest probability ←
- History
- Physical examination
- ABG
- ECG

Acquisition

DIAGNOSTIC HYPOTHESIS

	Pleural effusion suspected	PTX suspected	Increased lung density suspected
Patient position Probe selection & orientation Protocol selection	• Semisitting (or supine) • Low-frequency probe • Maintain postprocessing artifacts reduction algorithms	• Ideally supine • If possible, high-frequency probe • Consider M-mode and Power Doppler	• Semisitting or supine • Low-frequency and high-frequency probes • If B-line pattern analysis, deactivate post-processing artifacts reduction algorithms
Picture optimization	• Start examination from lung bases; identify diaphragm and spine	• Identify least dependent zone	• Complete lung examination (anterior, lateral, and posterior surfaces, bilaterally)

Interpretation

PLEURAL LINE INTERFACE

Fluid

Pleural effusion/ Hemothorax

- Size
- Fluid characteristics

A-line Pattern

Lung sliding? YES / NO
Lung pulse? YES / NO
Vertical artifact? YES / NO

PTX likely

Lung point? YES

PTX highly likely

Normal lung density at pleural line

Consider:
- PEEP effect/lung overinflation
- Lung pathology not reaching pleural line
- Early stages of lung pathology
- Performance of further tests

Diagnostic / Nondiagnostic

Increased Lung Density

- ***Increased lung weight*** (water, cells, pus, blood, proteins, connective tissue, lipids) ***and/or***
- ***Lung deflation***

B-line Pattern

Diffuse | **Focal**

Sonographic findings that may help in differential diagnosis
- B-lines distribution (homogeneous/nonhomogeneous distribution)
- B-lines "density" (B1 pattern; B2 pattern)
- Decreased lung sliding
- Decreased/increased lung pulse
- Gravity-dependent or -independent pattern
- Presence/absence of pleural line abnormalities
- Presence/absence of subpleural abnormalities (*e.g.*, focal consolidations)

Solid

Large area of lung consolidation | **Small subpleural consolidation**

Sonographic findings that may help in differential diagnosis
- Distribution
- Detection of air bronchogram(s)
- Detection of fluid bronchogram(s)
- Vascular pattern within the consolidation

Differential diagnosis

Fluid	A-line Pattern	Increased Lung Density
• Transdudate • Exudate • Hemothorax • Empyema	• PTX • Bullous disease • Lung overinflation (*e.g.*, COPD, mechanical ventilation) • Pleural adhesions • Bronchial obstruction	• Asthma exacerbation • COPD exacerbation • Pulmonary embolism • Infectious/neoplastic process without pleural line involvement • Lung overinflation (*e.g.*, COPD, mechanical ventilation) • Bronchial obstruction (early) • Metabolic or neurologic causes • Cardiogenic (hydrostatic) pulmonary edema • Nonhydrostatic pulmonary edema (*e.g.*, ARDS) • Infection • Pneumonitis • Idiopathic interstitial pneumonias and other ILDs • Alveolar hemorrhage • Alveolar proteinosis • Normal pattern (if isolated at lung bases) • Lung consolidation • Pulmonary infarct • Pulmonary contusion • Atelectasis (compression or obstruction) • Primary lung cancer/tumor or metastasis

AIR CONTENT ↑ — LUNG DENSITY →

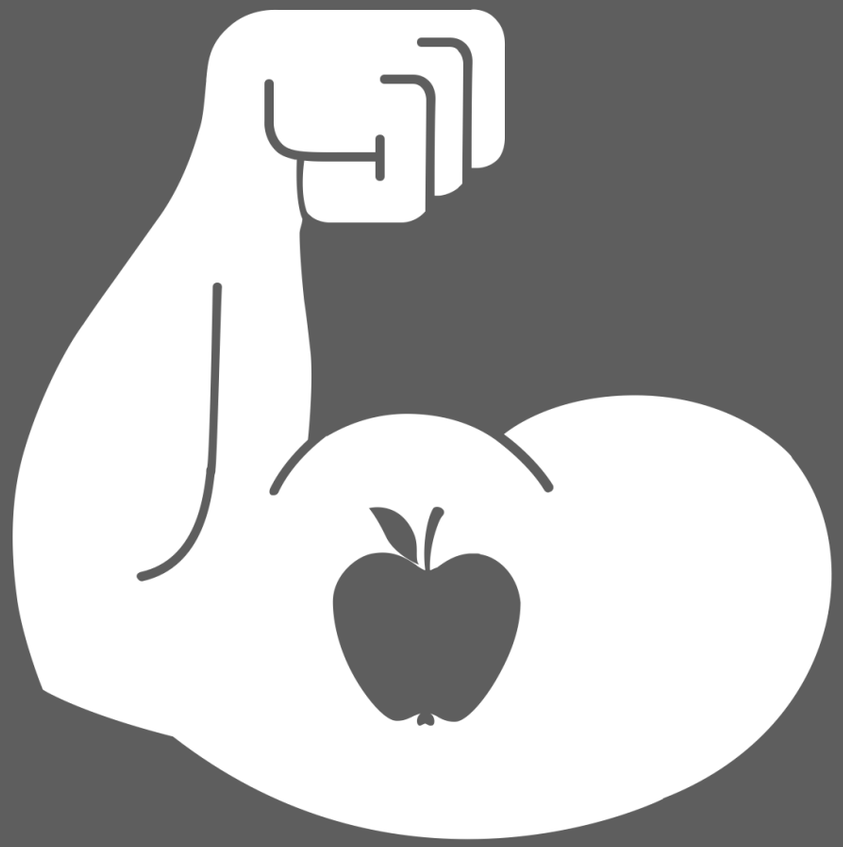
Medical Decision-making

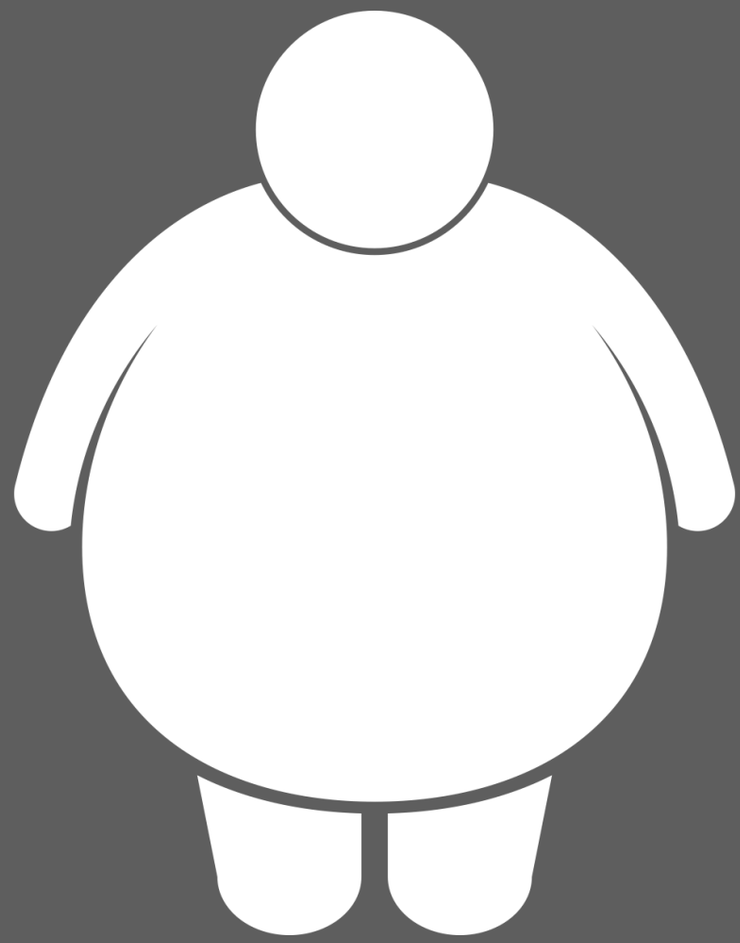
- Integration with clinical context (pretest probability)
- Consistency or inconsistency of findings with pretest diagnostic hypothesis
- LUS diagnostic or nondiagnostic
- Changes in diagnostic and therapeutic approach

Anesthesiology 2017, Vol.127, 568–582

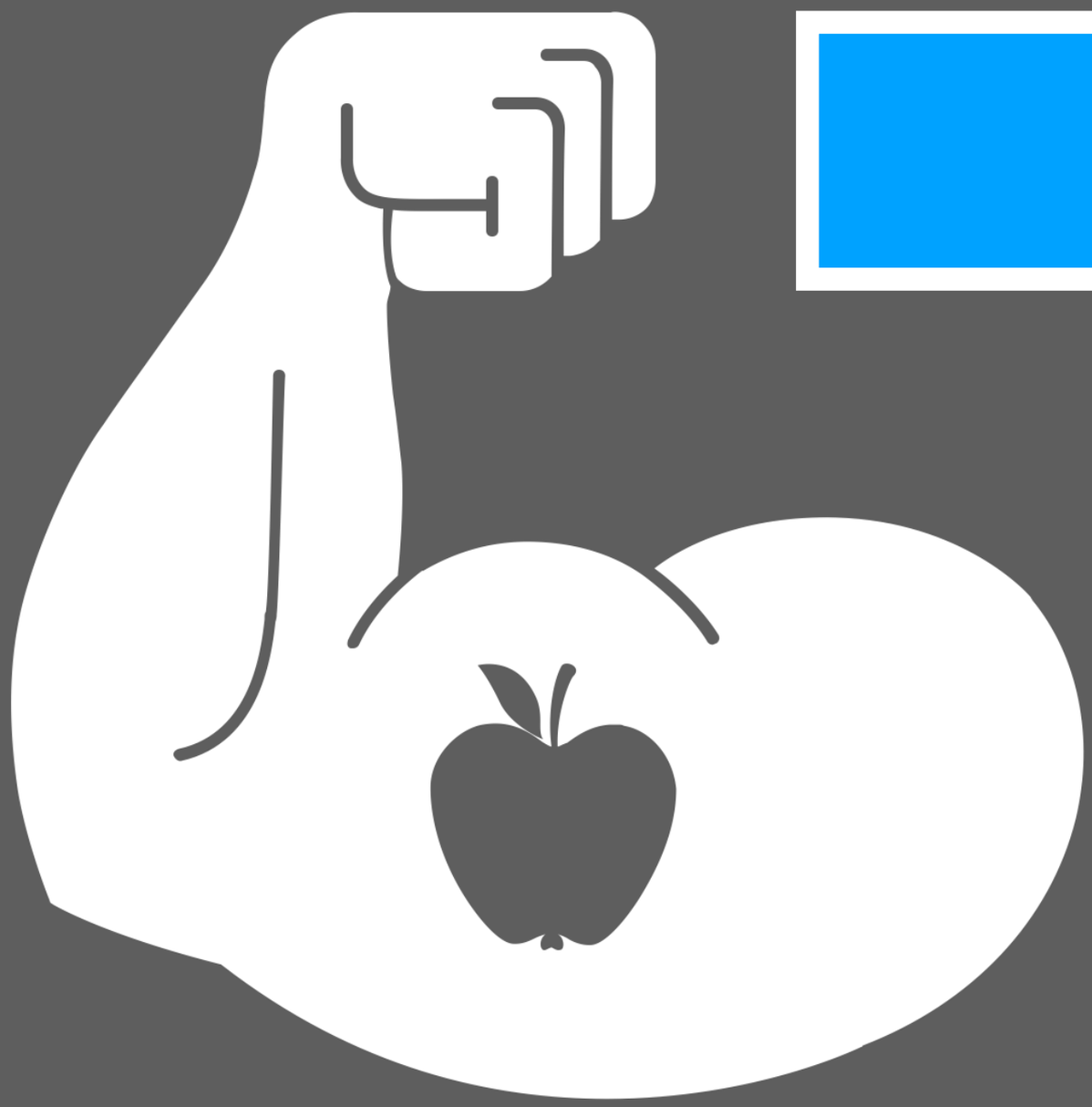
Nutrition

ACS



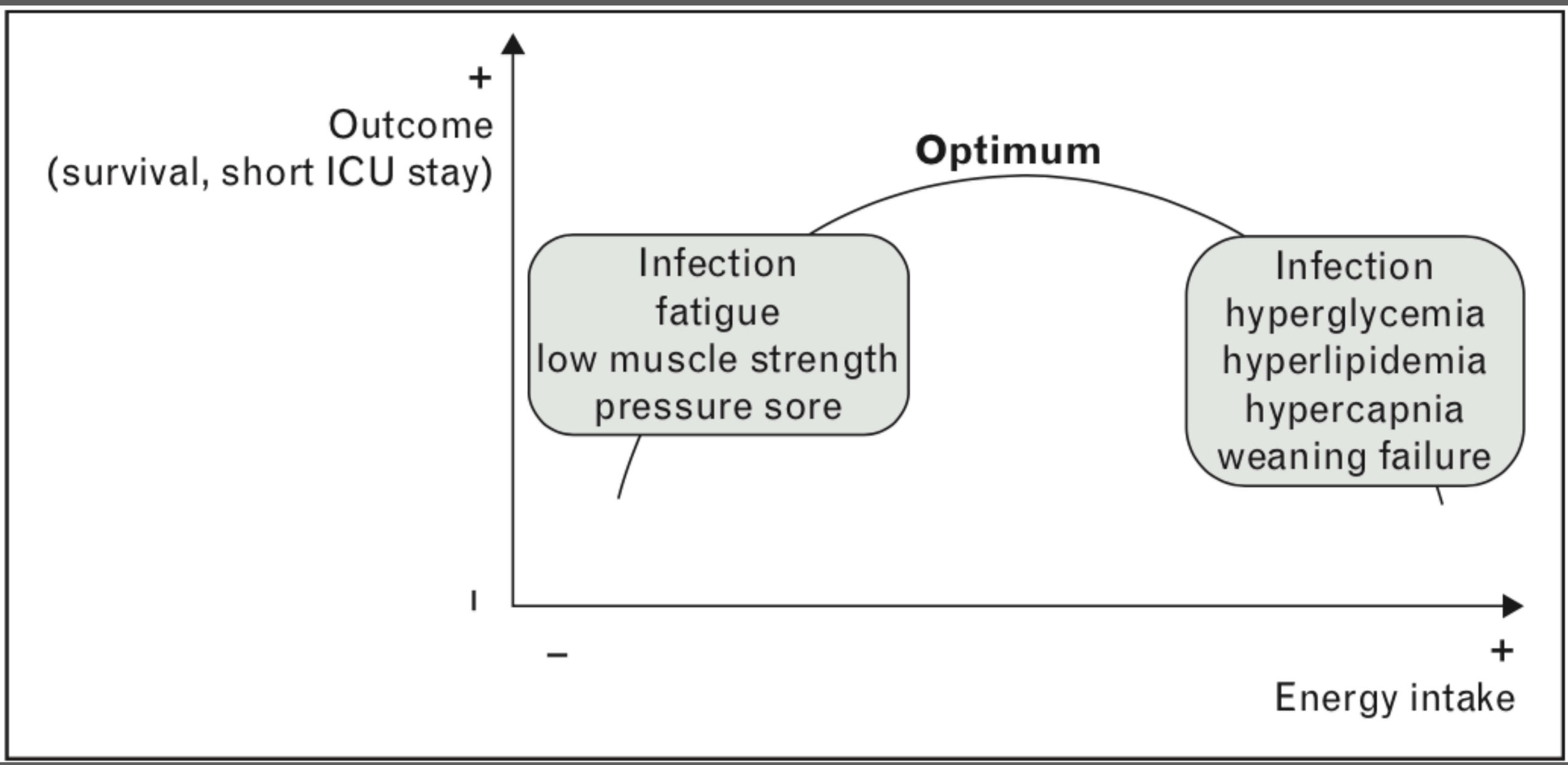


Nutrition is the key to survive & success



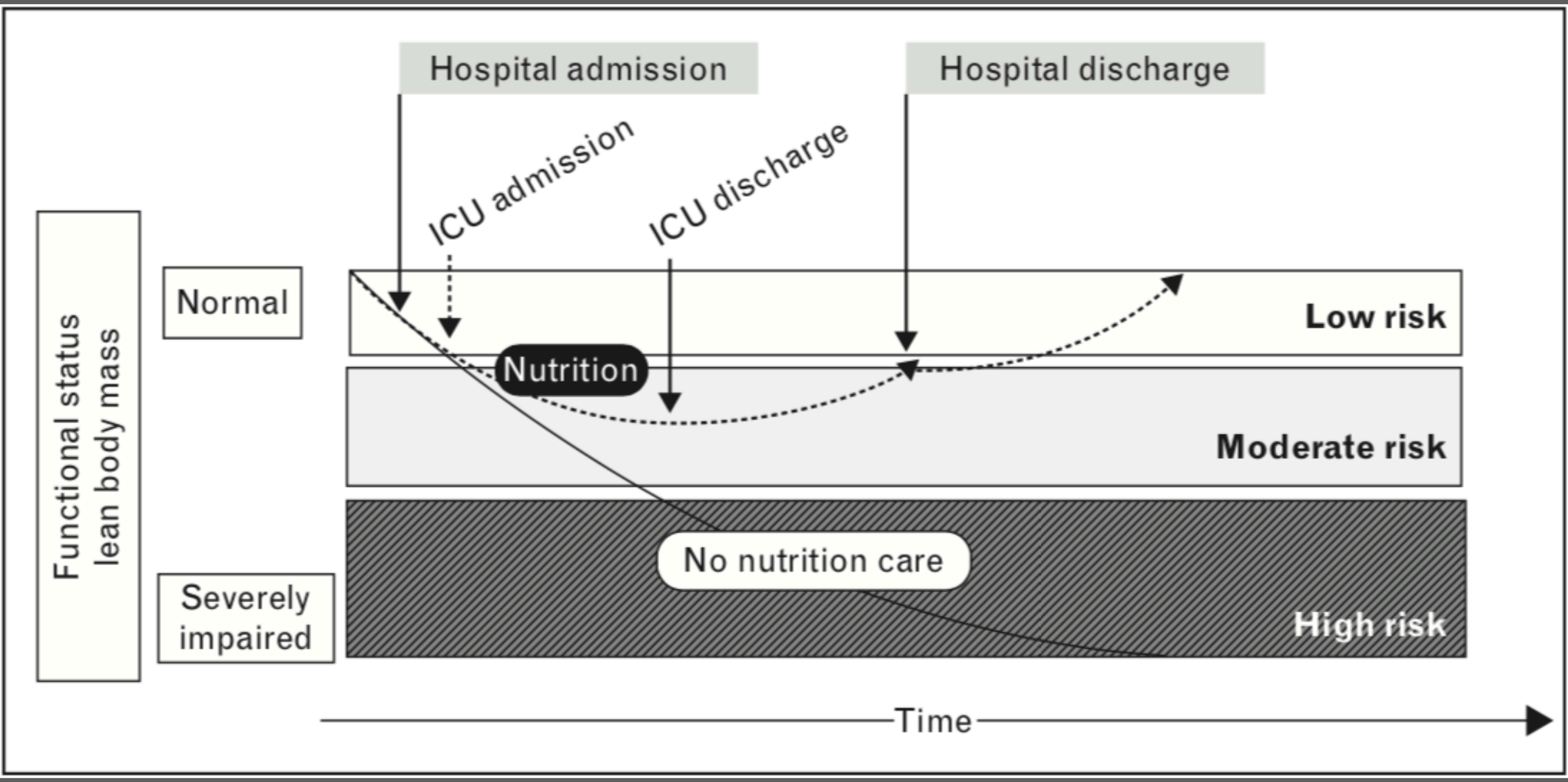
Nutrition

Goal: optimal nutrition



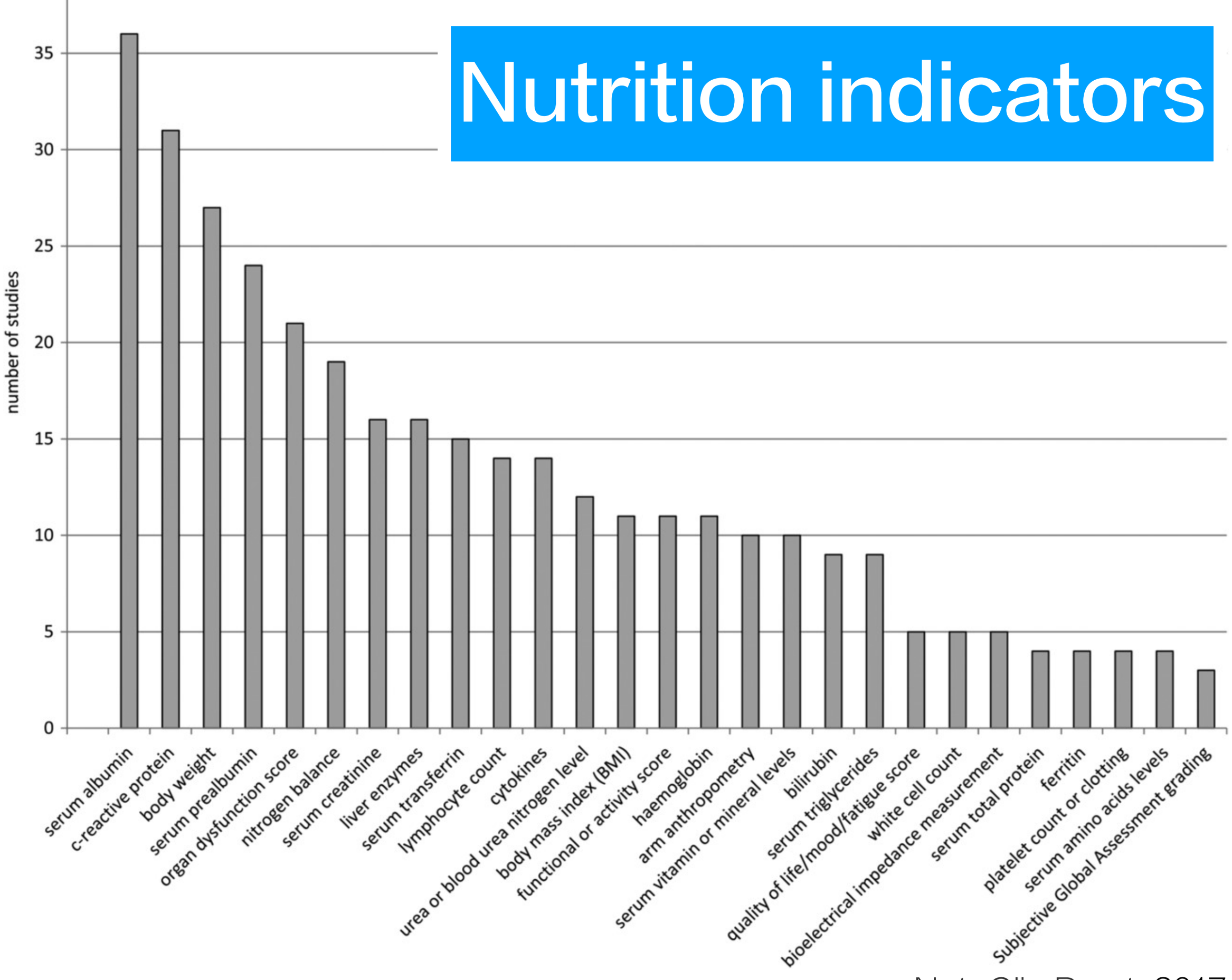
Curr Opin Clin Nutr Metab Care. 2012;15:174–80

to stop or slow lean mass losses



Curr Opin Clin Nutr Metab Care. 2012;15:174–80

Nutrition indicators



Nutr Clin Pract. 2017

Feasibility	Availability		
	High	Moderate	Low
High	Mid upper arm circumference Recumbent body length[a] Recumbent arm wingspan[a] Height estimated from ulnar length[a] Serum albumin[a] Serum transferrin[a] Serum urea[a] Serum creatinine[a] Hemoglobin[a] Total lymphocyte count[a] Subjective Global Assessment[a] NRS-2002 score Updated NUTRIC score Estimated body cell mass (from limb circumferences)	Triceps skinfold thickness Mid upper arm muscle circumference Serum prealbumin[a] Serum retinol-binding protein Serum cytokine level (interleukin 6) Original NUTRIC score Maastricht Index Insulin-like growth factor 1	Serum amino acids Plasma fibronectin Serum leptin Mononuclear cell mitochondrial complex 1 Serum α-1 acid glycoprotein PINI score Serum α-1-antitrypsin
Moderate	Weight[a] Percentage weight change[a] Body mass index[a] Nitrogen balance (urinary urea nitrogen)[a] Urinary creatinine Fatigue score	Ultrasound upper arm measurement Ultrasound forearm measurement Ultrasound thigh two-thirds measurement Handgrip strength Modified PNI score (with grip strength)	Nitrogen balance (urinary total nitrogen) Urinary 3-methyl histidine Body composition (DEXA scan) Body composition (bioelectrical impedance) Body composition (in vivo neutron activation) Whole-body amino acid kinetics (radiolabeled Leu or Tyr) Delayed hypersensitivity skin testing PNI score (with skin testing)
Low	Standing height	Ultrasound rectus femoris thickness Muscle thickness measurement on CT scan Lung function tests[a]	Adductor pollicis involuntary muscle function MRI measurement of muscle bioenergetics Limb arteriovenous amino acid level comparisons Lymphocyte activity measured with radiolabeled thymidine Muscle biopsy measure of protein synthesis Metabolomic analysis

Nutr Clin Pract. 2017

ICUAW

Intensive care unit acquired weakness

generalized weakness that develops during critical illness without other explanation

AJRCCM 2014

ICUAW

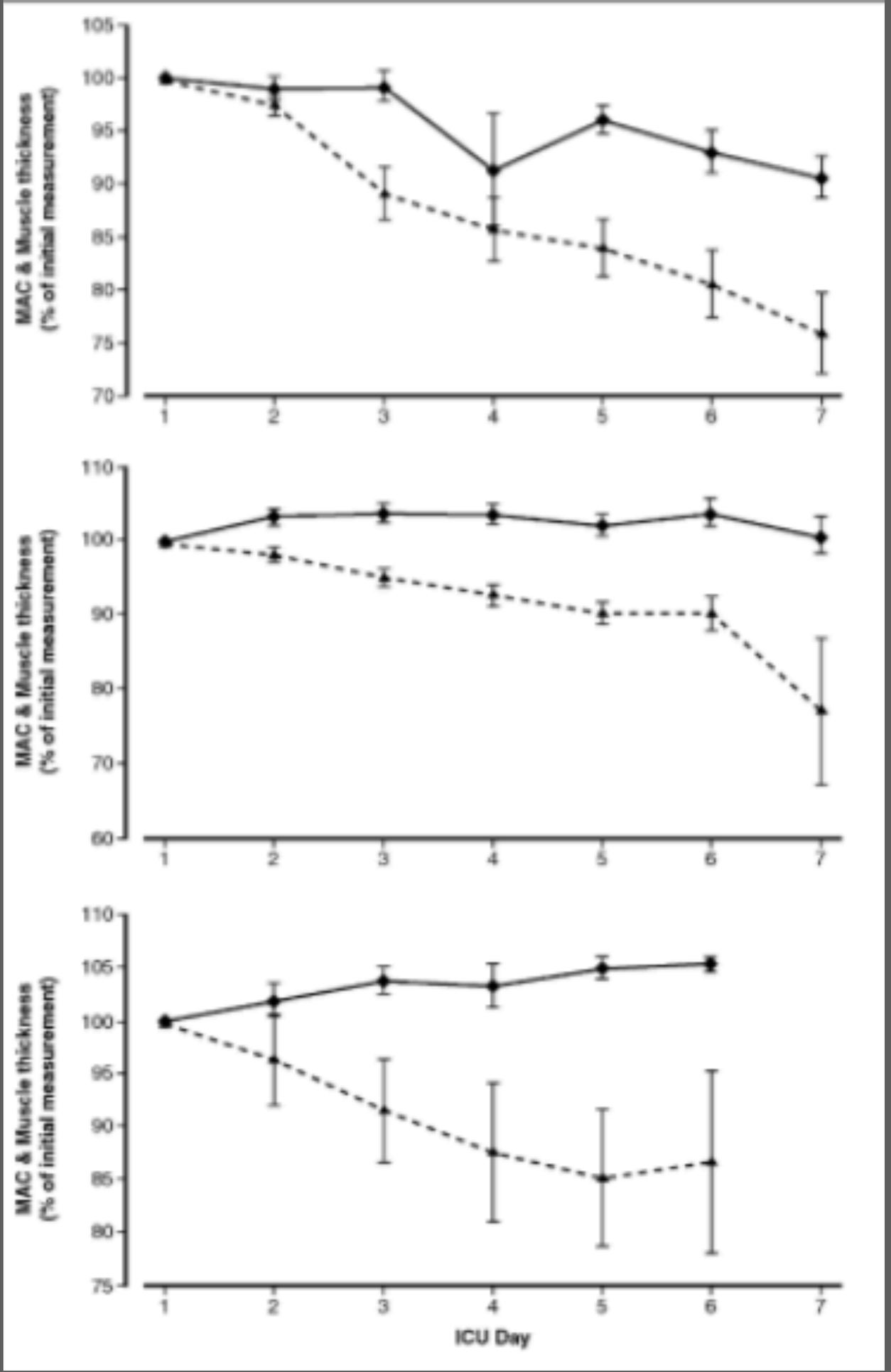
Intensive care unit acquired weakness

Severe sepsis

Difficult ventilator liberation

Prolonged mechanical ventilation

AJRCCM 2014



MAC

Mid-upper arm circumference

US is reliable in edema

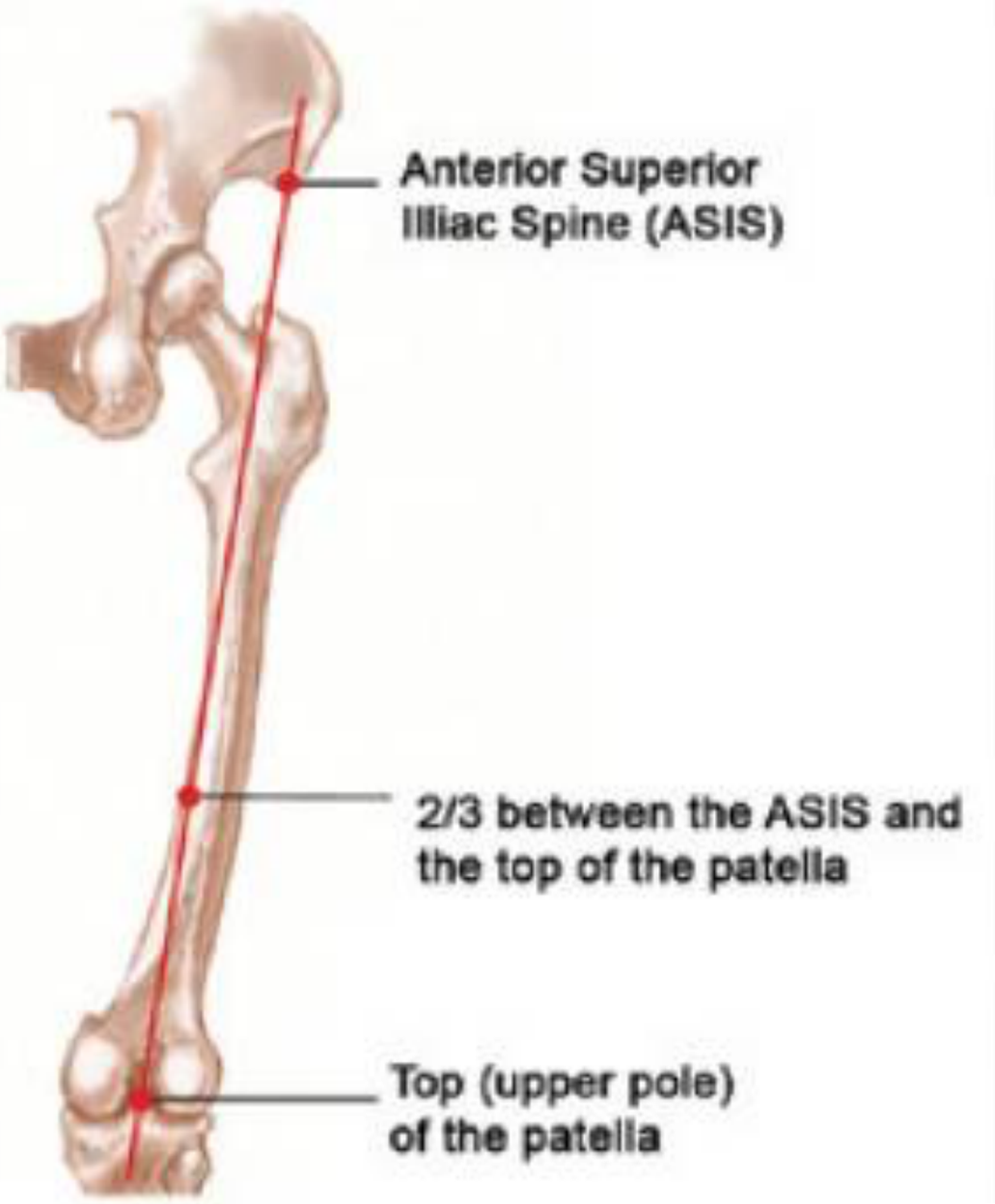
MT

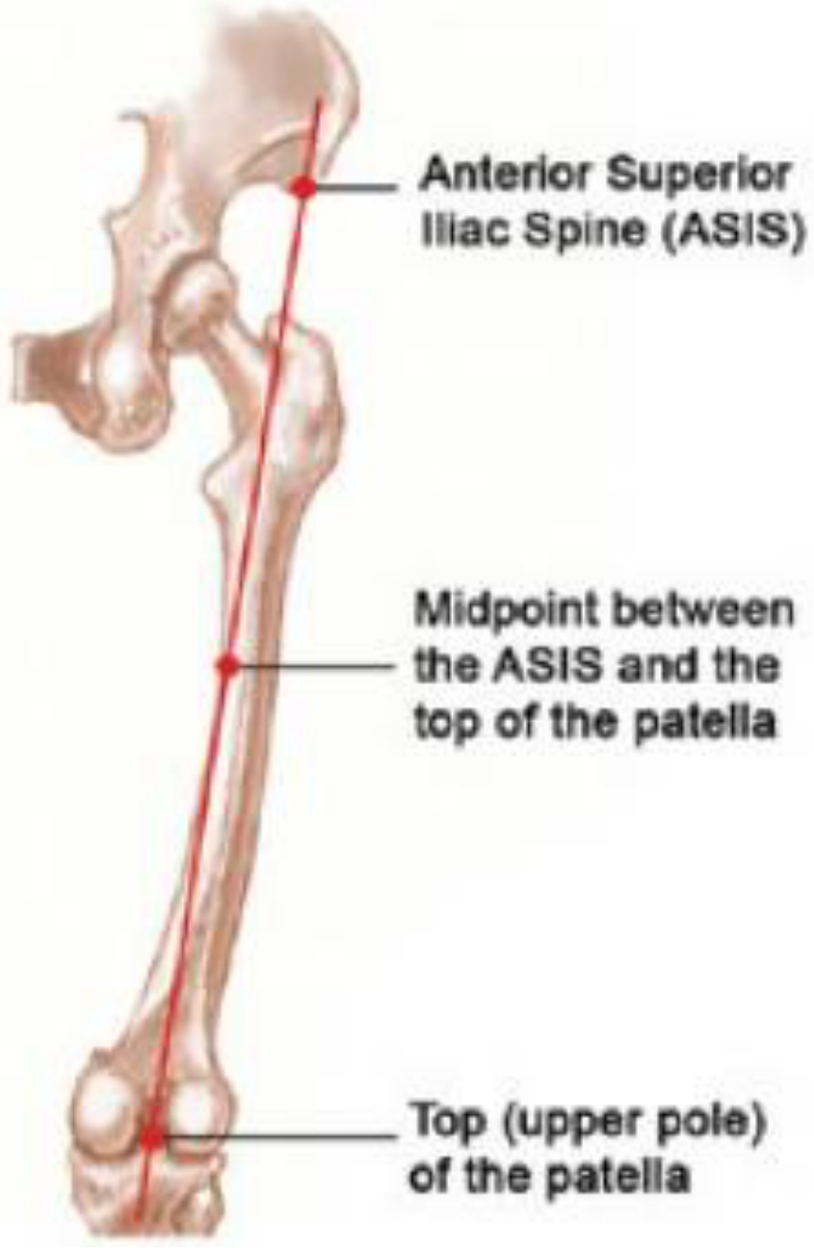
muscle thickness

Clinical nutrition. 2004;23:273-280

QMLT; Volunteers

Reading #1	Reading #2
At the border between the lower third and upper two-thirds between ASIS and upper pole of the patella.	At the midpoint between the ASIS and the upper pole of the patella.

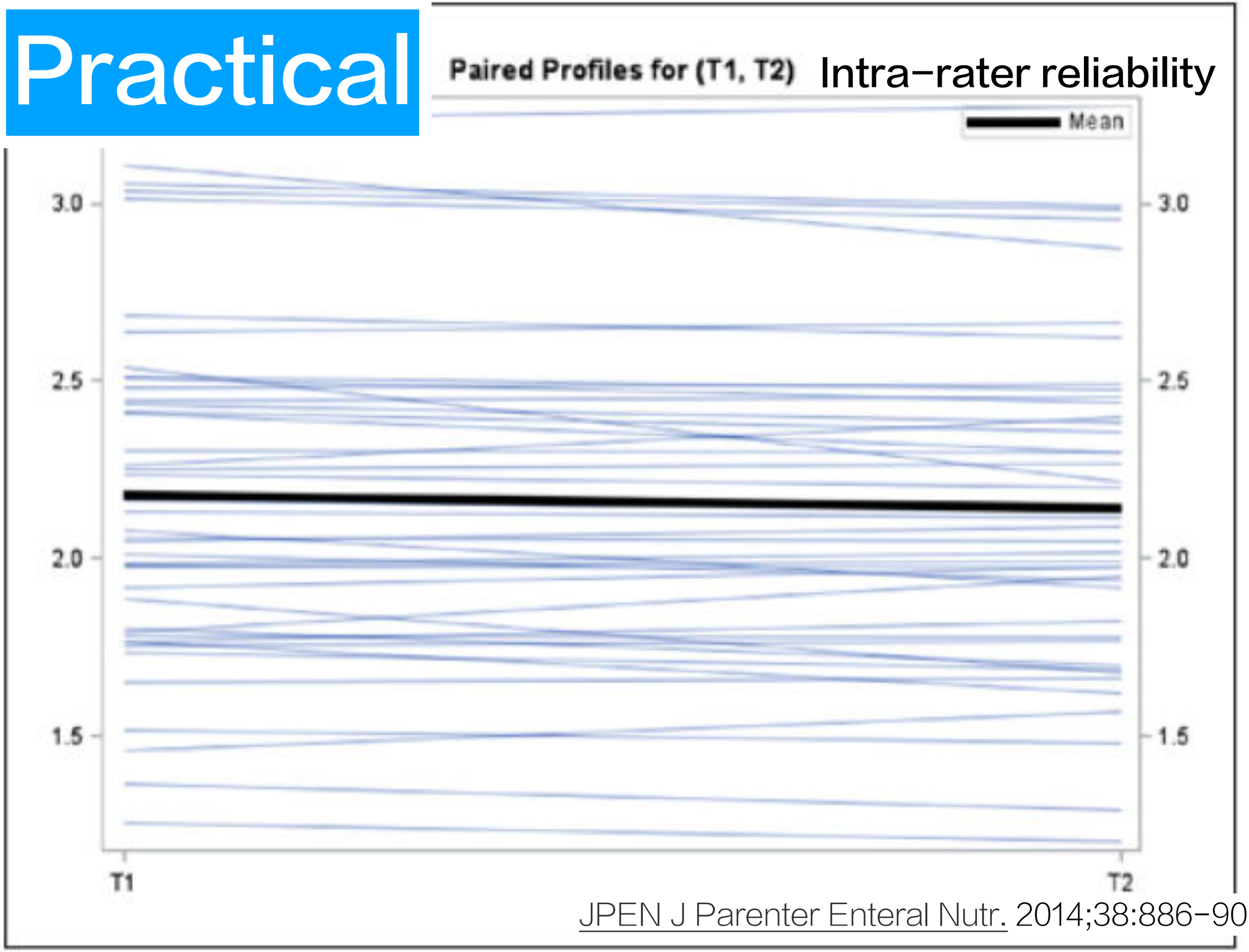




JPEN J Parenter Enteral Nutr. 2014;38:886–90

Practical

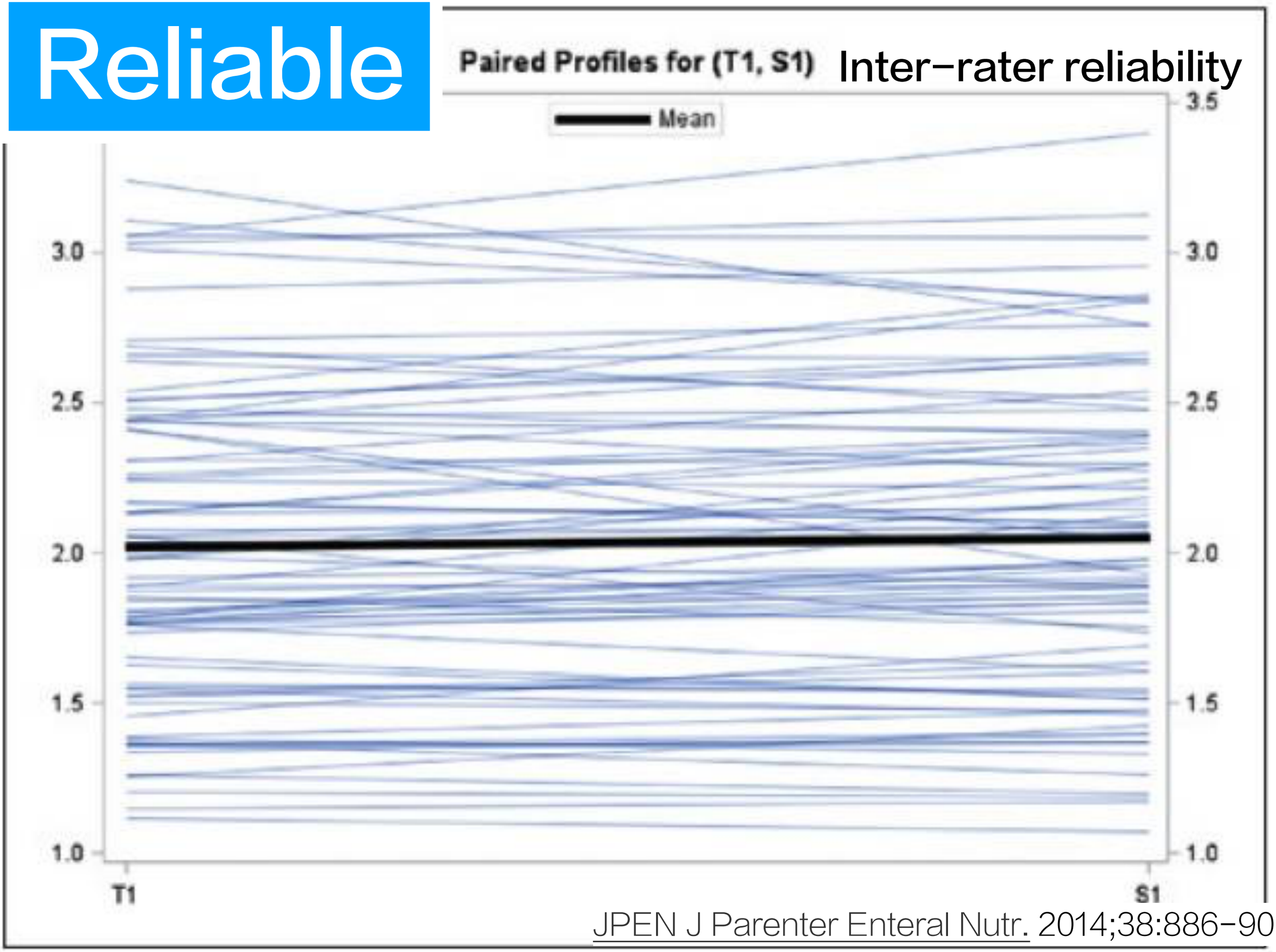
Intra-rater reliability



JPEN J Parenter Enteral Nutr. 2014;38:886-90

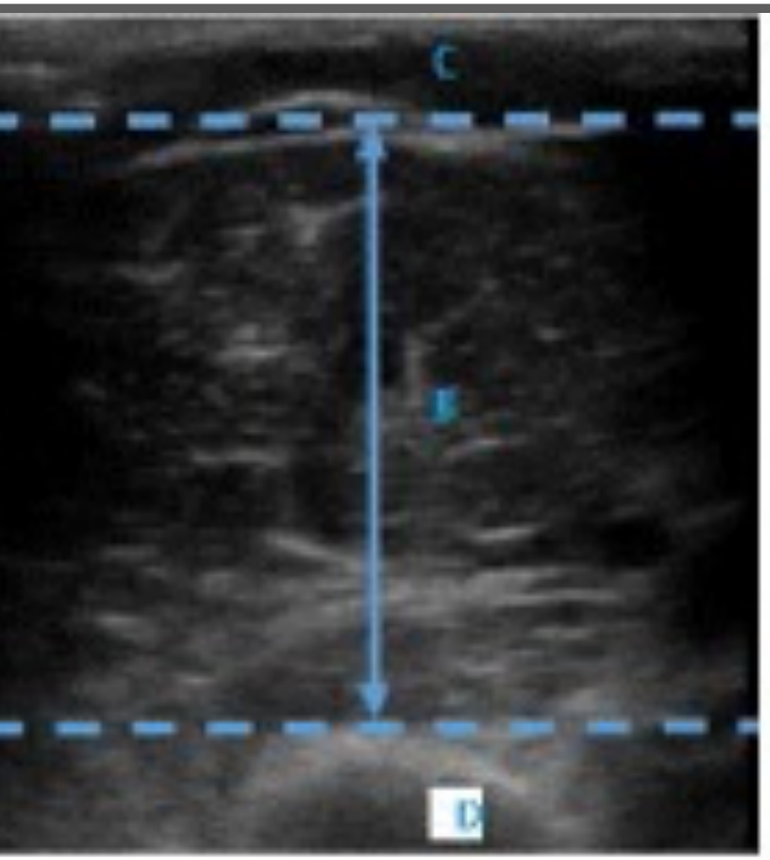
Reliable

Inter-rater reliability

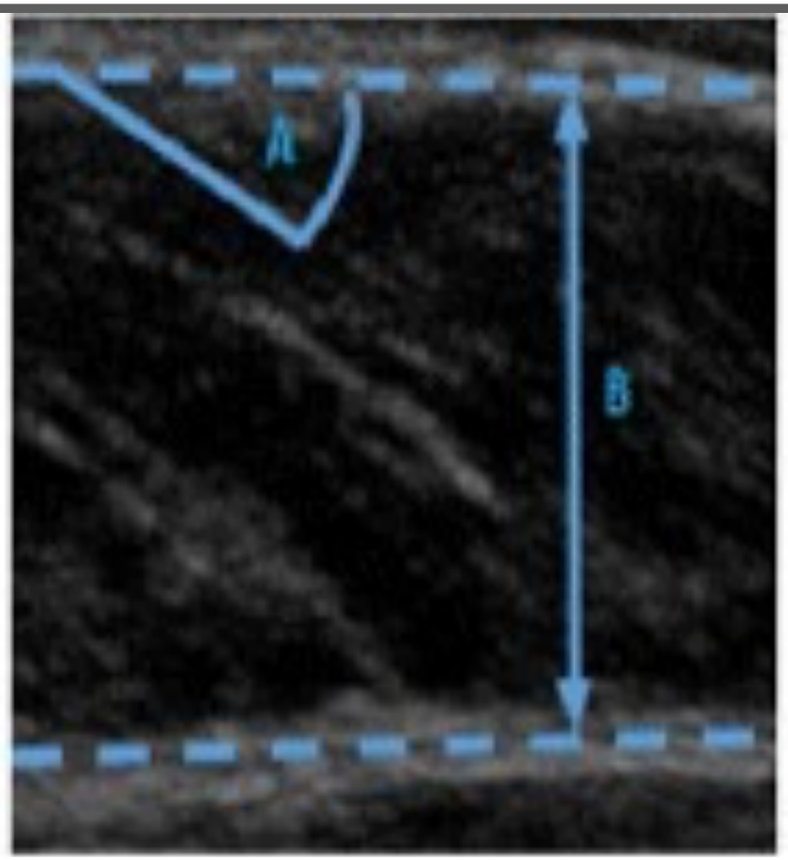


JPEN J Parenter Enteral Nutr. 2014;38:886-90

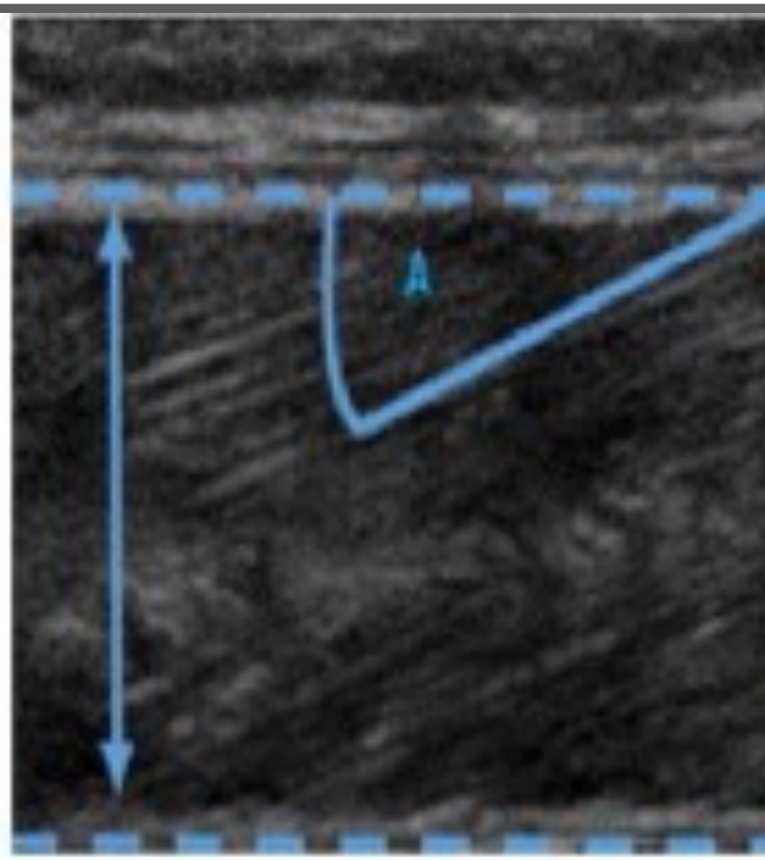
MT: muscle thickness
PA: Pennation angle



a Elbow flexor compartment



b Medial head of gastrocnemius



c Vastus lateralis

Key – A= measured pennation angle. B = Muscle thickness
C= subcutaneous fat. D = Humerus

BMC Anesthesiol. 2016; 16: 119.

Lower limb muscles prone to early dystrophy

	Day 1 ($n = 22$)	Day 5 ($n = 16$)	Day 10 ($n = 9$)	P-value
MT – Elbow flexor compartment, [cm] (median ± IQR)	3.20 ± 0.58	3.30 ± 0.87	2.98 ± 0.83	0.62
MT – Gastrocnemius, [cm] (median ± IQR)	1.29 ± 0.60	1.34 ± 0.43	1.14 ± 0.65	0.72
MT – Vastus lateralis [cm] (median ± IQR)	1.53 ± 0.77	1.40 ± 0.46	1.18 ± 0.36	0.002*
FL – Gastrocnemius [cm] (median ± IQR)	3.99 ± 1.84	3.69 ± 1.37	3.43 ± 2.12	0.90
FL – Vastus lateralis [cm] (median ± IQR)	8.1 ± 3.06	8.45 ± 4.55	7.85 ± 5.89	0.89
PA – Gastrocnemius [degrees] (median ± IQR)	20.93 ± 6.41	19.82 ± 5.65	17.5 ± 3.91	0.37
PA – Vastus lateralis [degrees] (median ± IQR)	11.09 ± 4.88	9.86 ± 3.69	8.03 ± 3.86	0.018*

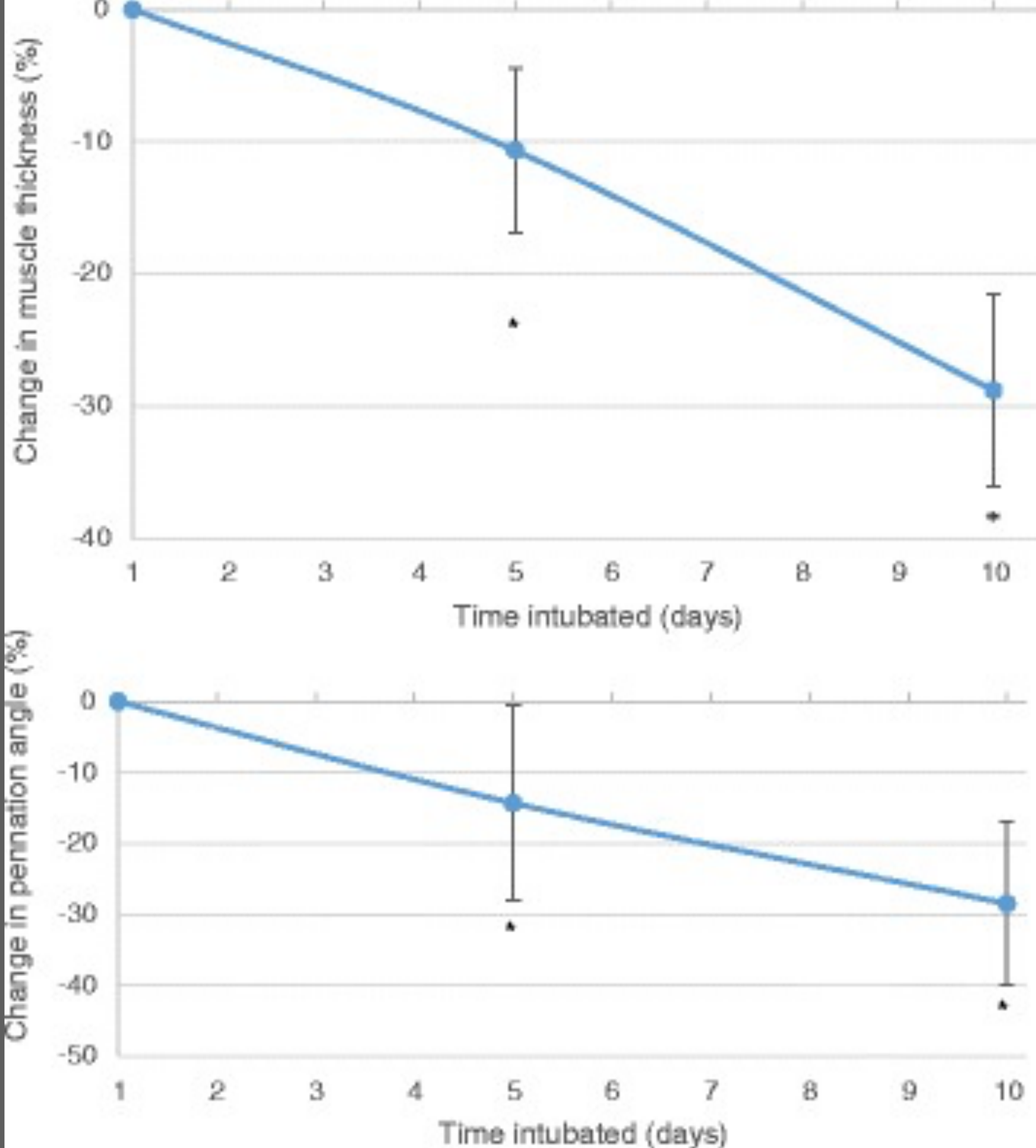
BMC Anesthesiol. 2016; 16: 119.

MT

Very early

PA

Vastus lateralis muscle



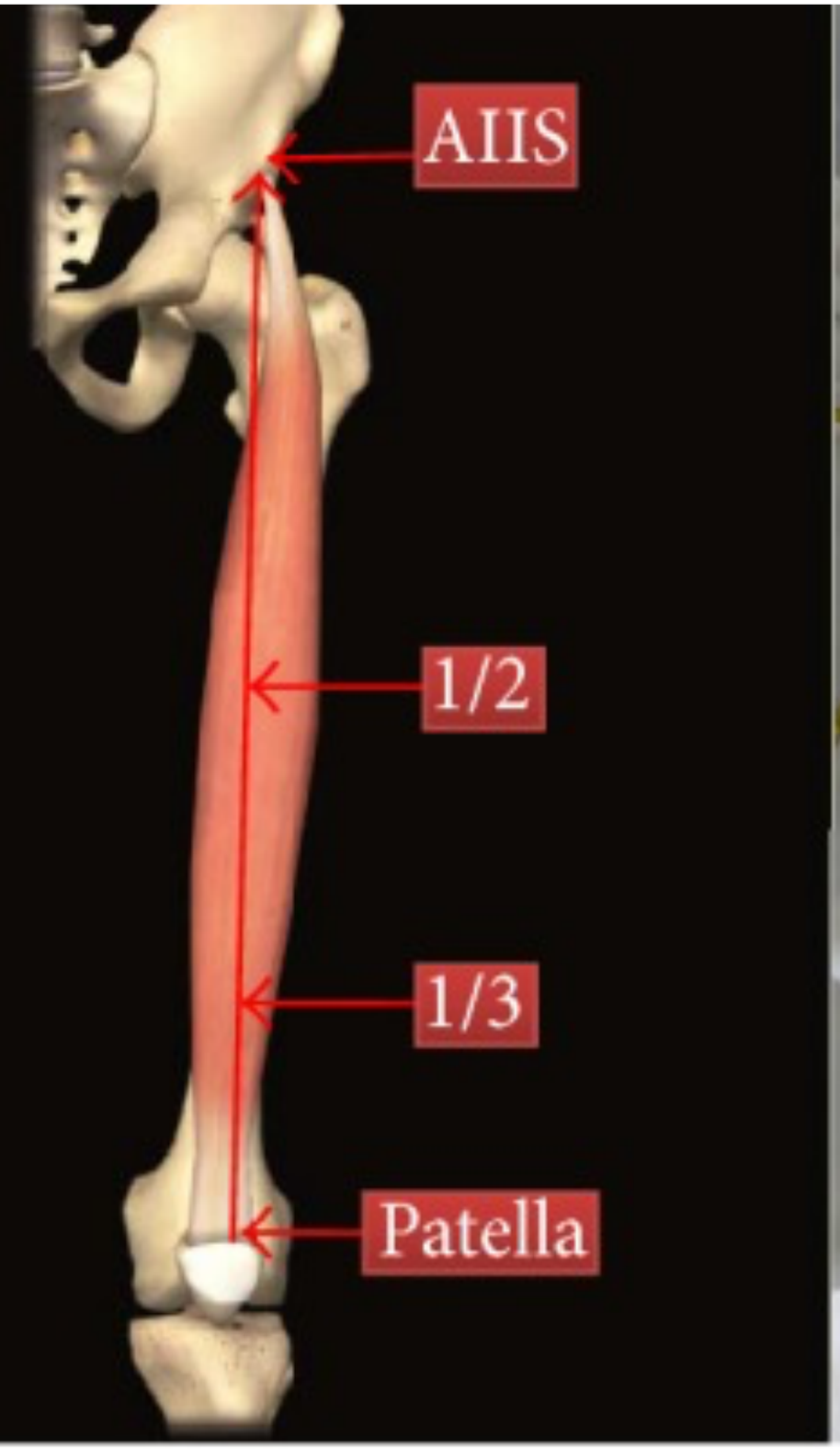
Critically ill patients

Lower limbs

Muscle wasting
Architectural remodeling

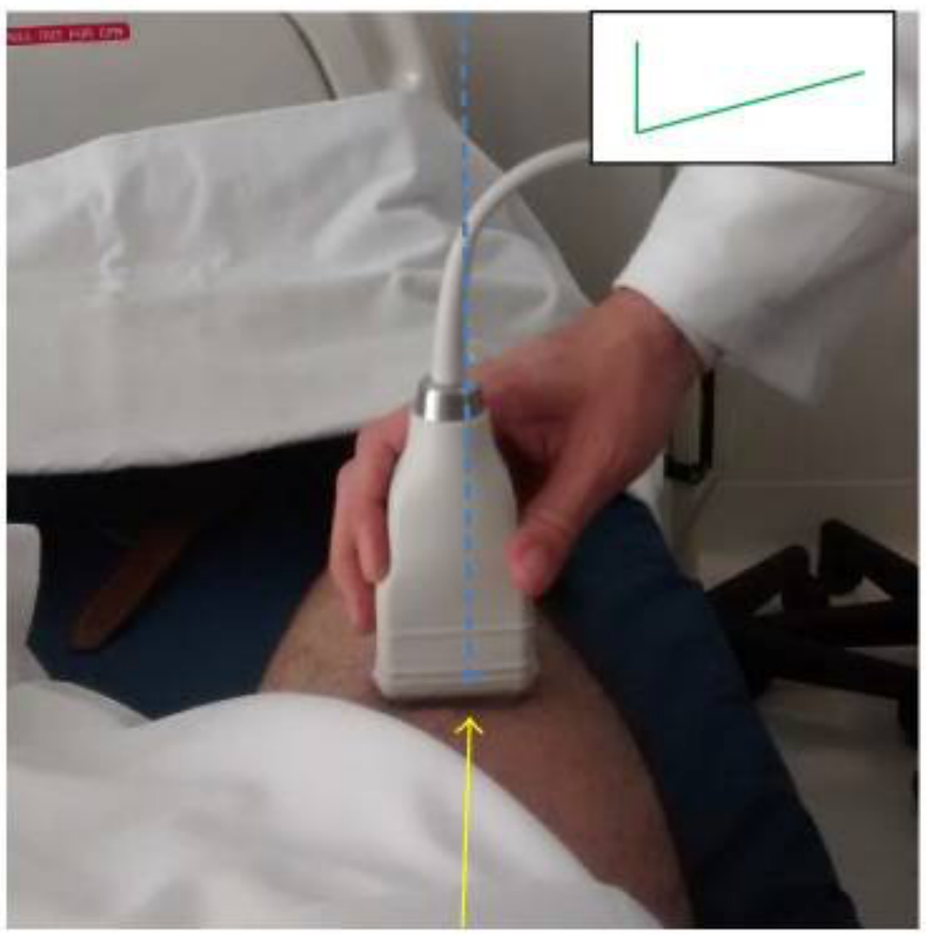
BMC Anesthesiol. 2016; 16: 119.

Where to measure ?

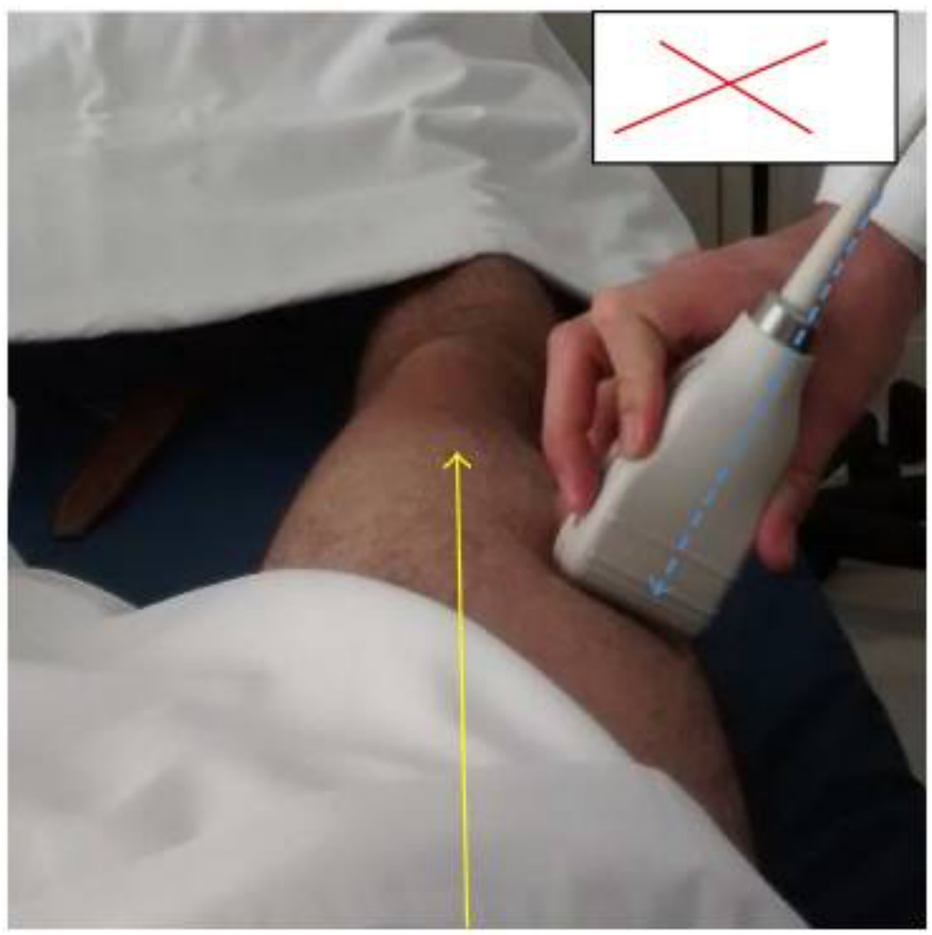


J Nutr Metab. 2017; 2017: 2767232.

Where to measure ?



(a)



(b)

J Nutr Metab. 2017; 2017: 2767232.

Structures

Order	Structure	Description
1	Skin	Hyperechoic layer adjacent to the transducer [18].
2	Subcutaneous tissue (fat)	Hypoechoic layer of variable thickness with hyperechoic lines resembling a feather [18].
3	Muscular fascia	Hyperechoic layer corresponding to the first interface where the RF interposes.
4	Rectus femoris	Semicircle structure delimited by the muscular fascia and the second interface.
5	Second interface	Hyperechoic layer where the VI interposes.
6	Vastus intermedius	Rectangular structure delimited by the second interface and the bony surface.
7	Bony surface	Hypoechoic circular structure delimited (acoustic shadow) by a hyperechoic layer corresponding the femur cortical layer (sonic surface) [18].

J Nutr Metab. 2017; 2017: 2767232.

Skin

Subcutaneous tissue

Lymph nodes

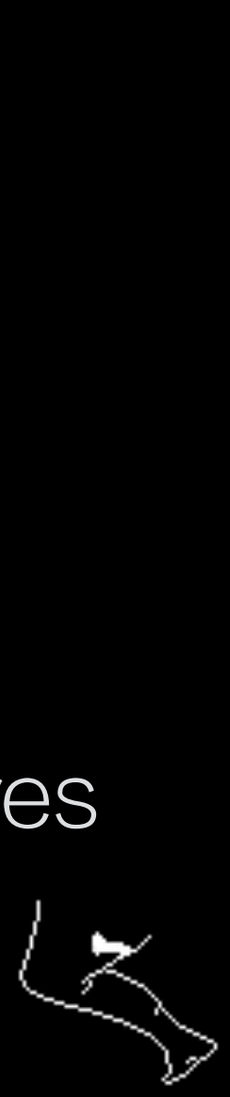
Fascia

Muscles

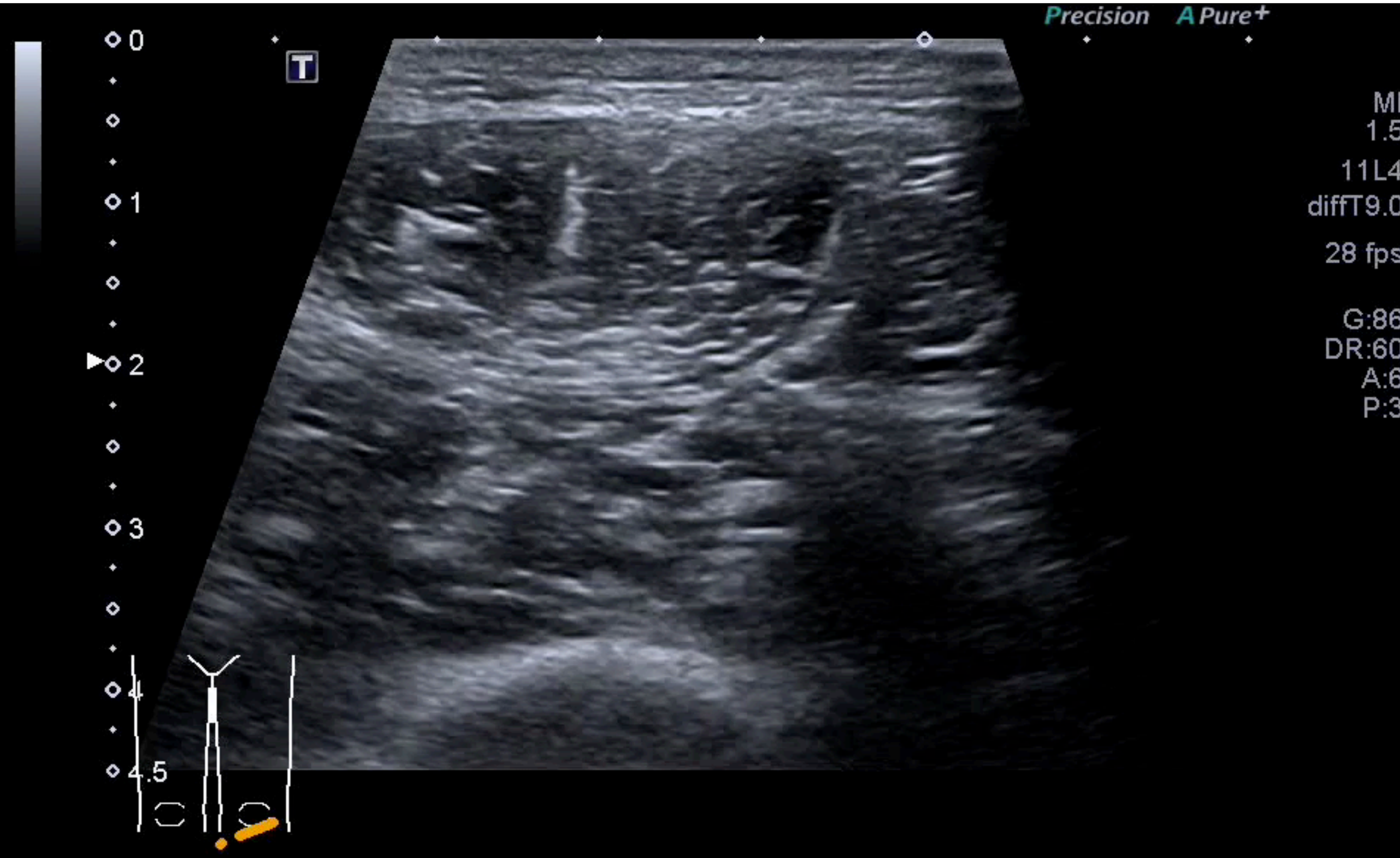
Tendon

Vascular structures

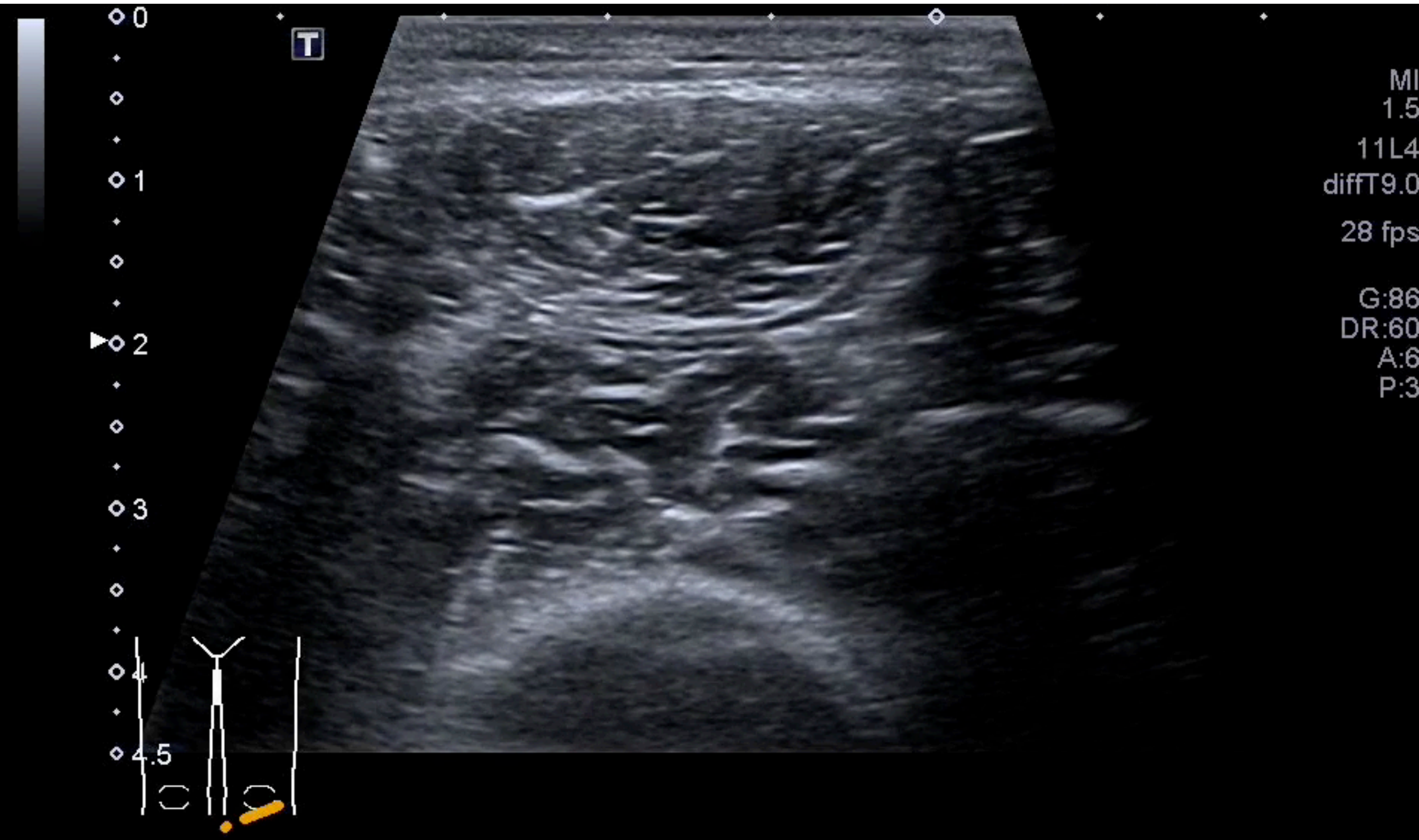
Bone



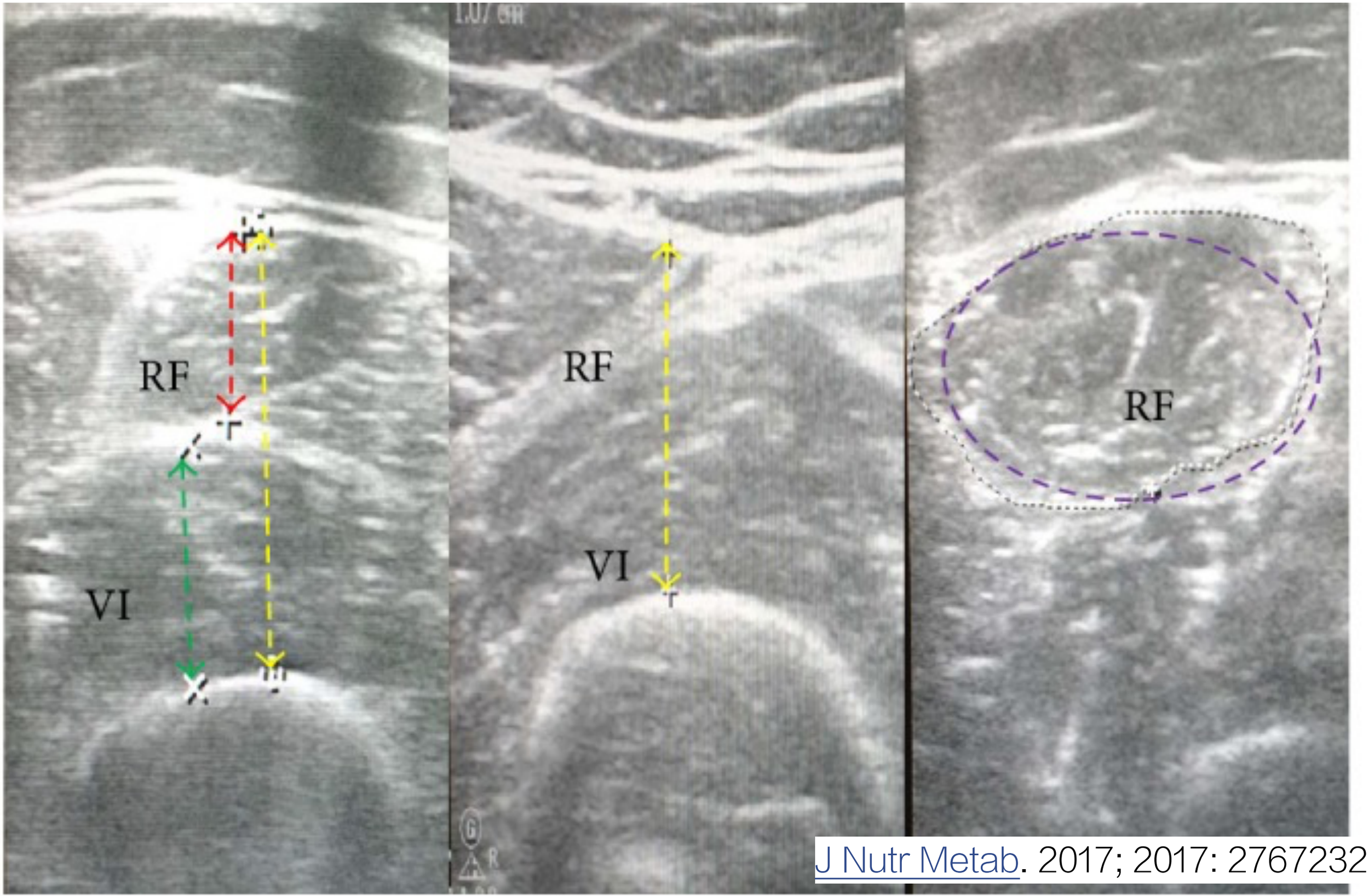
RF & VI


Precision
A Pure+
0
1
2
3
4
4.5
T
M
1.5
11L4
diffT9.0
28 fps
G:86
DR:60
A:6
P:3

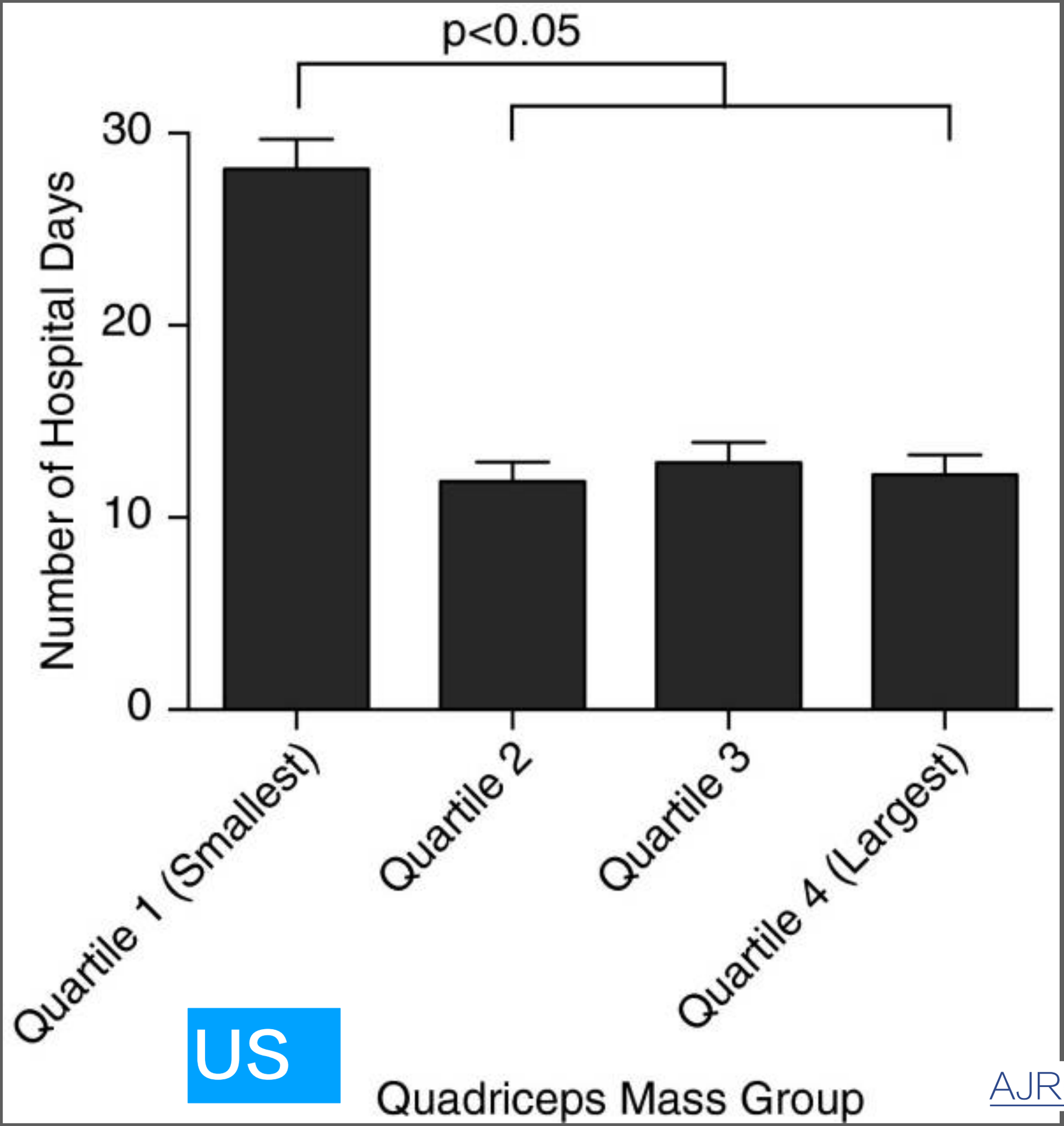
Effect of compression



1/3 position & 3 times



J Nutr Metab. 2017; 2017: 2767232.



US

COPD with AE

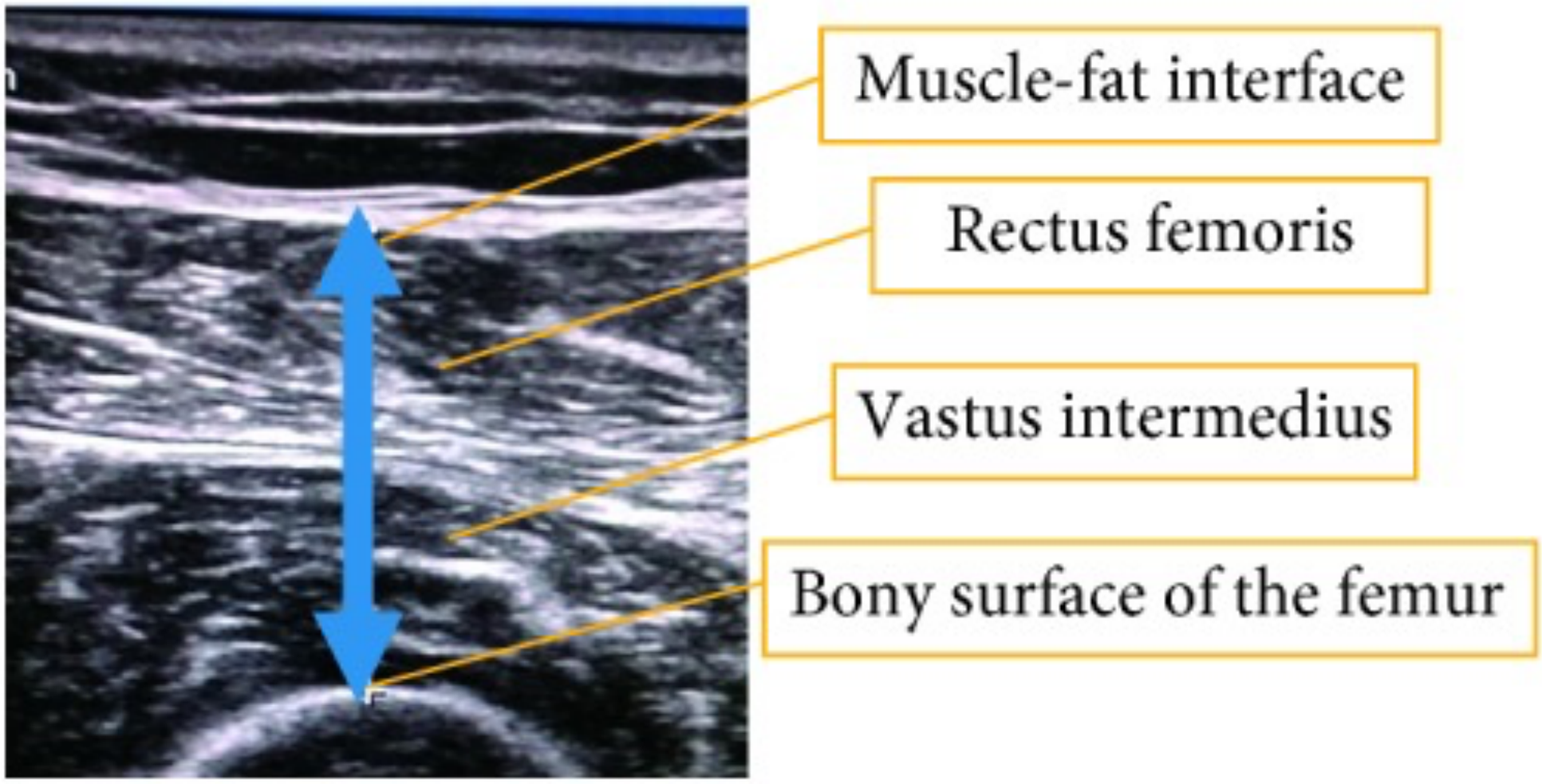
↑ LOS

AJRCCM. 2015; 192: 810–816

ROUNDS Studies

Relation of OUtcomes with Nutrition Despite Severity —Round One: Ultrasound Muscle Measurements in Critically Ill Adult Patients

J Nutr Metab. 2018; 2018: 7142325.



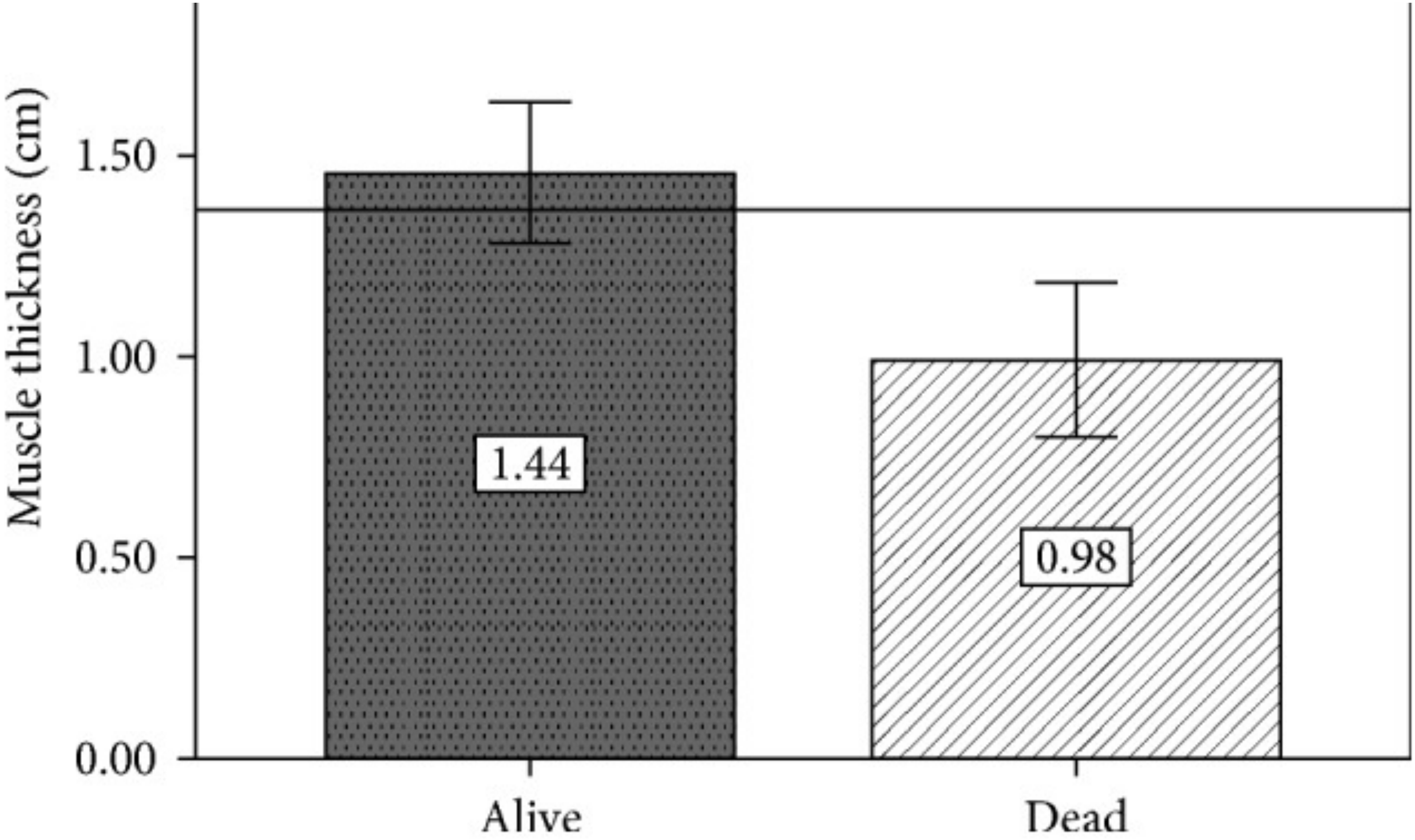
J Nutr Metab. 2018; 2018: 7142325.

Adult ICU

	Alive (*n*=47)	Nonsurvivors (*n*=12)	Total (*n*=59)
Age (years)[#]	59 (43–74)	73 (54–84)	63 (44–75)
Male, *n* (%)	15 (31.9)	5 (41.7)	20 (33.9)
BMI (kg/m^2)[&]	25.67 (5.81)	26.21 (6.61)	26.19 (5.08)
Sepsis diagnosis, *n* (%)	18 (38.3)	6 (50.0)	24 (40.7)
APACHE II (points)[&]	17 (7)*	24 (10)*	19 (8)
SOFA (points)[#]	3 (1–5)*	7 (3–10)*	4 (1–6)
CCI (points)[#]	2 (0–2)	2 (0–2)	2 (0–2)
NUTRIC (points)[#]	3 (2–5)	6 (2–7)	3 (2–5)

J Nutr Metab. 2018; 2018: 7142325.

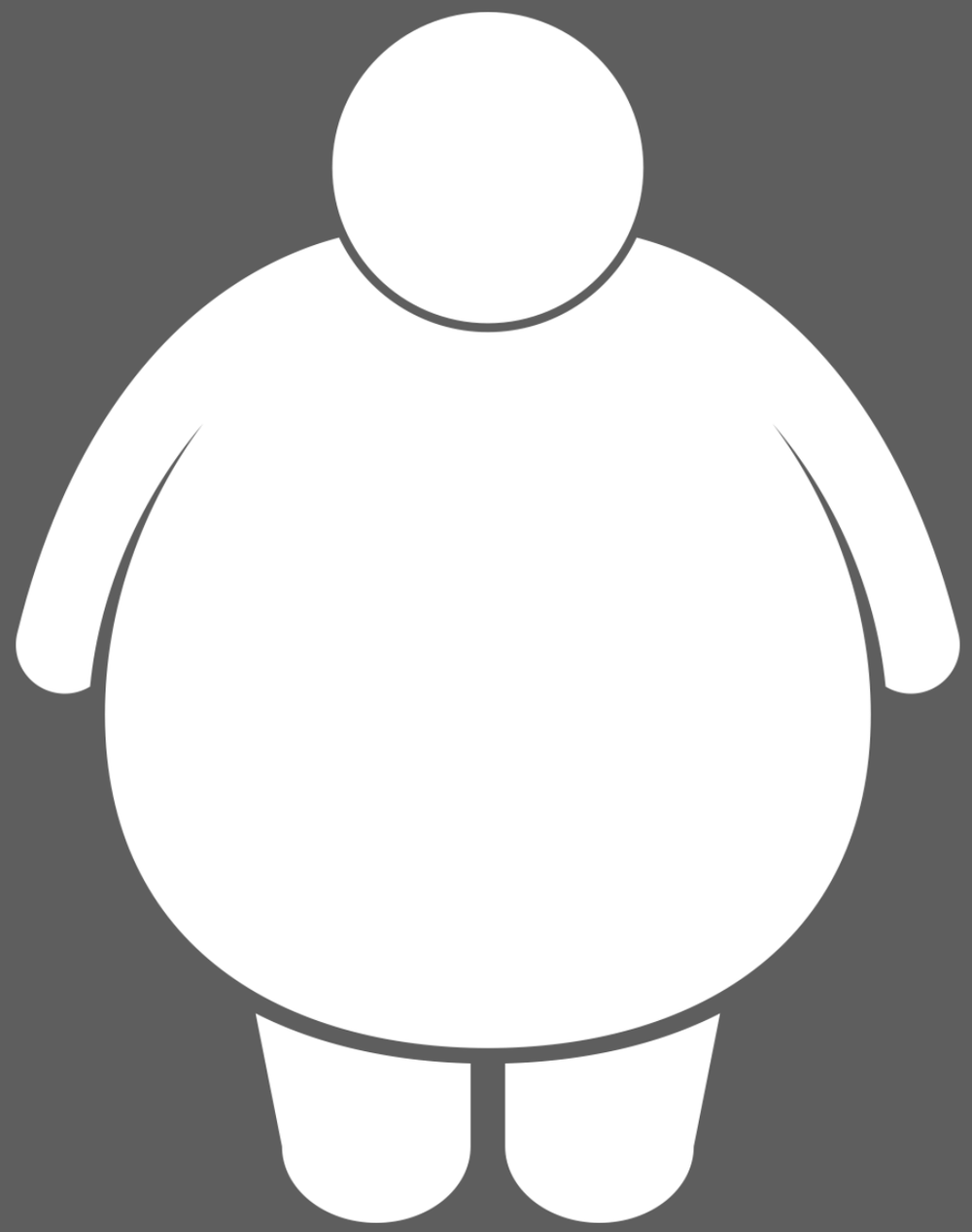
MT @ admission



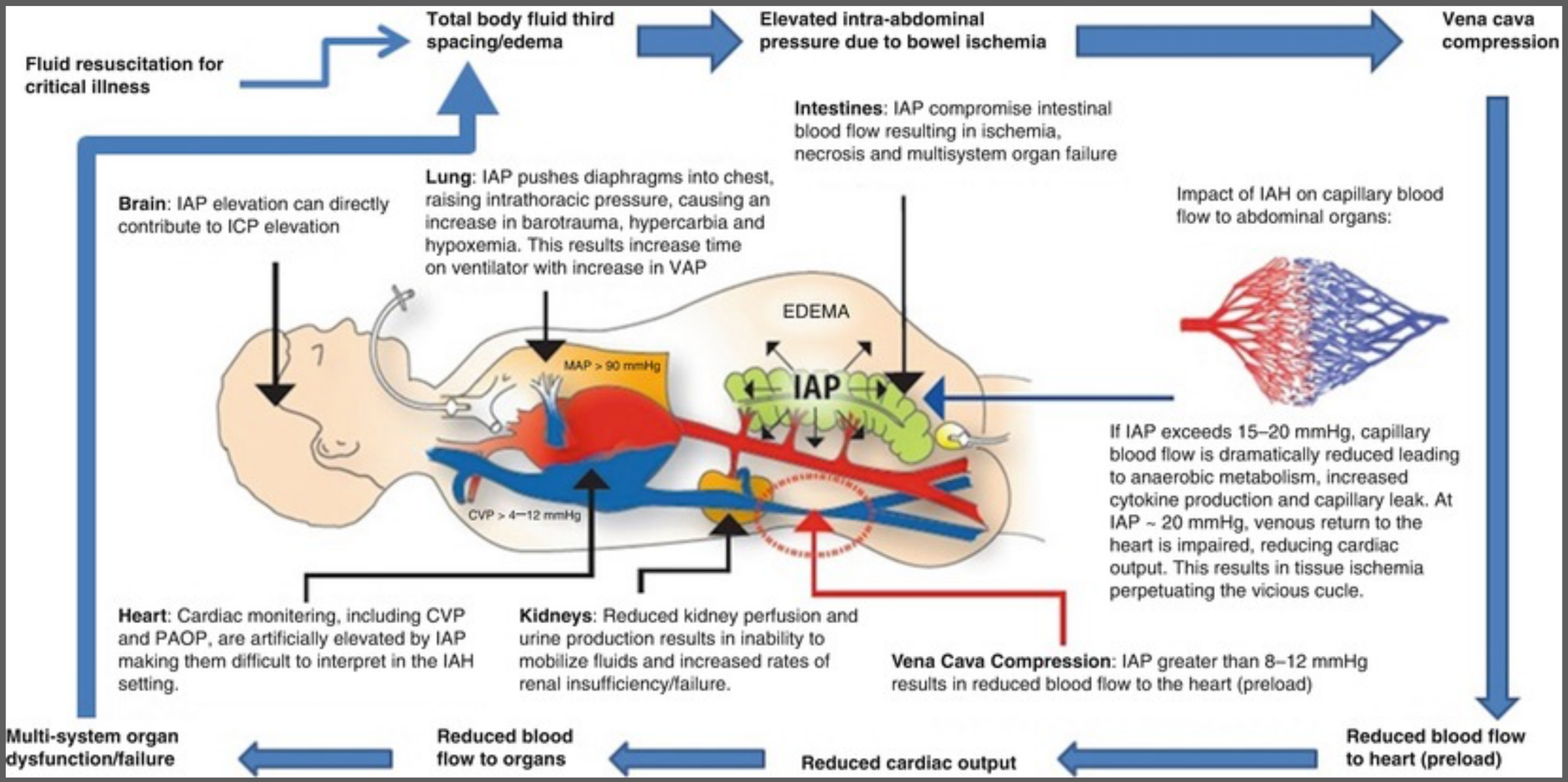
J Nutr Metab. 2018; 2018: 7142325.

ACS

Abdominal Compartment Syndrome



Vicious cycle



Risk factors for IAH

- High-volume fluid resuscitation
  - Septic shock
  - Hemorrhagic shock, particularly when resuscitated using crystalloid solutions in lieu of colloid/blood products
  - Large-surface-area burn
  - Pancreatitis
- Decreased abdominal wall compliance
  - Large or circumferential torso burn
  - Ventral hernia repair with tight abdominal wall closure
  - Prone positioning
- Increased abdominal content
  - Tense ascites in patients with cirrhosis
  - Large neoplasm
  - Pancreatitis

WSACS

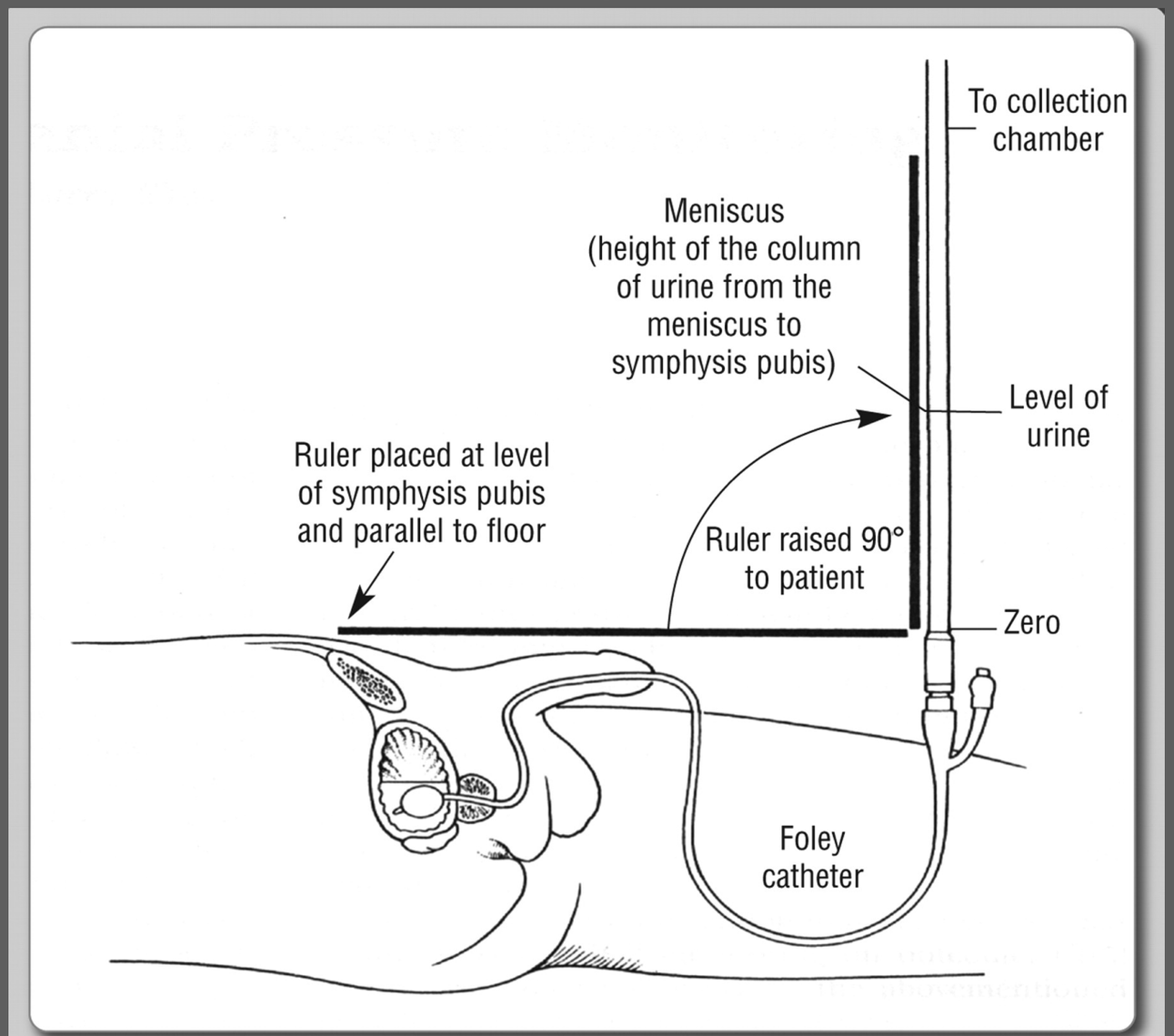
The Abdominal Compartment Society

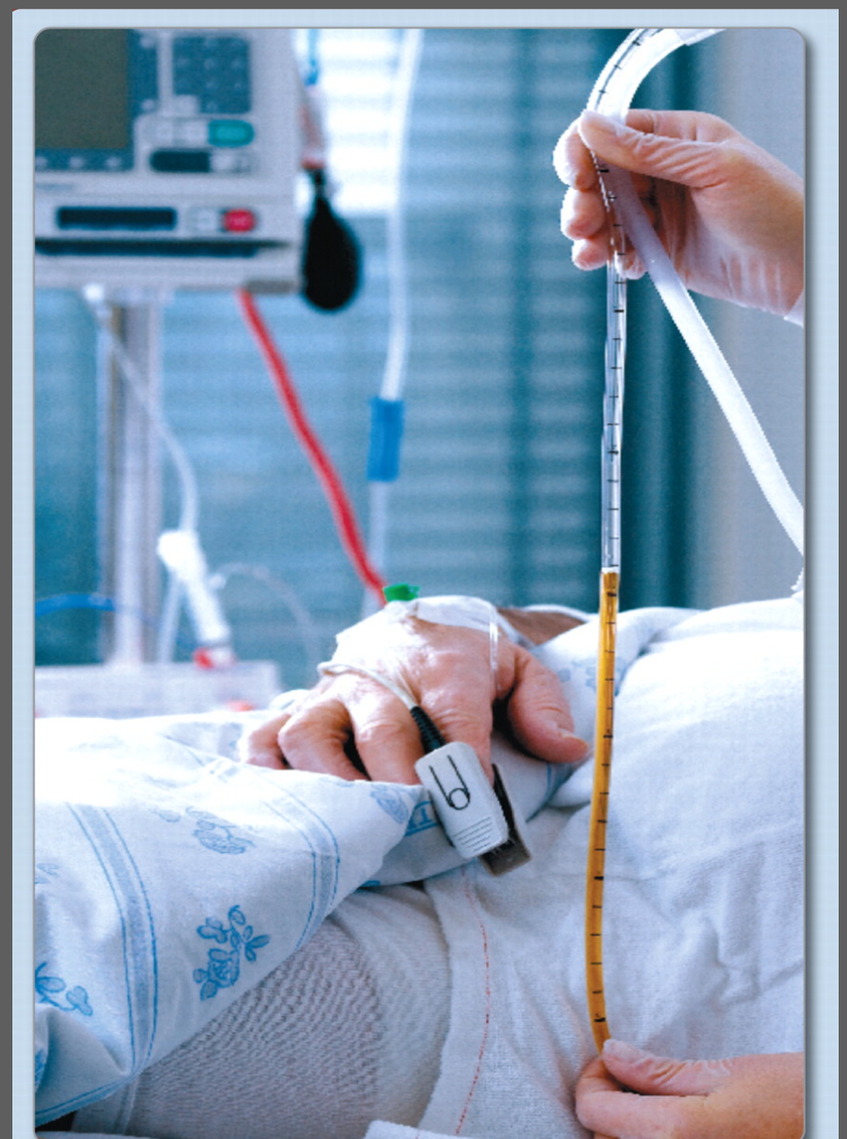
Intra-abdominal hypertension and the abdominal compartment syndrome: updated consensus definitions and clinical practice guidelines from the World Society of the Abdominal Compartment Syndrome

Intensive Care Med 2013;39:1190–1206

Intra-Abdominal Pressure (IAP)

the steady-state pressure concealed within the abdominal cavity
5-7 mmHg in critically ill patients





Intra-Abdominal Hypertension (IAH)

Grade	IAP (mmHg)
I	12 – 15
II	16 – 20
III	21 – 25
IV	> 25

New organ dysfunction/failure

ACS
Acute Compartment Syndrome

IAH or ACS

Primary	In the abdominopelvic region
Secondary	outside the abdominopelvic region
Recurrent	Redevelops

Malbrain ML et al.International Conference of Experts on Intra−Abdominal hypertension and Abdominal Compartment Syndrome. Intensive Care Medicine 2006;32:1722 −1732

Abdominal Perfusion Pressure (APP)

APP = MAP – IAP

Malbrain ML et al.International Conference of Experts on Intra–Abdominal hypertension and Abdominal Compartment Syndrome. Intensive Care Medicine 2006;32:1722 –1732

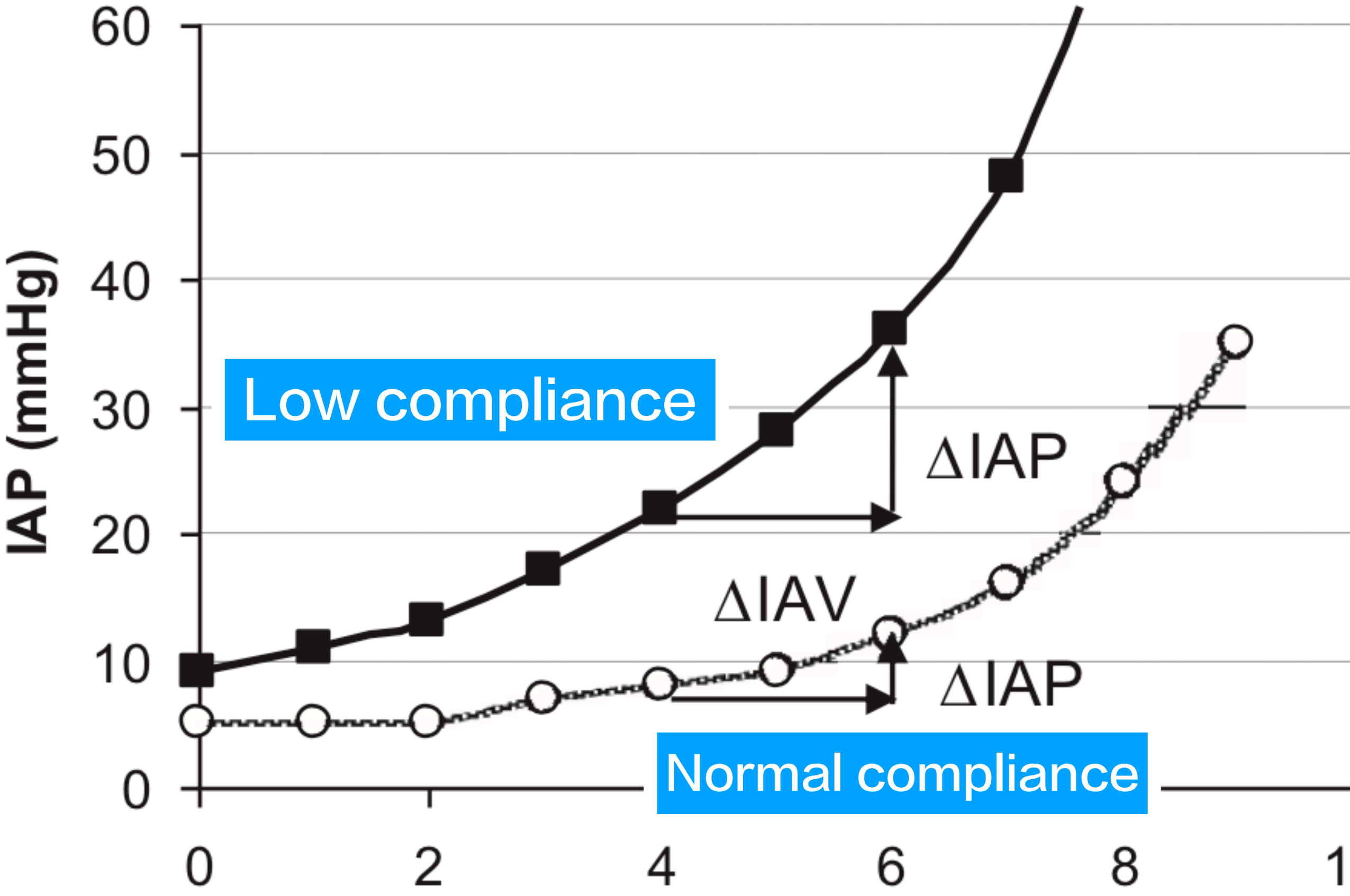
Abdominal compliance

the ease of abdominal expansion

elasticity of abdominal wall & diaphragm

$$C = \frac{\triangle \text{intra-abdominal volume}}{\triangle \text{intra-abdominal pressure}} \quad \begin{matrix} \text{mL} \\ \text{mmHG} \end{matrix}$$

Malbrain ML et al.International Conference of Experts on Intra-Abdominal hypertension and Abdominal Compartment Syndrome. Intensive Care Medicine 2006;32:1722 -1732


60
50
40
30
20
10
0
IAP (mmHg)
Low compliance
ΔIAP
ΔIAV
ΔIAP
Normal compliance
0
2
4
6
8
Abdominal Volume (L)

INTRA-ABDOMINAL HYPERTENSION (IAH) ASSESSMENT ALGORITHM

- *Patients should be screened for IAH/ACS risk factors upon admission and with new or progressive organ failure*
- *If two or more risk factors are present, a baseline IAP measurement should be obtained.*
- *If IAH is present, serial IAP measurements should be performed throughout the patient's critical illness.*

Patient has TWO or more risk factors for IAH/ACS upon either ICU admission or in the presence of new or progressive organ failure

↓

Measure patient's IAP to establish baseline pressure

IAP measurements should be:
1. Expressed in mmHg (1mmHg = 1.36 cm H_2O)
2. Measured at end-expiration
3. Performed in the supine position
4. Zeroed at the iliac crest in the mid-axillary line
5. Performed with an installation volume of no greater than 25 mL of saline [1 mL/kg for children up to 20 kg] (for bladder technique)
6. Measured 30-60 seconds after installation to allow for bladder detrusor muscle relaxation (for bladder technique)
7. Measured in the absence of active abdominal muscle contractions

↓

Sustained IAP ≥ 12 mmHg?

YES → **Patient has IAH** → **Notify patient's doctor of elevated IAP. Proceed to IAH/ACS management algorithm.**

NO → **Patient does not have IAH** → **Observe patient. Recheck IAP if patient deteriorates clinically.**

Risk Factors for IAH/ACS

1. Diminished abdominal wall compliance
   - Acute respiratory failure, especially with elevated intrathoracic pressure
   - Abdominal surgery with primary fascial or tight closure
   - Major trauma/bums
   - Prone positioning, head of bead > 30 degrees
   - High body mass index (BMI), central obesity
2. Increased intra-luminal contents
   - Gastroparesis
   - Ileus
   - Colonic pseudo-obstruction
3. Increased abdominal contents
   - Hemoperitoneum/pneumoperitoneum
   - Ascites/liver dysfunction
4. Capillary leak/fluid resuscitation
   - Acidosis (pH < 7.2)
   - Hypotension
   - Hypothermia (core temperature < 33°C
   - Polytransfusion (>10 units of blood/24 hrs
   - Coagulopathy (platelets < 55 000/mm^3 OR prothrombin time (PT) > 15 seconds OR partial thromboplastin time (PTT) > 2 times normal OR international standardised ratio (INR) > 1.5)
   - Massive fluid resuscitation (> 5 L/24 hours)
   - Pancreatitis
   - Oliguria
   - Sepsis
   - Major trauma / burns
   - Damage control laparotomy

IAH Grading

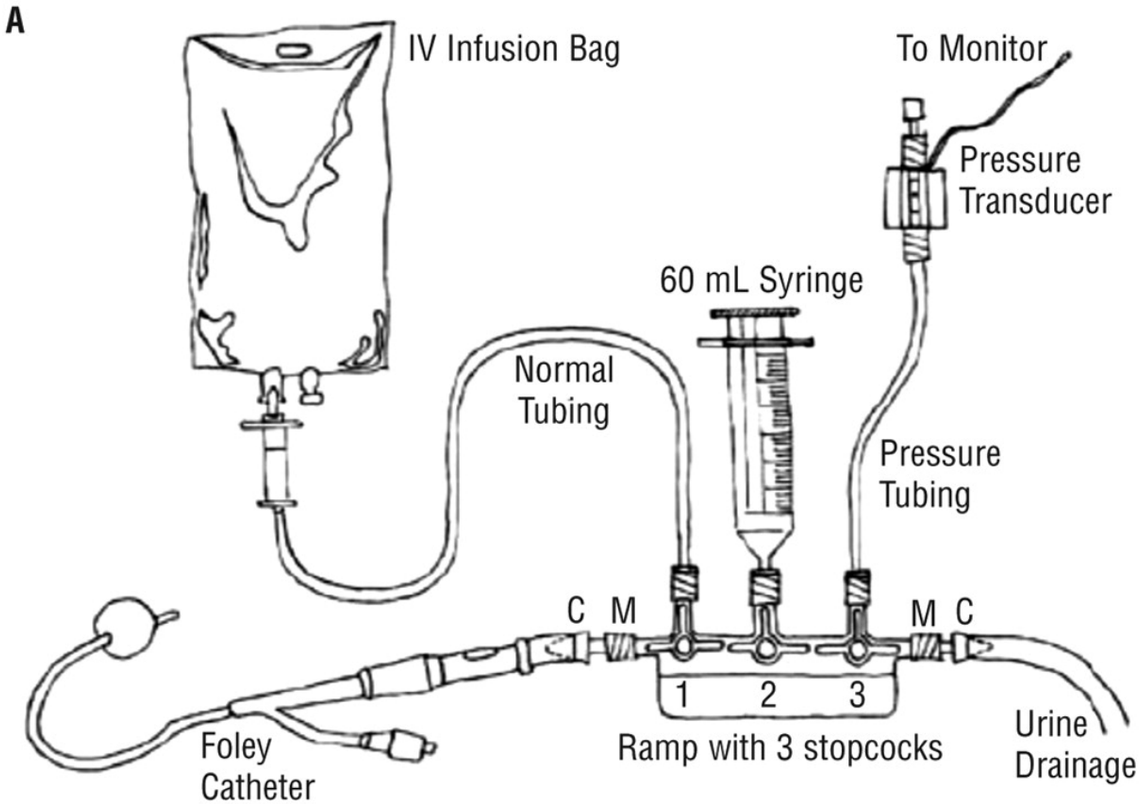
Grade I	IAP 12-15 mmHg
Grade II	IAP 16-20 mmHg
Grade III	IAP 21-25 mmHg
Grade IV	IAP ≥ 15 mmHg

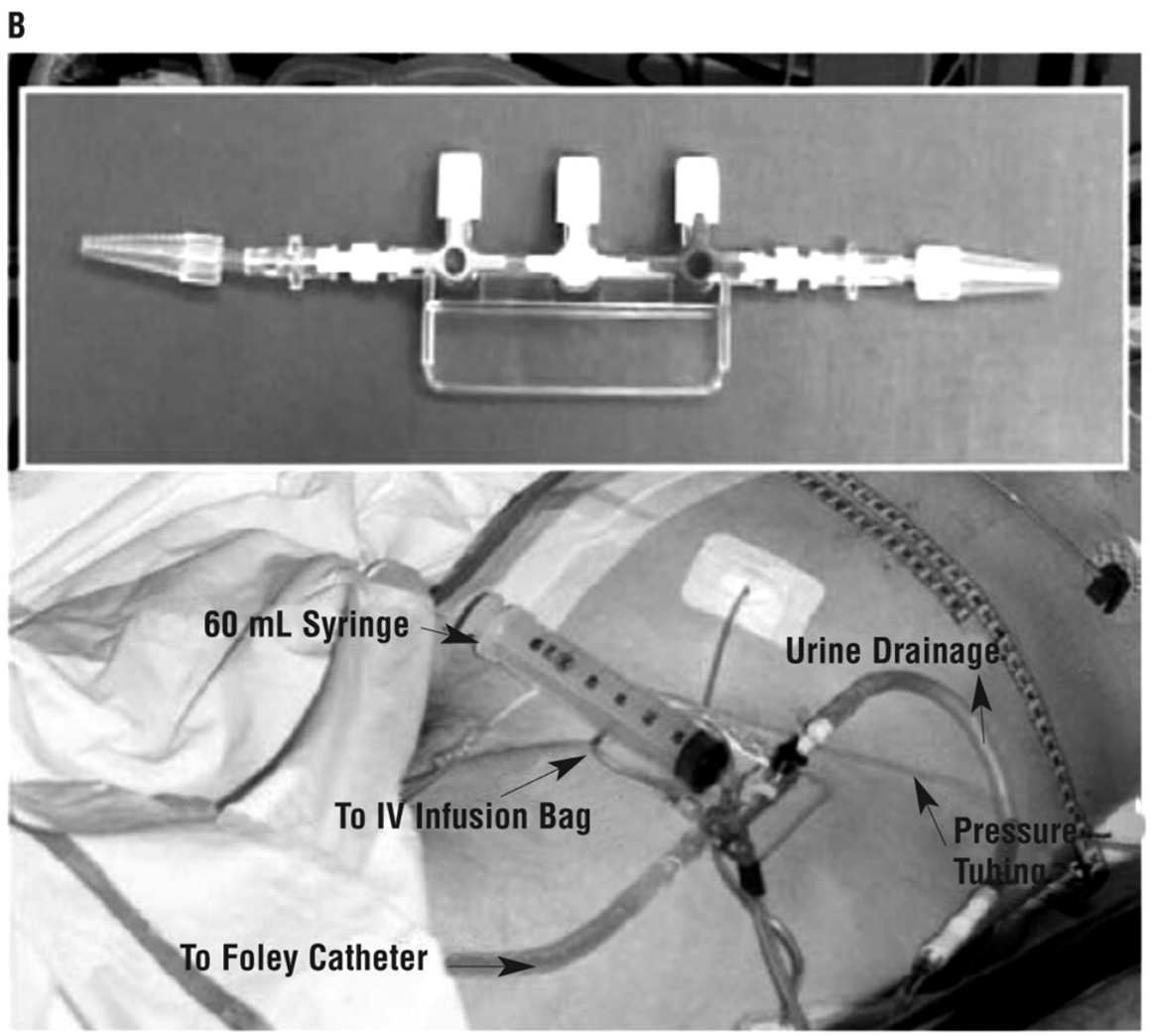
Abbreviations
IAH - intra-abdominal hypertension
ACS - abdominal compartment syndrome
IAP - intra-abdominal pressure

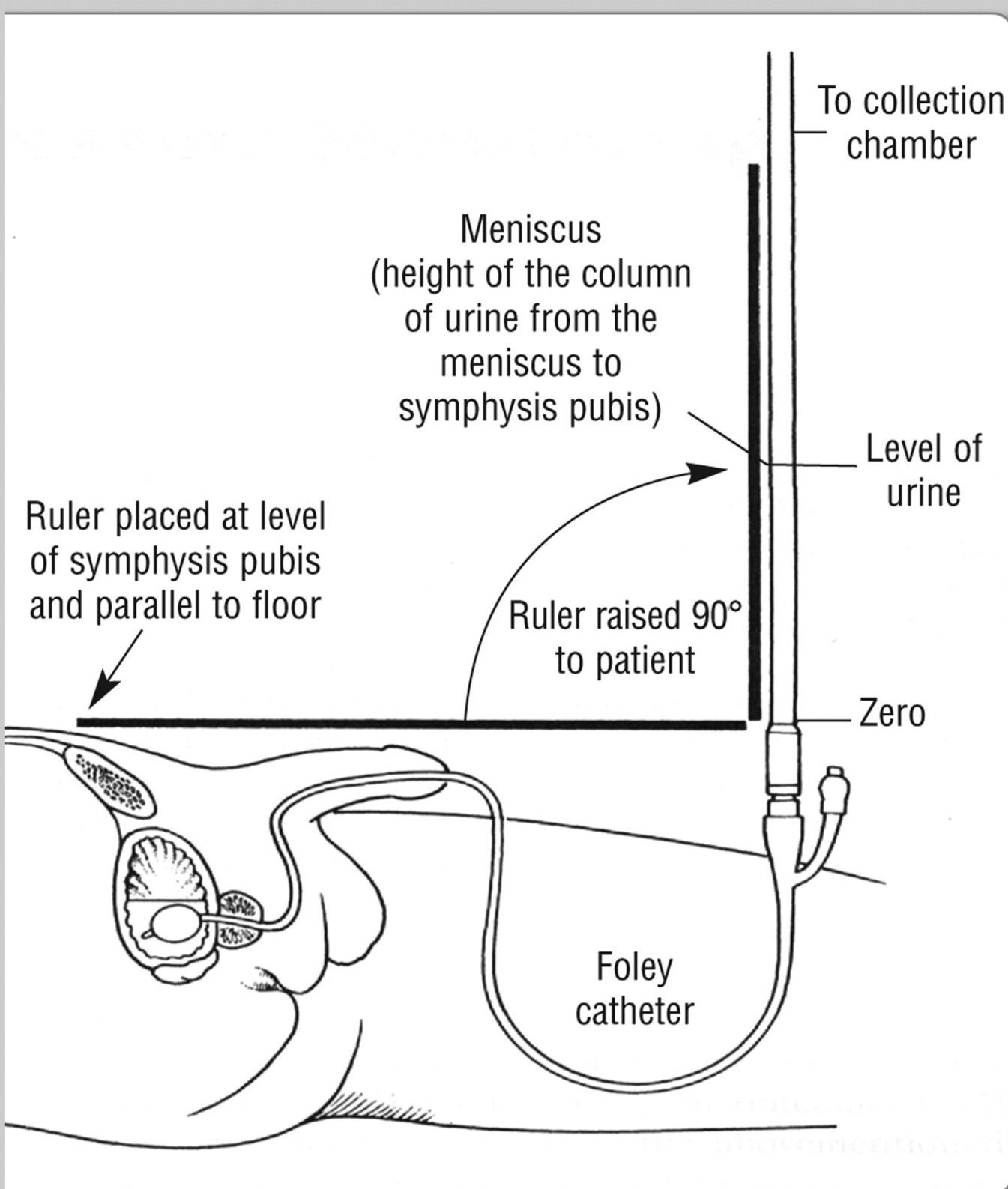
Adapted from *Intensive Care Medicine* 2006;32(11):1722-1732 & 2007;33(6):951-962

World Society of the Abdominal Compartment Syndrome (WSACS)
ZNA Stuivenberg, Lange Beeldekensstraat 267, B-2060 Antwerpen 6, Belgium
Tel: +32 3 2177092 Fax: +32 3 2177279 e-mail: info@wsacs.org
Website: http://www.wsacs.org

Measure IAP


A
IV Infusion Bag
To Monitor
Pressure Transducer
60 mL Syringe
Normal Tubing
Pressure Tubing
C M
M C
1 2 3
Foley Catheter
Ramp with 3 stopcocks
Urine Drainage


B
60 mL Syringe
Urine Drainage
To IV Infusion Bag
Pressure Tubing
To Foley Catheter


Meniscus (height of the column of urine from the meniscus to symphysis pubis)
To collection chamber
Level of urine
Ruler placed at level of symphysis pubis and parallel to floor
Ruler raised 90° to patient
Zero
Foley catheter

Patient has IAH
(IAP ≥ 12 mmHg)

NO

IAH assessment

Initiate treatment to reduce IAP
Avoid excessive fluid resuscitation
Optimize organ perfusion
(GRADE 1C)

IAP > 20 mmHg with new organ failure?

YES

Patient has ACS

NO

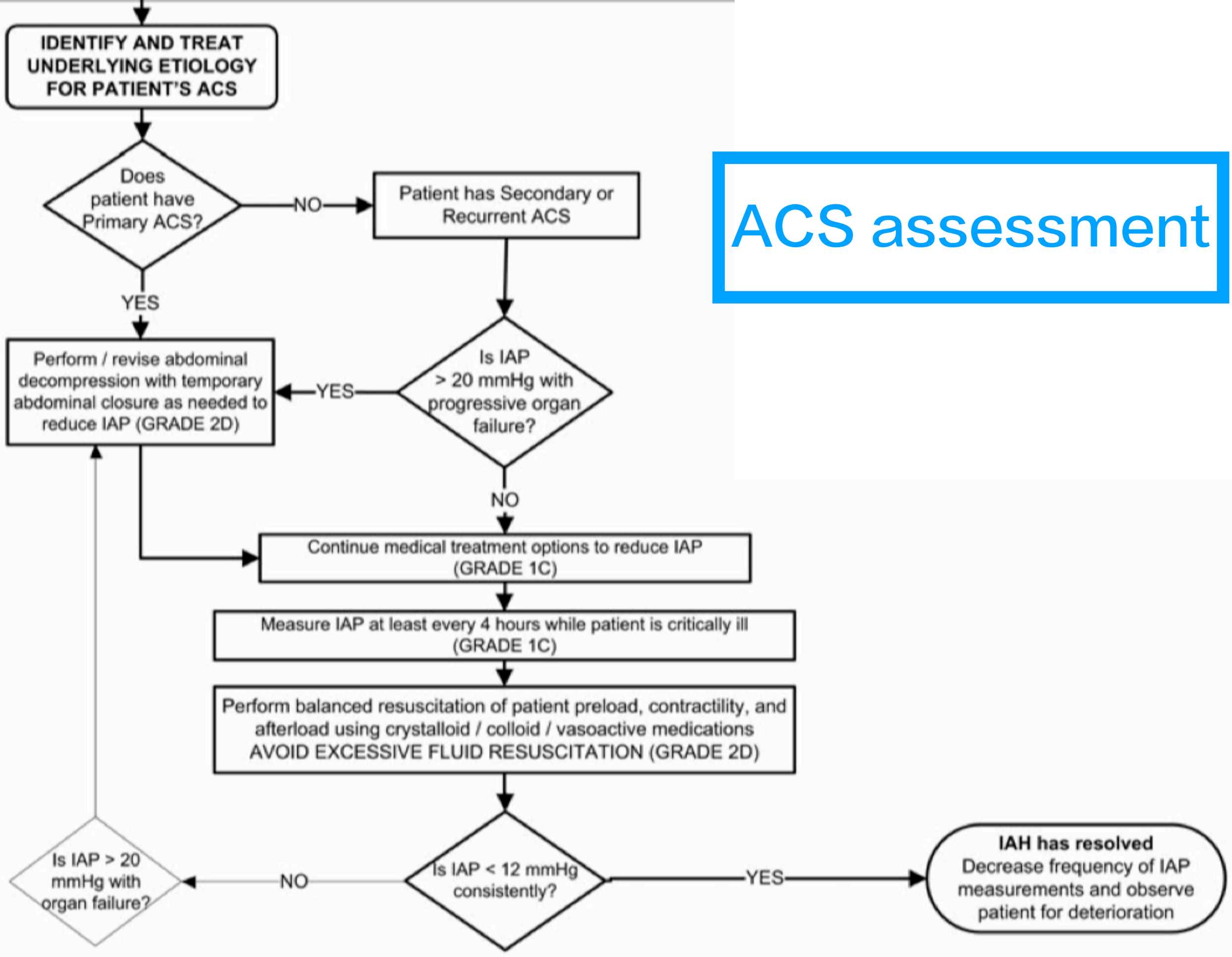
Monitor IAP with serial measurements at least every 4 hours while patient is critically ill
(GRADE 1C)

IAP < 12 mmHg consistently?

YES

IAH has resolved
Discontinue IAP measurements and monitor patient for clinical deterioration

ACS assessment



IAH/ACS MEDICAL MANAGEMENT ALGORITHM

- *The choice (and success) of the medical management strategies listed below is strongly related to both the etiology of the patient's IAH / ACS and the patient's clinical situation. The appropriateness of each intervention should always be considered prior to implementing these interventions in any individual patient.*
- *The interventions should be applied in a stepwise fashion until the patient's intra-abdominal pressure (IAP) decreases.*
- *If there is no response to a particular intervention, therapy should be escalated to the next step in the algorithm.*

Patient has IAP ≥ 12 mmHg
Begin medical management to reduce IAP

Measure IAP/APP at least every 4-6 hours or continously.
Titrate therapy to maintain IAP ≤ 15 mmHg and APP 60 mmHg

	Evacuate intraluminal contents	Evacuate intra-abdominal space occupying lesions	Improve abdominal wall compliance	Optimize fluid administration	Optimize systemic/regional perfusion
Step 1	Insert nasogastric and/or rectal tube	Abdominal ultrasound to identify lesions	Ensure adequate sedation & analgesia	Avoid excessive fluid resuscitation	Goal-directed fluid resuscitation
	Initiate gastro-/colo-prokinetic agents		Remove constrictive dressings, abdominal eschars	Aim for zero to negative fluid balance by day 3	Maintain abdominal perfusion pressure (APP) ≥ 60 mmHg
Step 2	Minimize enteral nutrition	Abdominal computed tomography to identify lesions	Avoid prone position, head of bed > 20 degrees	Resuscitate using hypertonic fluids, colloids	Hemodynamic monitoring to guide resuscitation
	Administer enemas	Percutaneous catheter drainage	Consider reverse Trendelenberg position	Fluid removal through judicious diuresis once stable	
Step 3	Consider colonoscopic decompression	Consider surgical evacuation of lesions	Consider neuromuscular blockade	Consider hemodialysis/ultrafiltration	Vasoactive medications to keep APP ≥ 60 mmHg
	Discontinue enteral nutrition				

Step 4

If IAP > 25 mmHg (and/or APP < 50 mmHg) and new organ dysfunction/failure is present, patient's IAH/ACS is refractory to medical management. Strongly consider surgical abdominal decompression.

Adapted from *Intensive Care Medicine* 2006;32(11):1722-1732 & 2007;33(6):951-962

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Management principles

Evacuate intraluminal contents
Evacuate intra-abdominal contents
Improve abdominal wall compliance
Optimize fluid administration
Optimize perfusion

5

VIA MEDICA

ORIGINAL AND CLINICAL ARTICLES

Anaesthesiology Intensive Therapy
2017, vol. 49, no 5, 373–381
ISSN 1642–5758
10.5603/AIT.a2017.0074

The role of point-of-care ultrasound in intra-abdominal hypertension management

Bruno M. Pereira[1, 2], Renato G. Pereira[2], Robert Wise[3], Gavin Sugrue[4], Tanya L. Zakrison[5], Alcir E. Dorigatti[6], Rossano K. Fiorelli[2], Manu L.N.G. Malbrain[7–9]

Table 1. Inclusion criteria adopted for the study

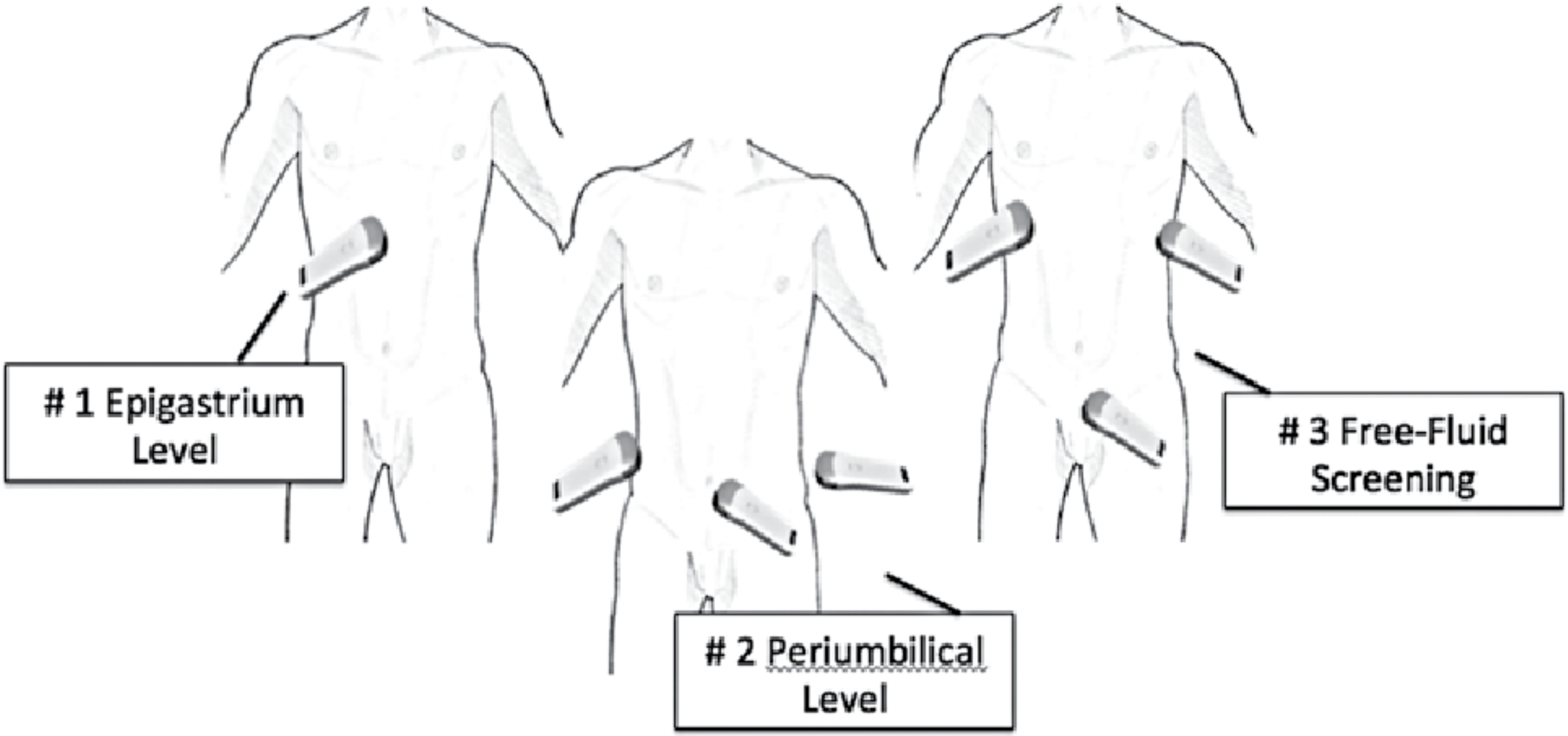
Inclusion criteria	
A	ICU patients/ minimum ICU stay of 3 days
B	18 years of age or older
C	Intubated and mechanically ventilated
D	Adequately sedated (RASS-4 or -5)
E	Able to lie in a supine position for all measurements
F	Undergoing treatment for IAH/ACS
G	Not exhibiting abdominal respiratory muscle activity
H	Not having a temporary open abdomen
I	Not exhibiting abdominal respiratory muscle activity

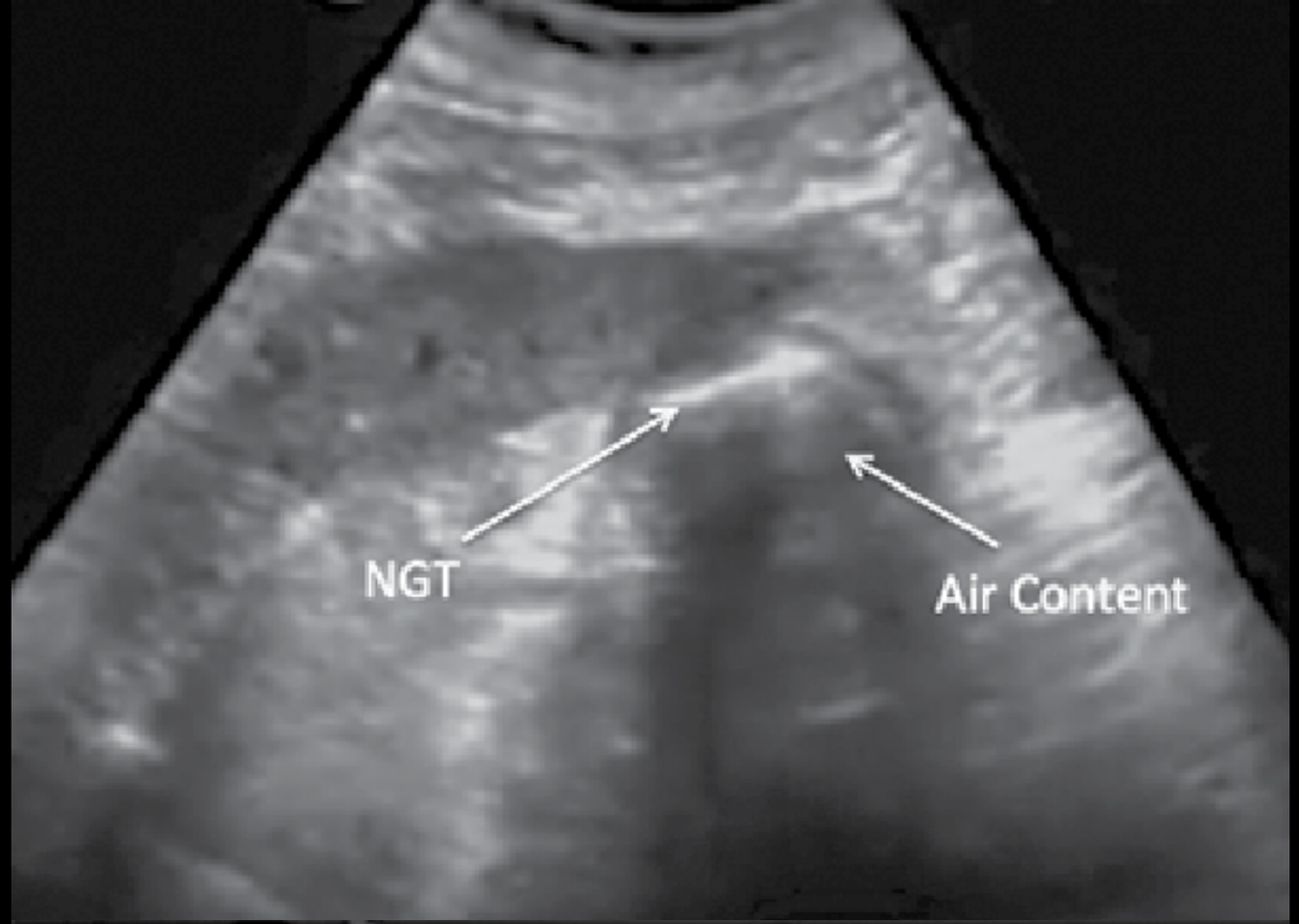
Patient has IAP ≥ 12 mm Hg
Begin medical management to reduce IAP (GRADE 1C)

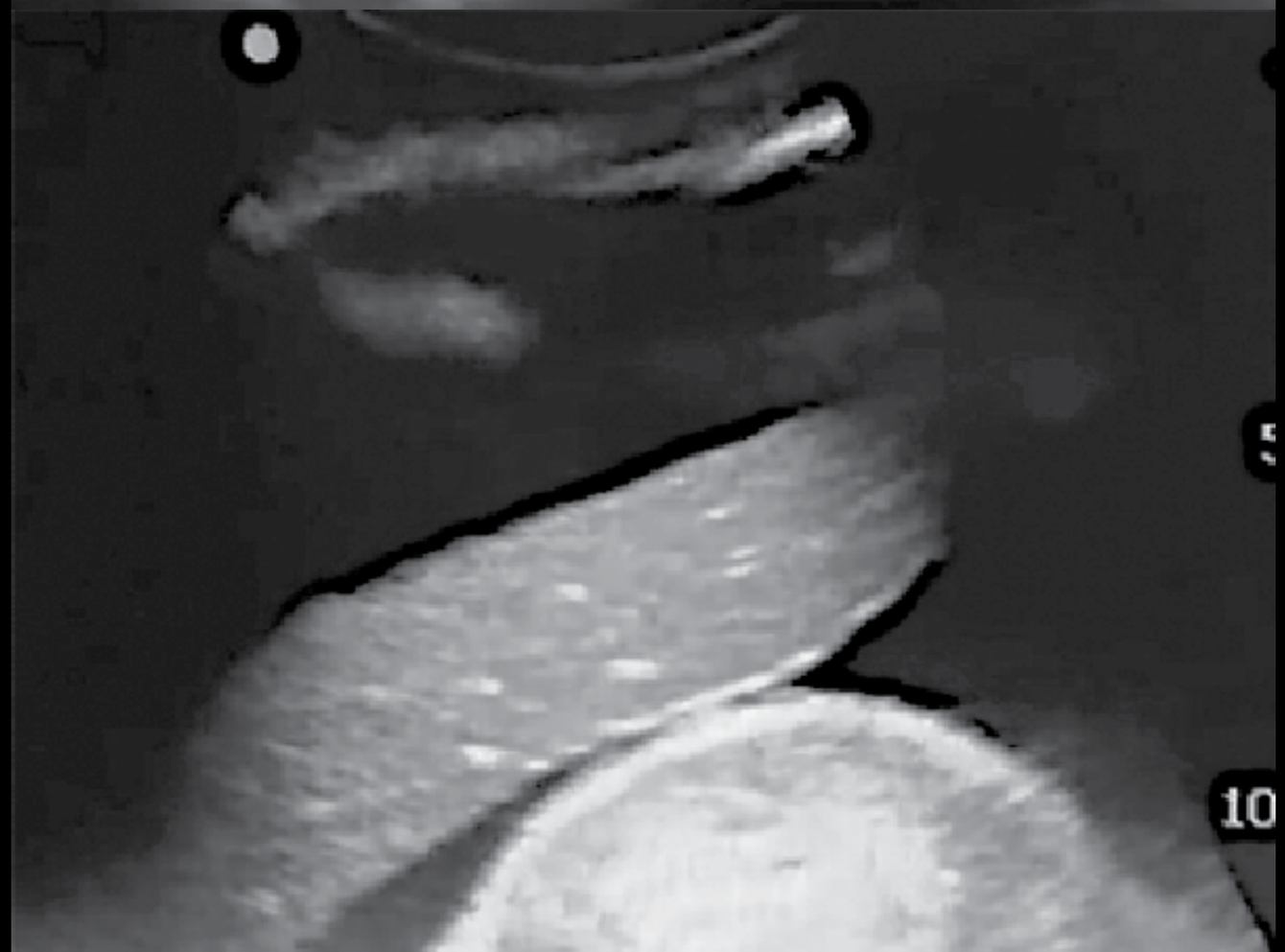
Measure IAP at least every 44 hours or continuously
Titrate therapy to maintain IAP < 13 mm Hg (GRADE 1C)

	Evacuate intraluminal contents	Evacuate infra-abdominal space occupying lesions	Improve abdominal wall compliance	Optimie fluid adminstration	Optimize systemic/ /regional perfusion
Step 1	Insert nesogastric and/or rectal tube	Abdominal ultrasound to identify lesions	Ensure adequate sedation & analgesia (GRADE 1D)	Avoid excessive fluid resuscitation (GRADE 2C)	Goal-directed fluid resuscitation
	Initiate gastro-/colo-prokinalc agents (GRADE 2D)		Remove constrictive dressings, abdominal etchers	Alm for zero to negative fluid balance by day 3 (GRADE 2C)	
Step 2	Minimize enteral nutrition	Abdominal computed tomography to identity lesions	Consider reverse Trendelenberg position	Resuscitate using hypertonic fluids, colloids	Hemodynamlc monitoring to guide resuscitation
	Administer enemas (GRADE ID)	Percutaneous catheter drainage (GRADE 2C)		Fluid removal through judicious diuresis once stable	
Step 3	Consider tolonosooplc decompression (GRADE ID)	Consider surgical evacuation of lesions (GRADE ID)	Consider neuromuscular blockade (GRADE ID)	Consider haemodialysis/ /ultrafiltration	
	Discontinue enteral nutrition				
Step 4	If IAP > 20 mm Hg and new organ dysfunction/failure Is present, patient's IAH I ACS is refractory to medical management. Strongly consider surgical abdominal decompression (GRADE ID)				

Role of POCUS




NGT
Air Content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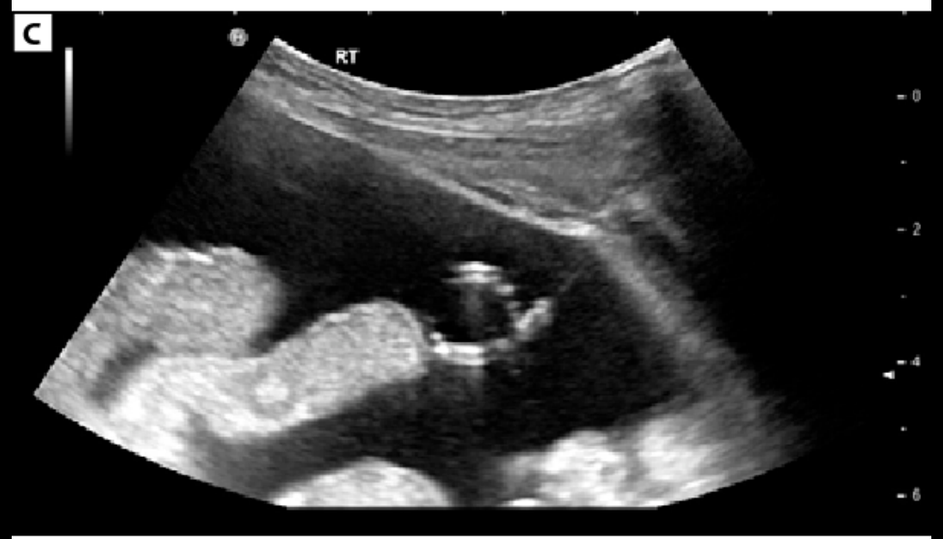
A


B
RT


C
RT

Parameters	Participants (N = 50)
Participant characteristics	
Mean age (years)	55 (39–71)
Gender (male)	29 (58%)
BMI (kg m^{-2})	27
Clinical data	
Mean SBP (mm Hg)	108.5 (83–134)
Mean HR (beats min^{-1})	94 (60–128)
IMV (%)	50 (100%)
Mean admission IAP (mm Hg)	23 (12–34)
Mean admission APP (mm Hg)	85
Vasopressor use (n %)	42 (84%)
Admission diagnosis	
Bowell obstruction (%)	28 (56%)
Abdominal sepsis (%)	12 (24%)
Gastrointestinal bleeding (%)	8 (16%)
Other (%)	2 (4%)

3 consecutive days on IAH treatment

	Day 1	Day 2	Day 3
Mean IAP (mm Hg)	23 (12–34)	17.5 (10–25)	15 (8–22)
Mean APP (mm Hg)	85.5	91.5	107
Mean SBP (mm Hg)	108.5 (83–134)	109 (90–128)	122 (101–143)
Mean HR (beats min^{-1})	113 (98–128)	89.5 (60–119)	82 (58–106)
Mean Urinary Output (mL $24h^{-1}$)	1,500 (400–2,600)	1,105 (310–1,105)	1,200 (0–2,400)
Fluid Balance (last 24h)	+ 2,160	+1,730	+ 2,931
NGT tube need (n)	46	46	42
US gastric content observed (n)	50	50	50
NGT observed on US (n)	46	46	42
Positive bowel content (before enema) viewed on US (n)	50	50	50
Positive bowel content (after enema) viewed on US (n)	36	28	21
Bowel movements observed on US (n)	42	47	50
Number of patients with free abdominal fluid seen on US (n)	27	24	23
Positive moderate to large amount of free abdominal fluid seen on US (n)	6	6	4
US-guided paracentesis (n)	2	0	0

Patient has IAP > 12 mm Hg
Begin medical management to reduce IAP

	Evacuate intraluminal contents	Evacuate intraabdominal space occupying lesions	Abdominal wall compliance Improve	Optimize fluid administration	Optimize systemic/ /regional perfusion
Step 1	Confirmation of NG tube position	Detect and quantify volume of abdominal fluid (blood, abscess, ascites)	Detect whether there is any	ECHO to assess cardiac function	Assessment of renal, hepatic arterial and portovenous blood flow
	Assess gastric contents (solids vs. liquids) and residual volumes				
Step 2	Assess the degree of bowel activity, dilation or faeces.	US-guided percuta neous drainage of abdominal fluid collections.		US of IVC to assess volume status and response to fluids or	
	Identify the need for enema therapy				
Step 3		Short term US or CT follow up to determine evolution of collections			

POCUS for ACS

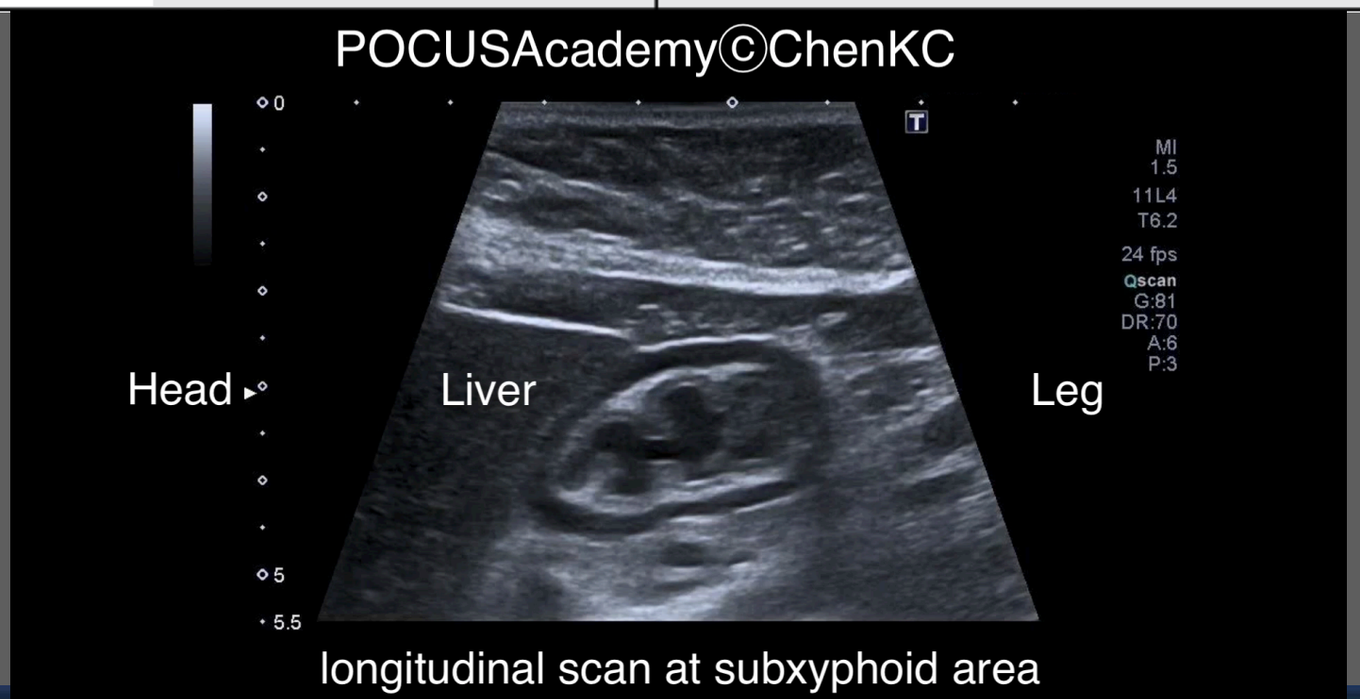
POCUS for ACS

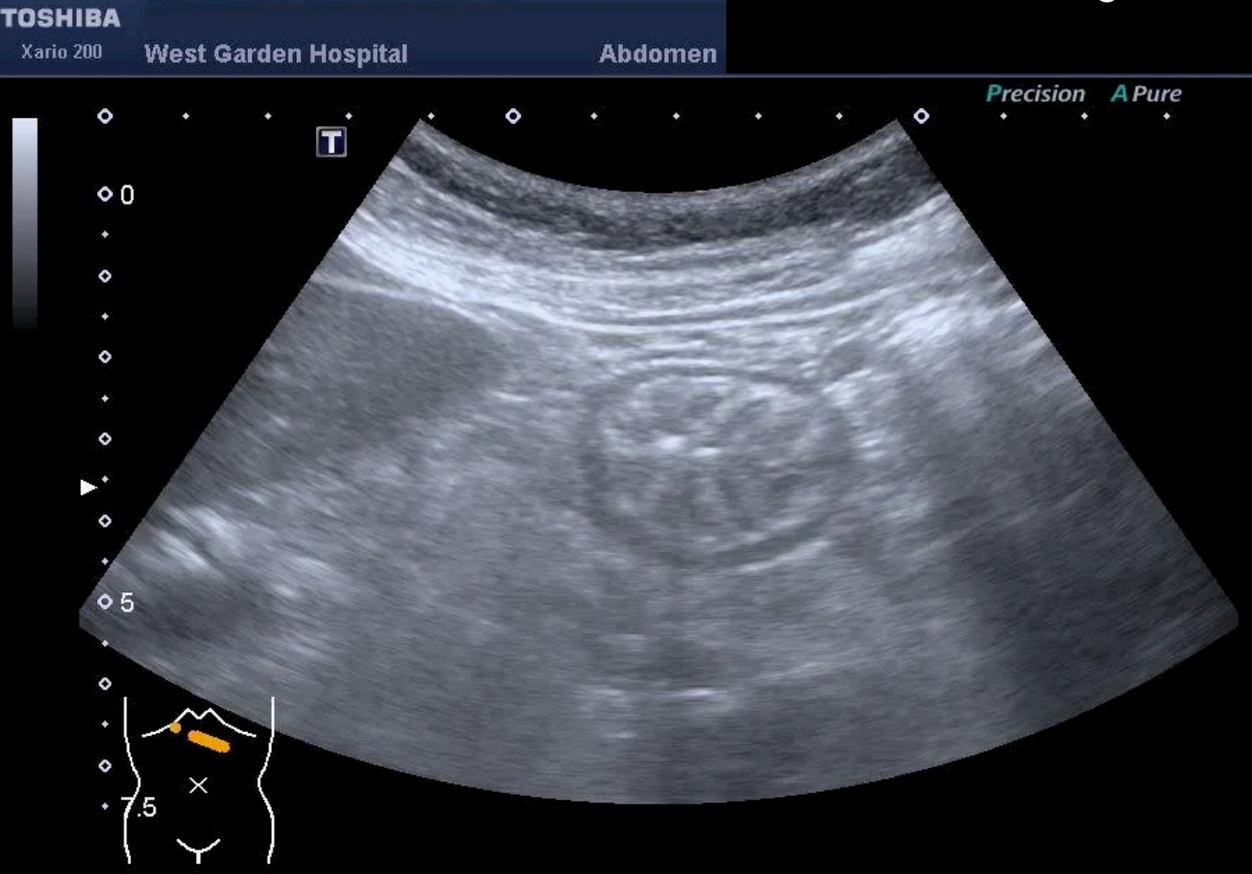
Patient has IAP > 12 mm Hg
Begin medical management to reduce IAP

Step 1

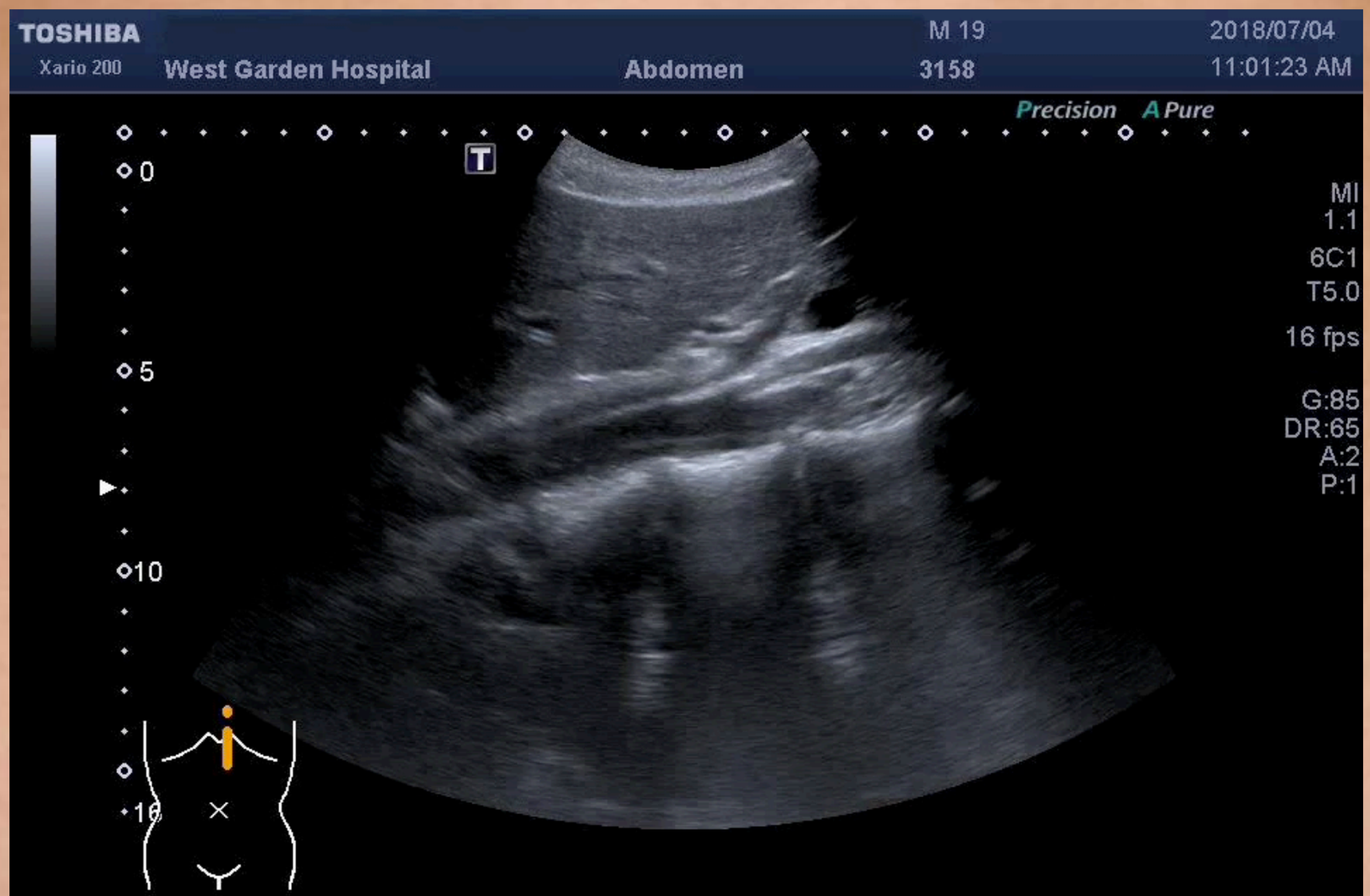
Evacuate intraluminal contents

Confirmation of NG tube position





Stomach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Precision
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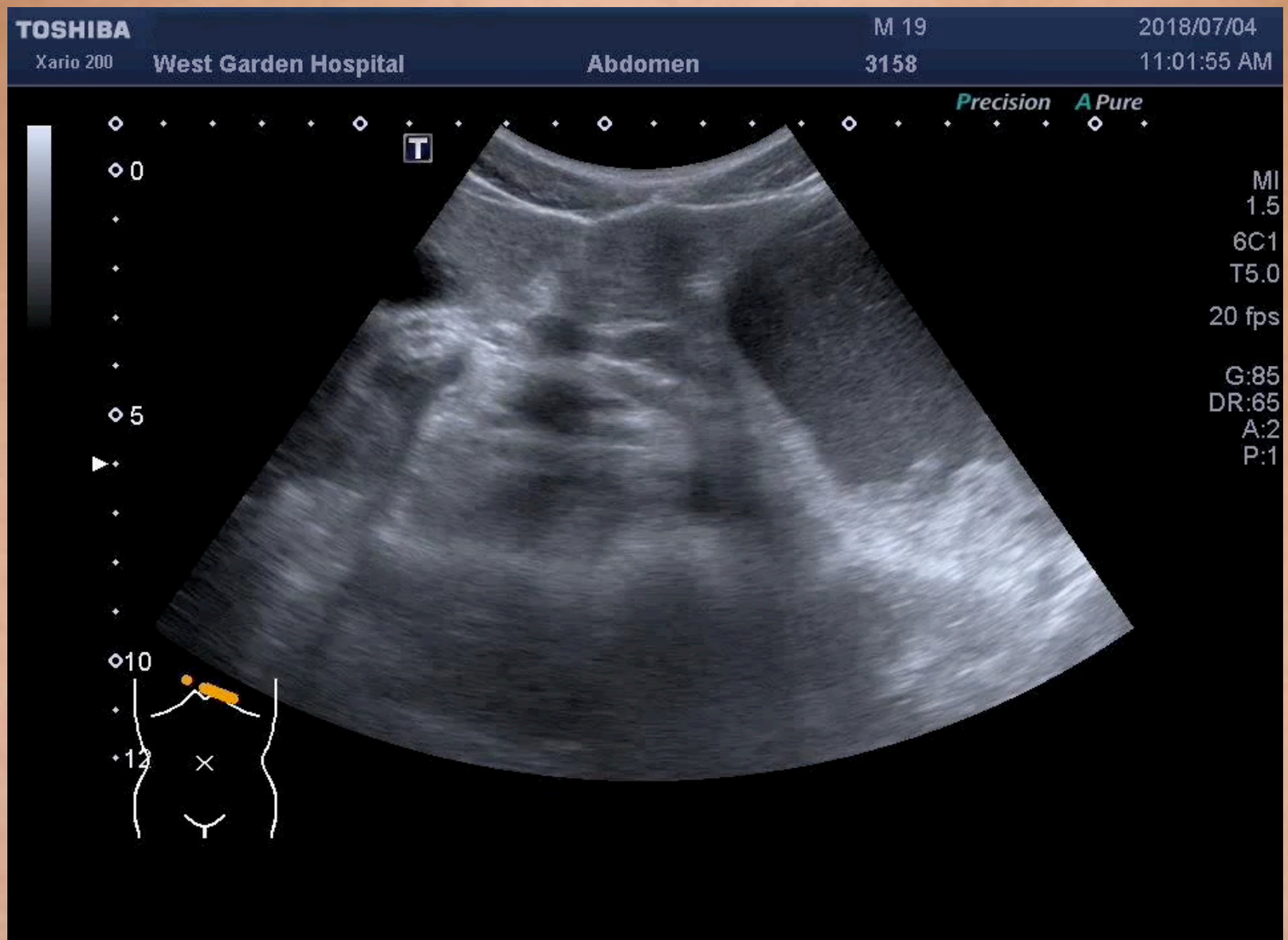
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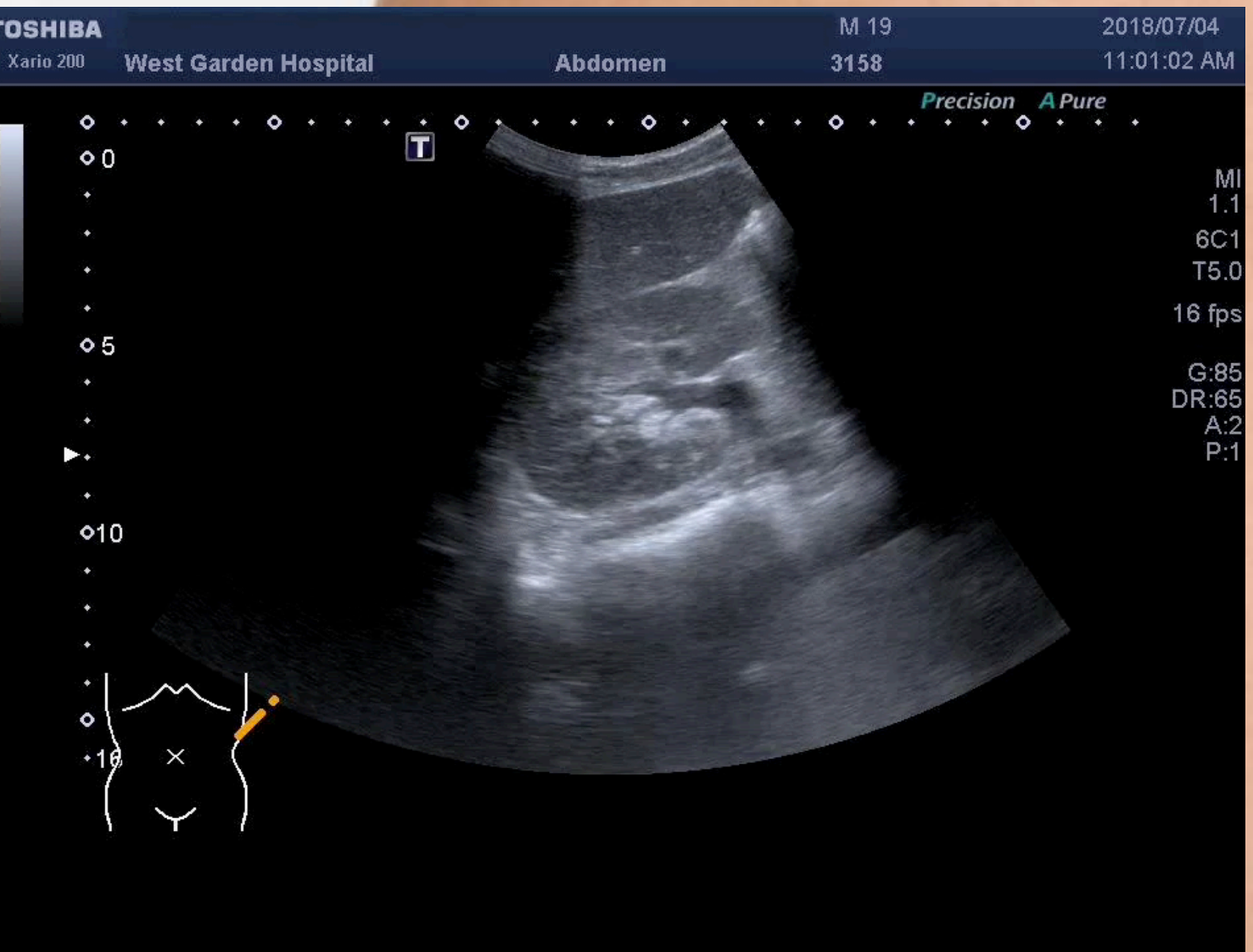
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Abdomen
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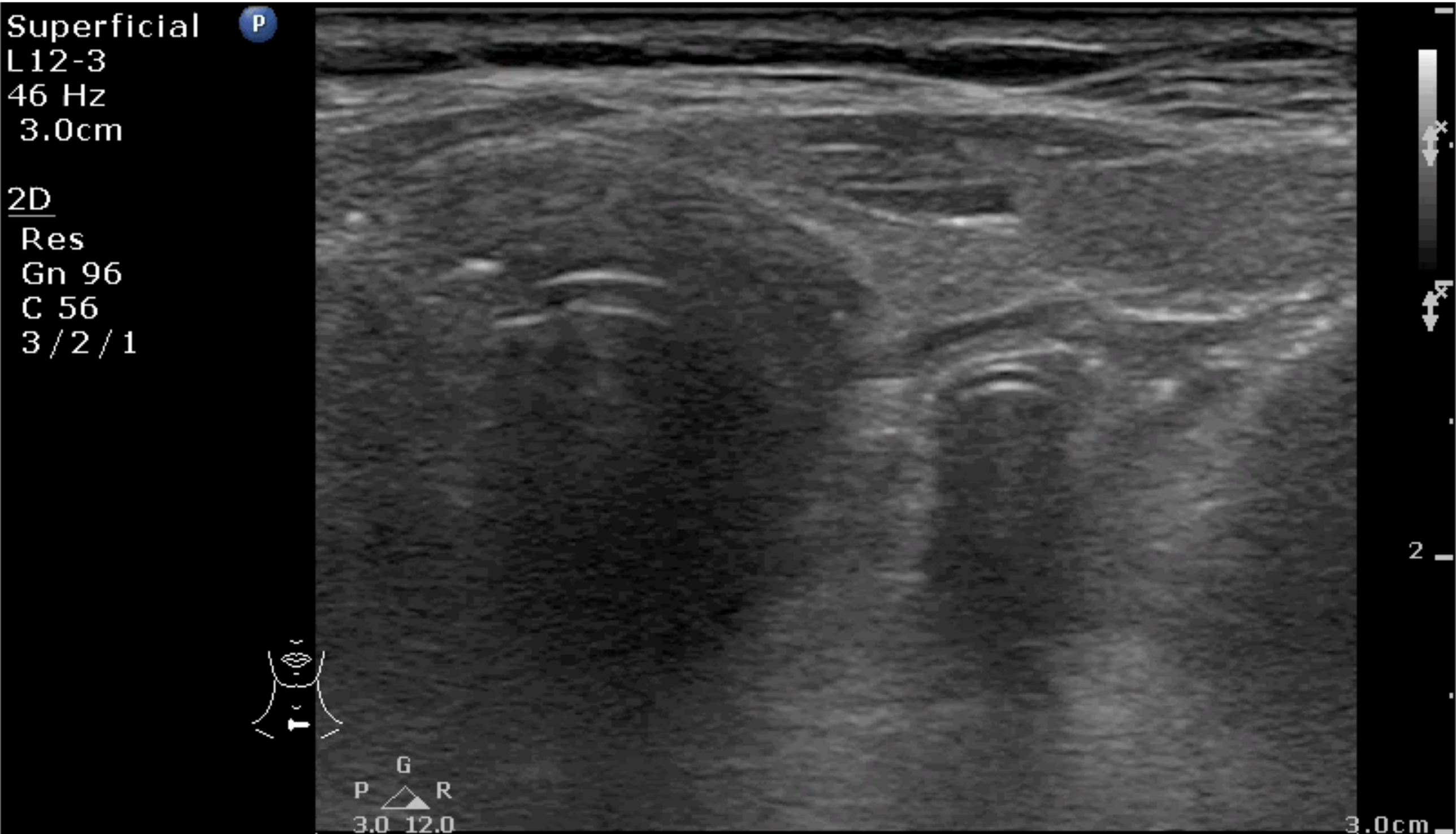
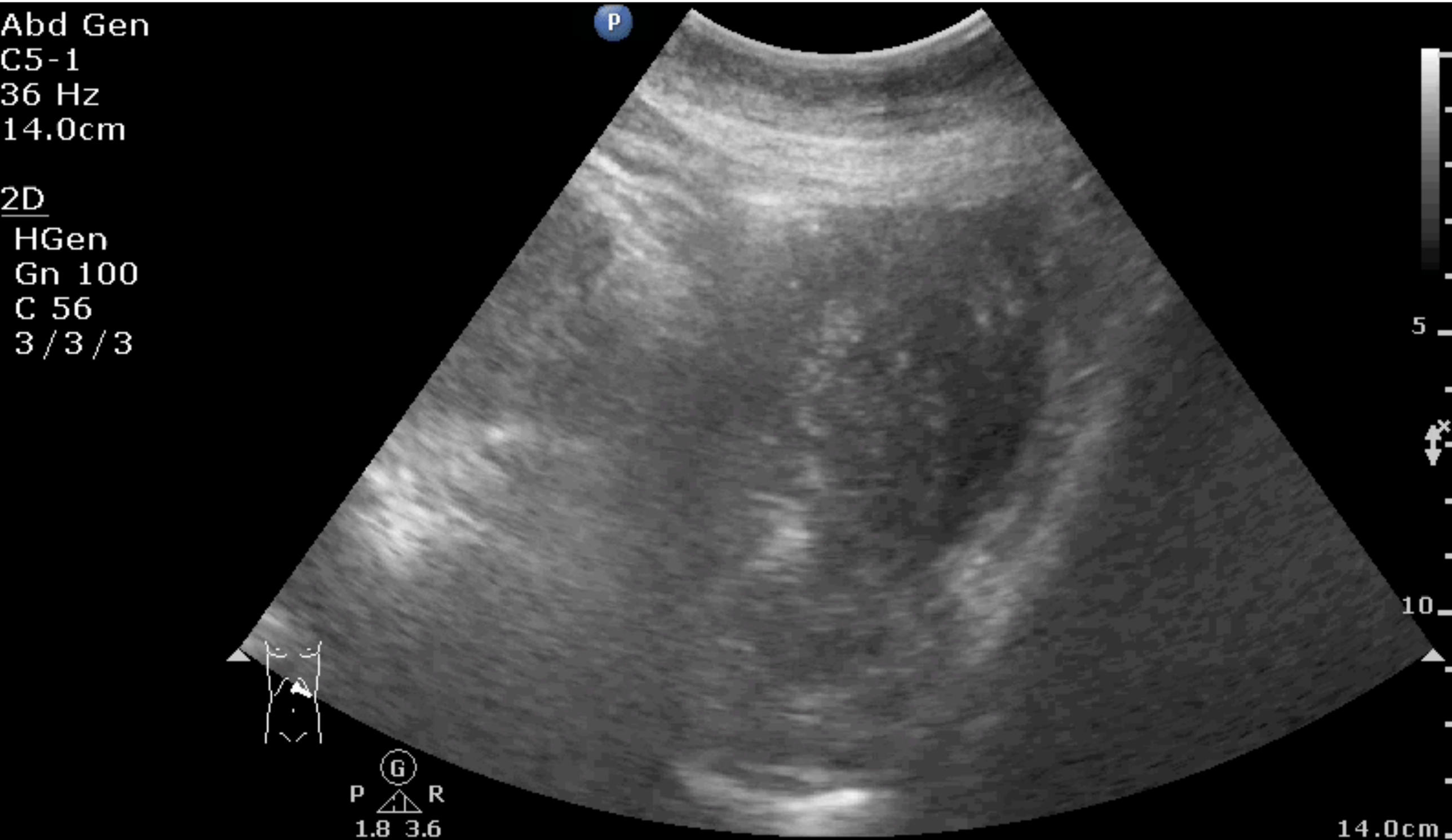
15

ETT & NG (Neck)


Superficial
P
L12-3
46 Hz
3.0cm
2D
Res
Gn 96
C 56
3/2/1
G
P
R
3.0 12.0
2
3.0cm

NG (stomach)


Abd Gen
C5-1
36 Hz
14.0cm
2D
HGen
Gn 100
C 56
3/3/3
P
5
10
14.0cm
G
P
R
1.8 3.6

NG for stomach blood

POCUS for ACS

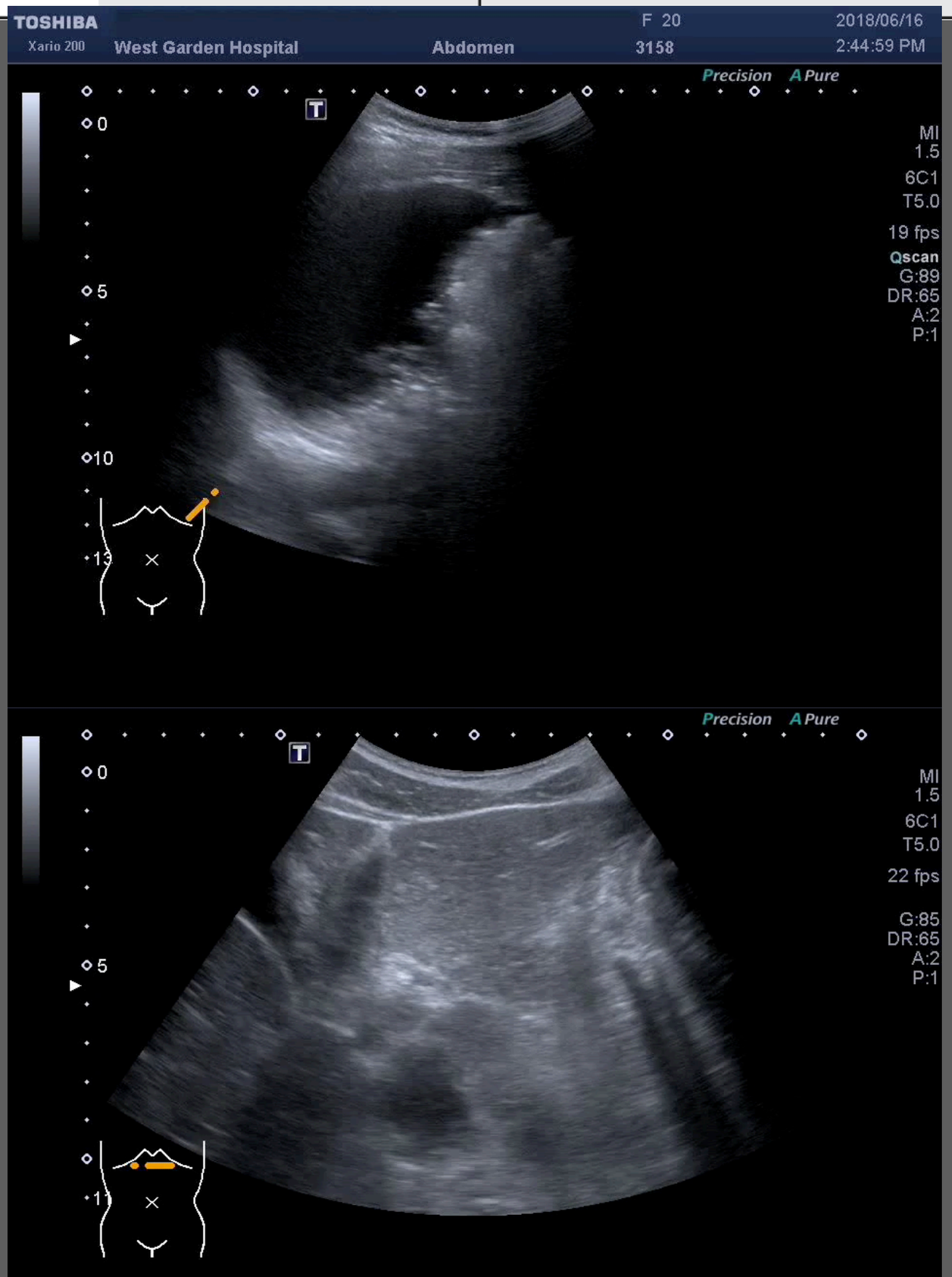
Patient has IAP > 12 mm Hg
Begin medical management to reduce IAP

Step 1

Evacuate intraluminal contents

Confirmation of NG tube position

Assess gastric contents (solids vs. liquids) and residual volumes



POCUS for ACS

Patient has IAP > 12 mm Hg
Begin medical management to reduce IAP

Step 1

Evacuate intraluminal contents

Confirmation of NG tube position

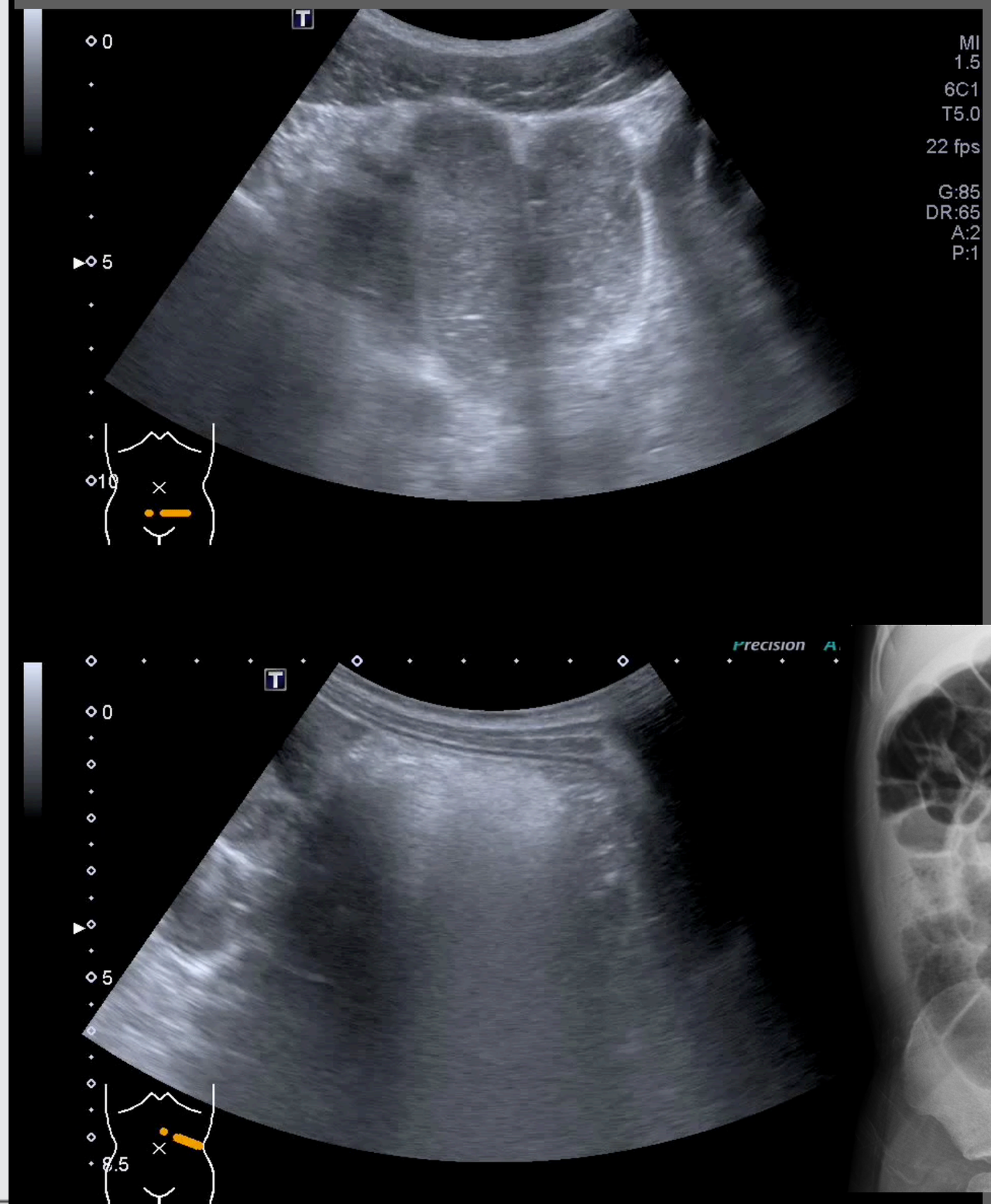
Assess gastric contents (solids vs. liquids) and residual volumes

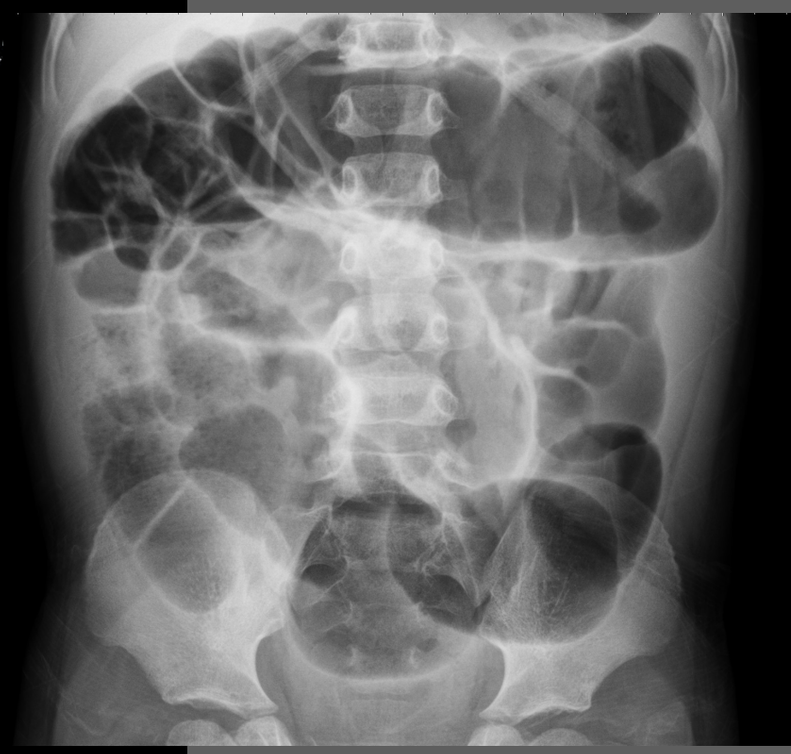
Step 2

Assess the degree of bowel activity, dilation or faeces.

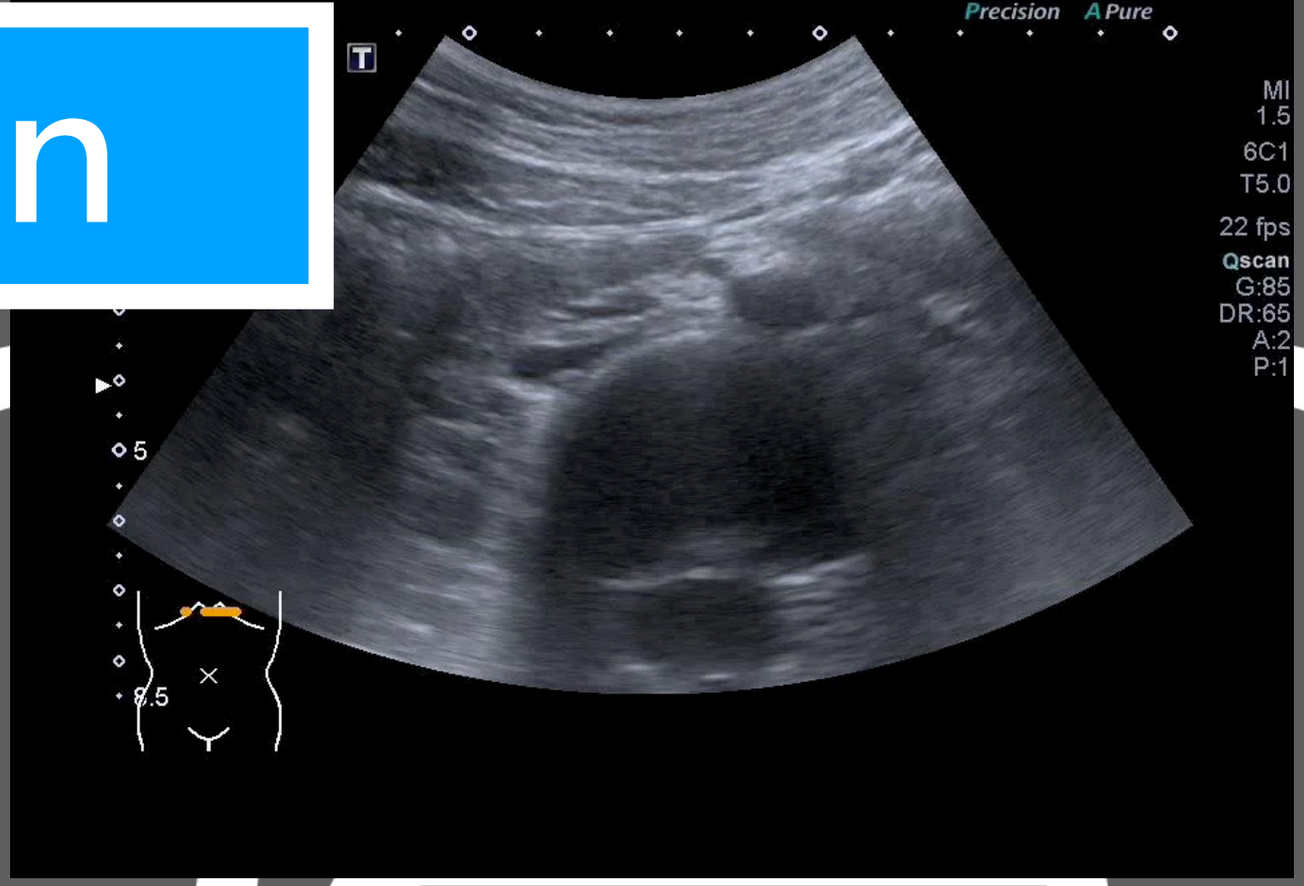
Identify the need for enema therapy

Step 3





Colon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T5.0
22 fps
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DR:65
A:2
P:1
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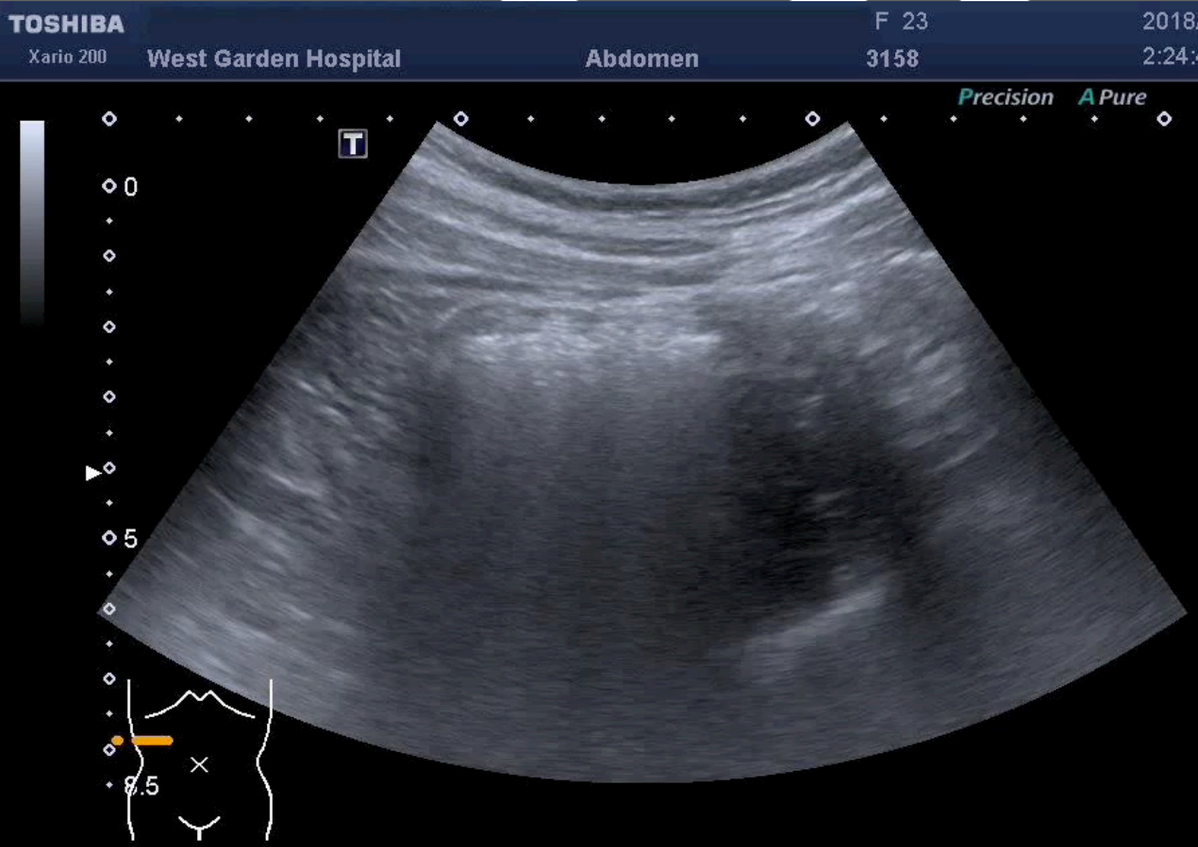
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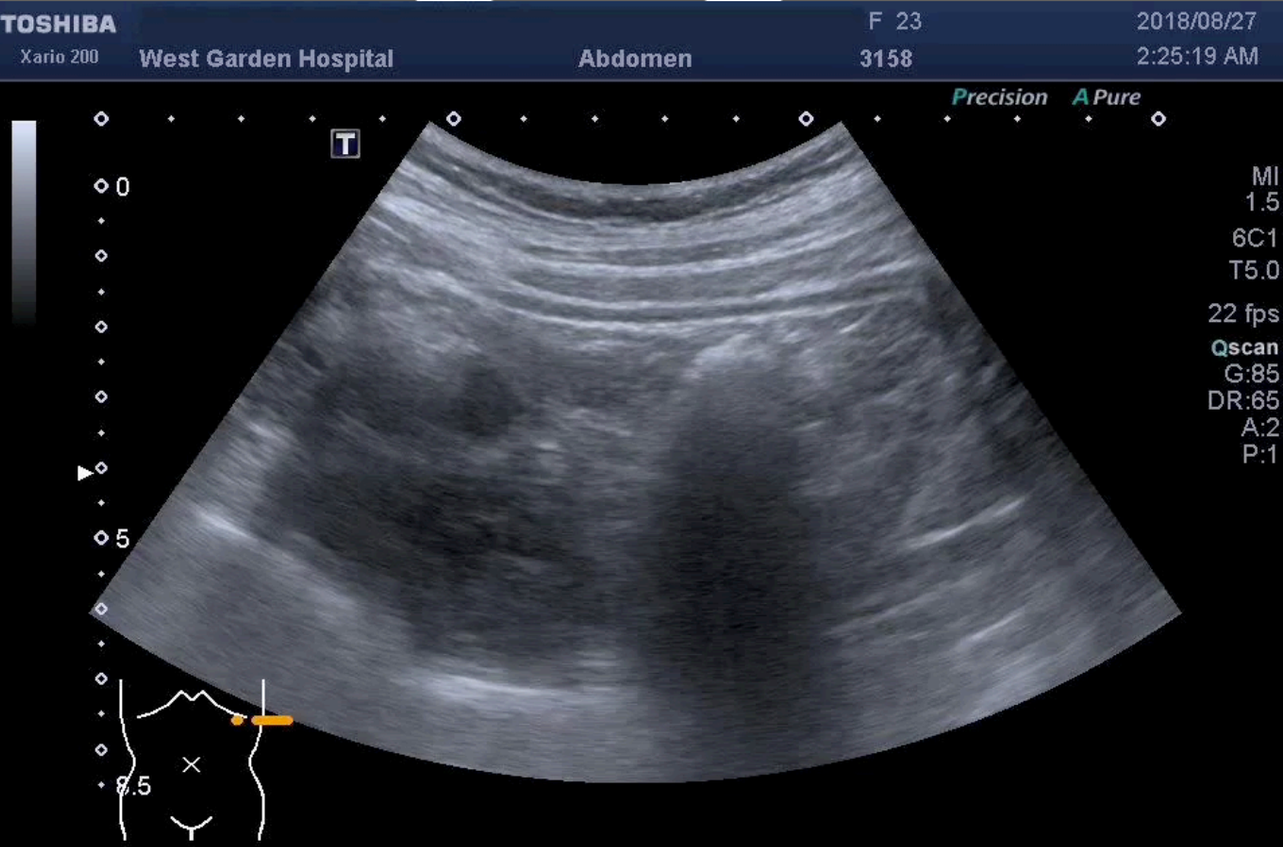
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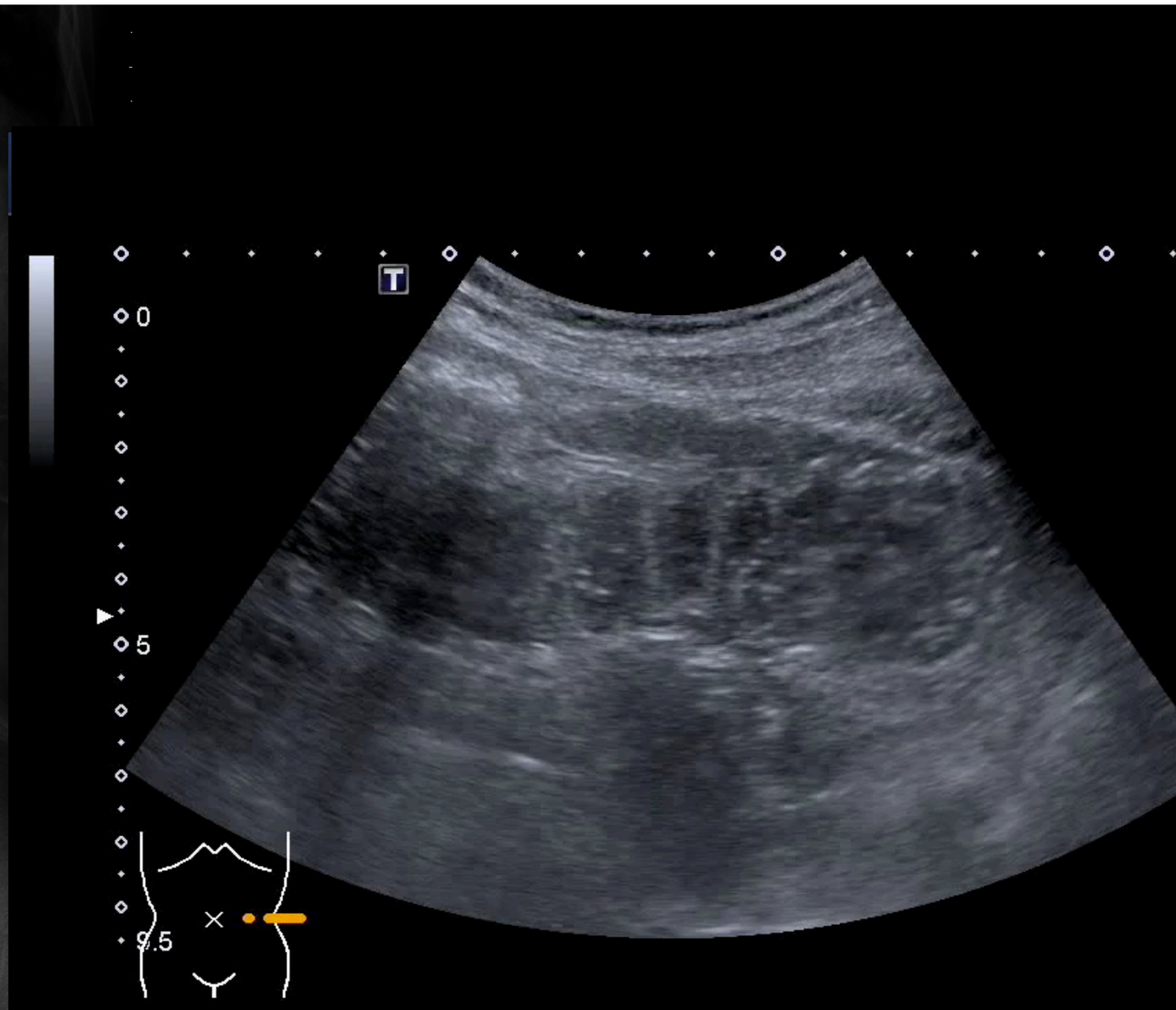
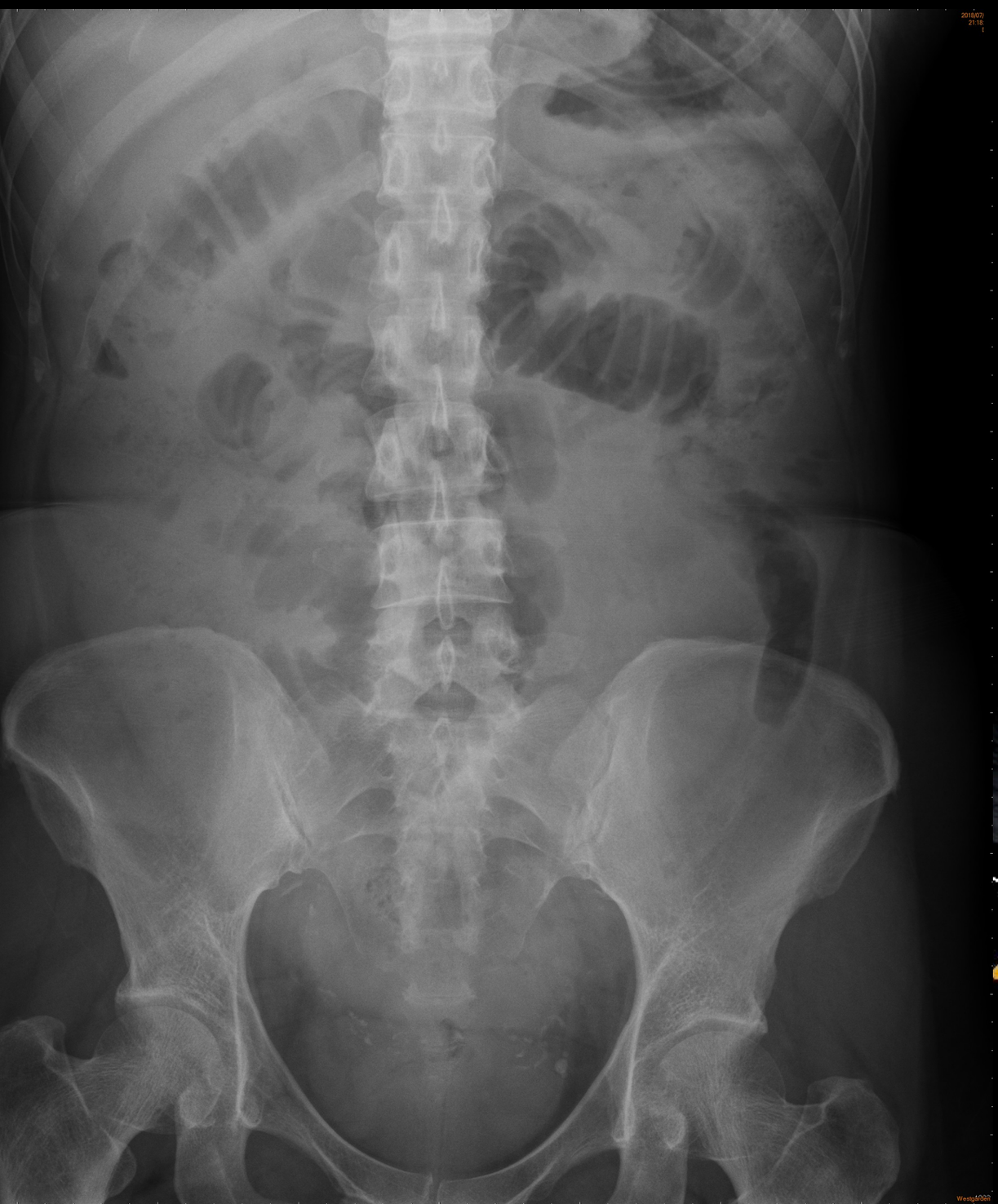
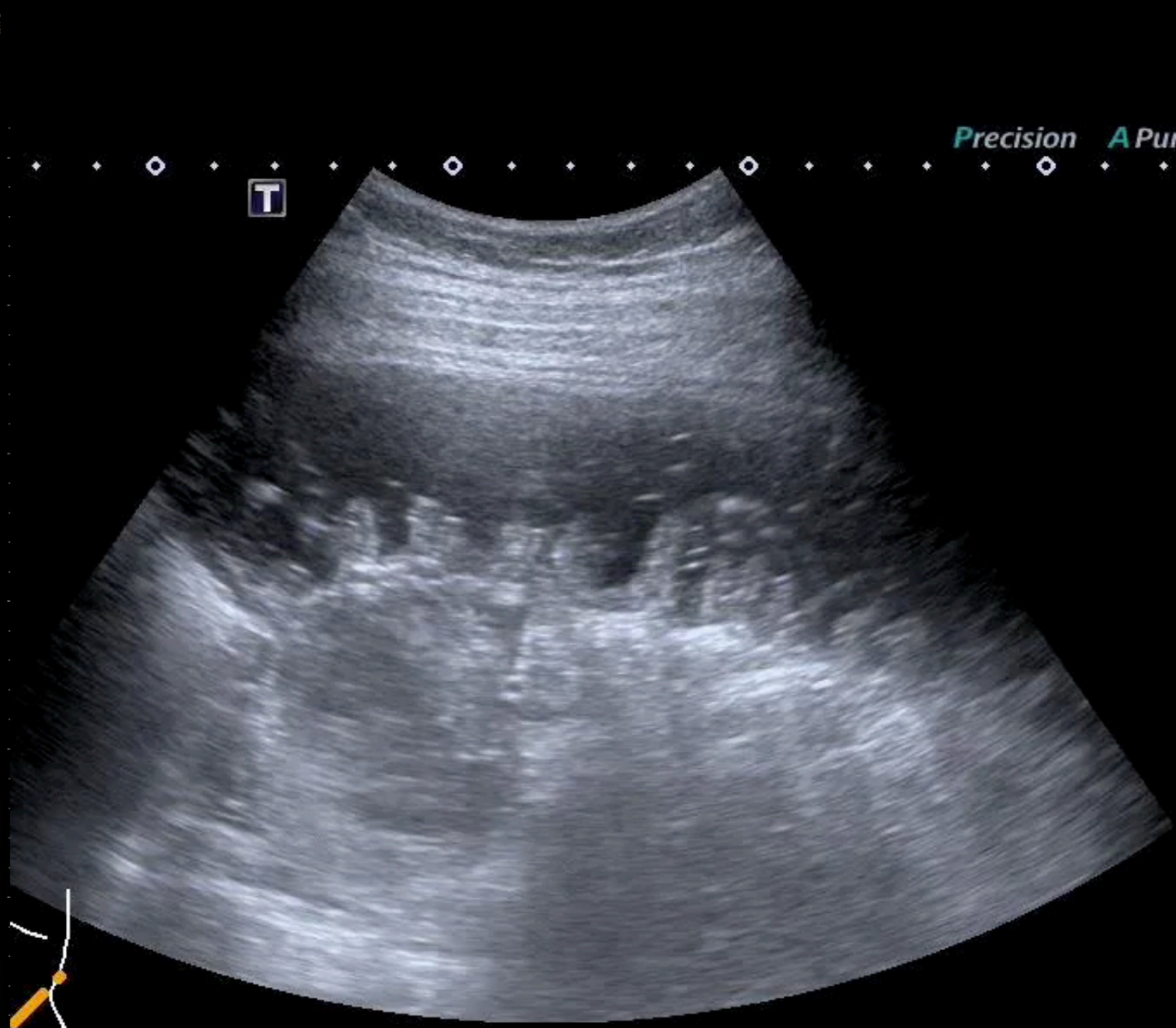
5
8.5

To-N-Fro movement

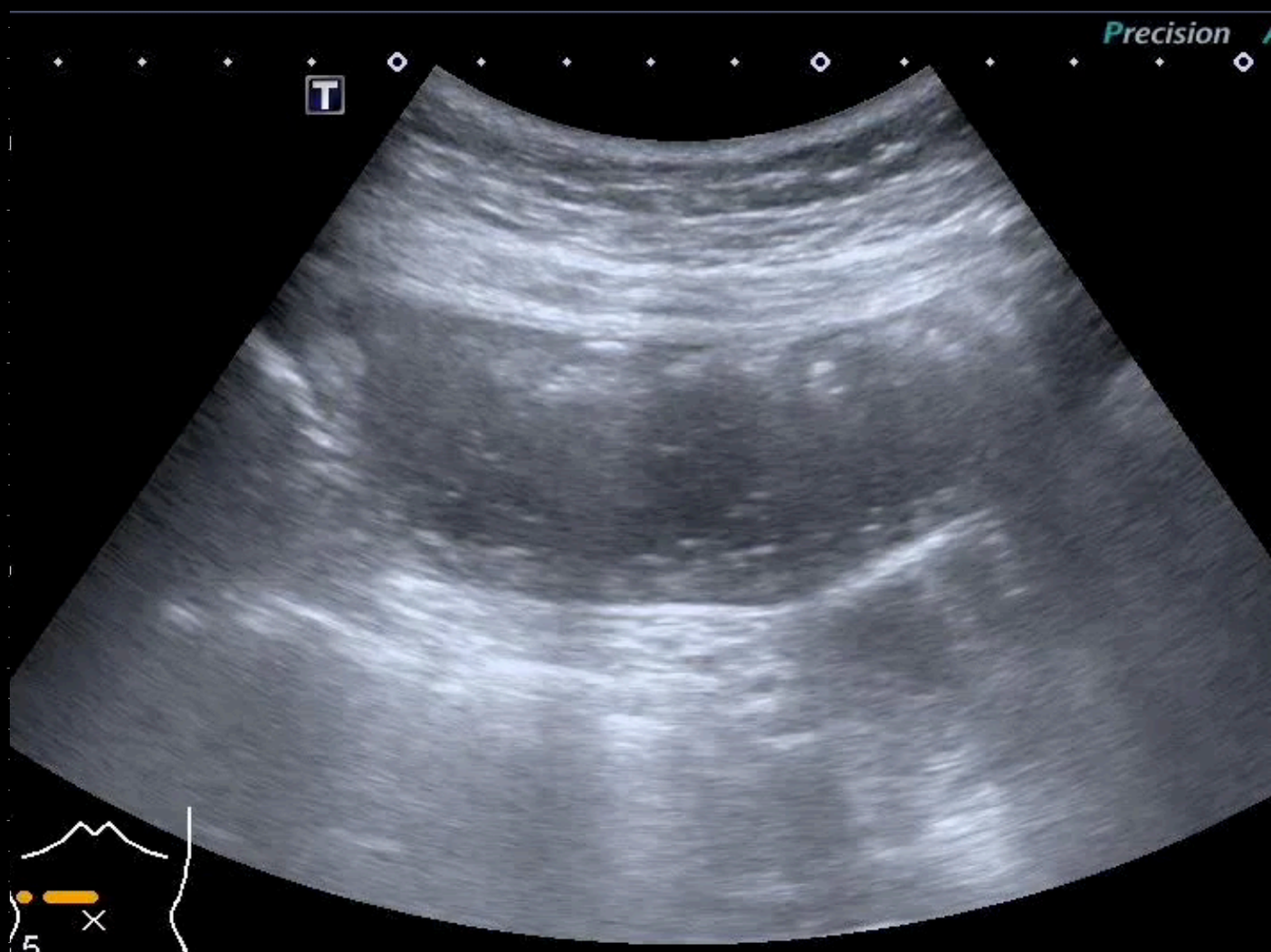


Keyboard sign





String-of-beads sign



POCUS for ACS

Patient has IAP > 12 mm Hg
Begin medical management to reduce IAP

Step 1

Evacuate intraluminal contents

Confirmation of NG tube position

Assess gastric contents (solids vs. liquids) and residual volumes

Evacuate intraabdominal space occupying lesions

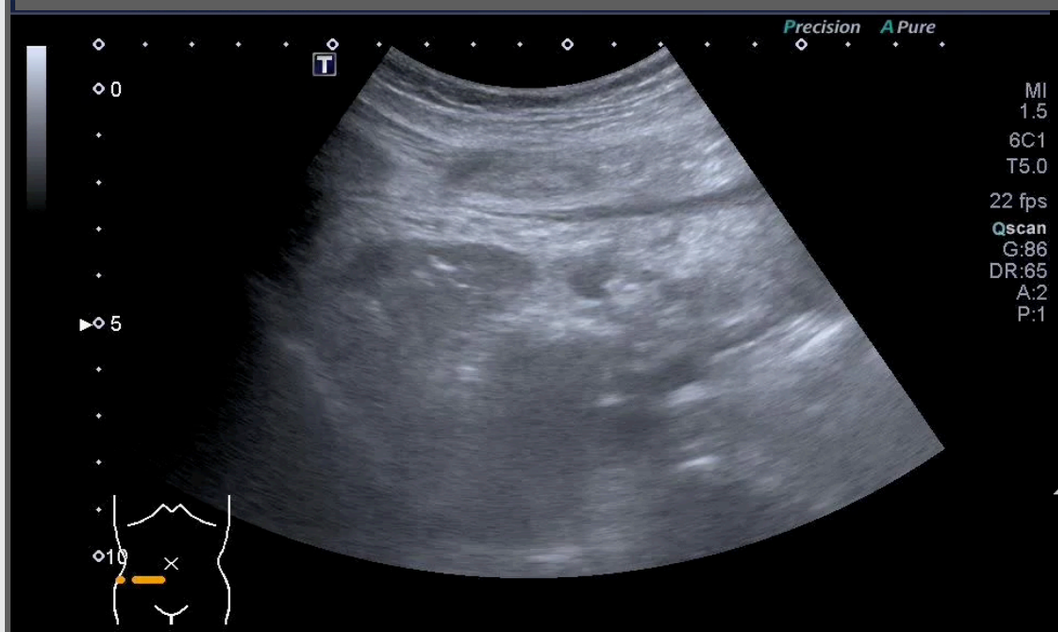
Detect and quantify volume of abdominal fluid (blood, abscess, ascites)

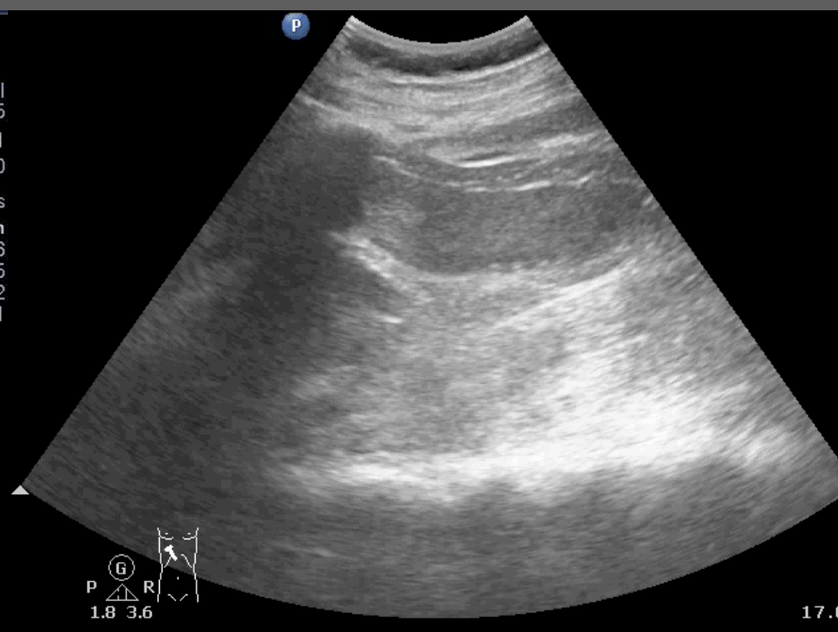
Step 2

Assess the degree of bowel activity, dilation or faeces.

Step 3

Identify the need for enema therapy

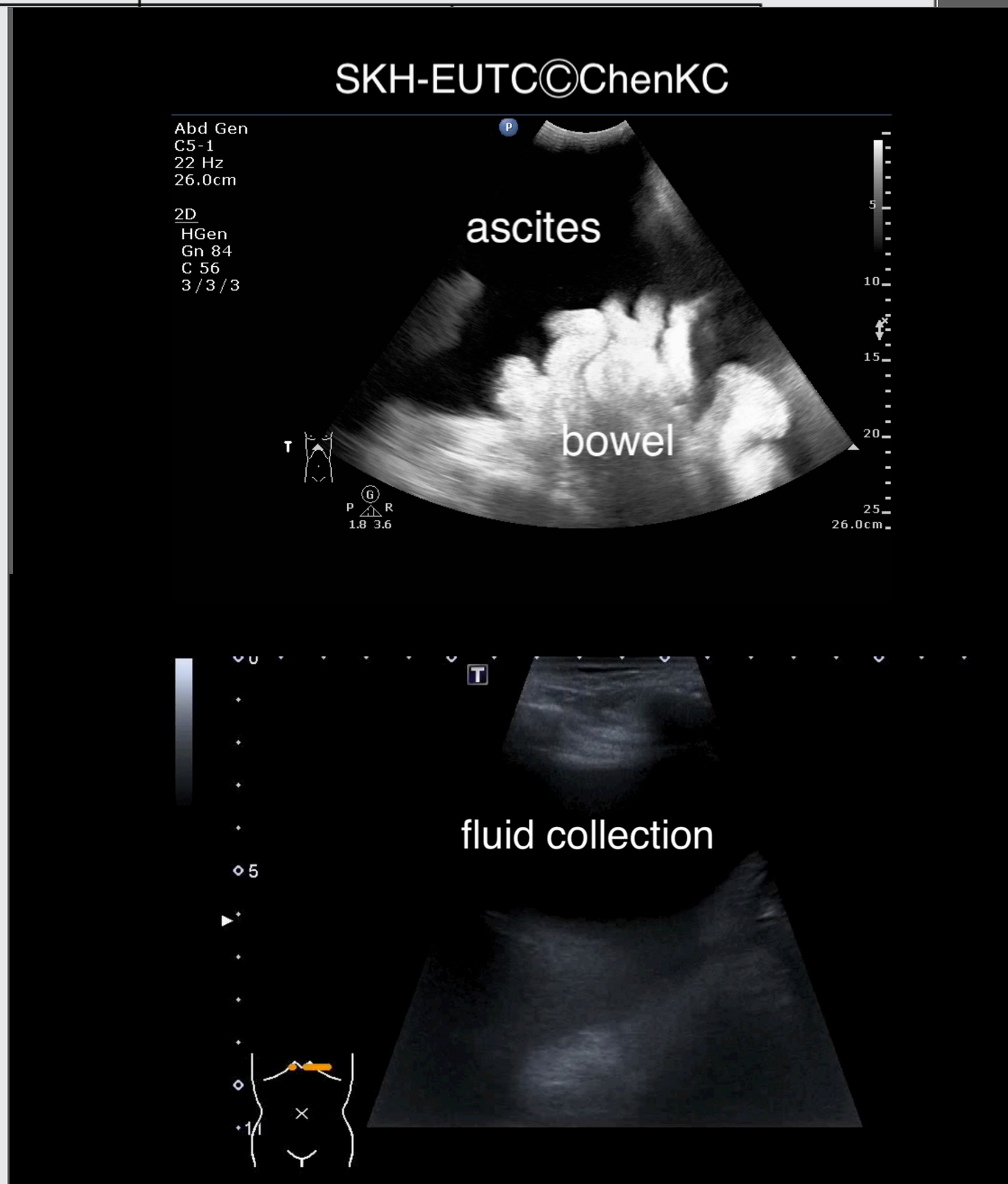




POCUS for ACS

Patient has IAP > 12 mm Hg
Begin medical management to reduce IAP

Step 1	Evacuate intraluminal contents	Evacuate intraabdominal space occupying lesions
	Confirmation of NG tube position	Detect and quantify volume of abdominal fluid (blood, abscess, ascites)
	Assess gastric contents (solids vs. liquids) and residual volumes	
Step 2	Assess the degree of bowel activity, dilation or faeces.	US-guided percutaneous drainage of abdominal fluid collections.
	Identify the need for enema therapy	
Step 3		Short term US or CT follow up to determine evolution of collections



Dynamic Echo Drainage

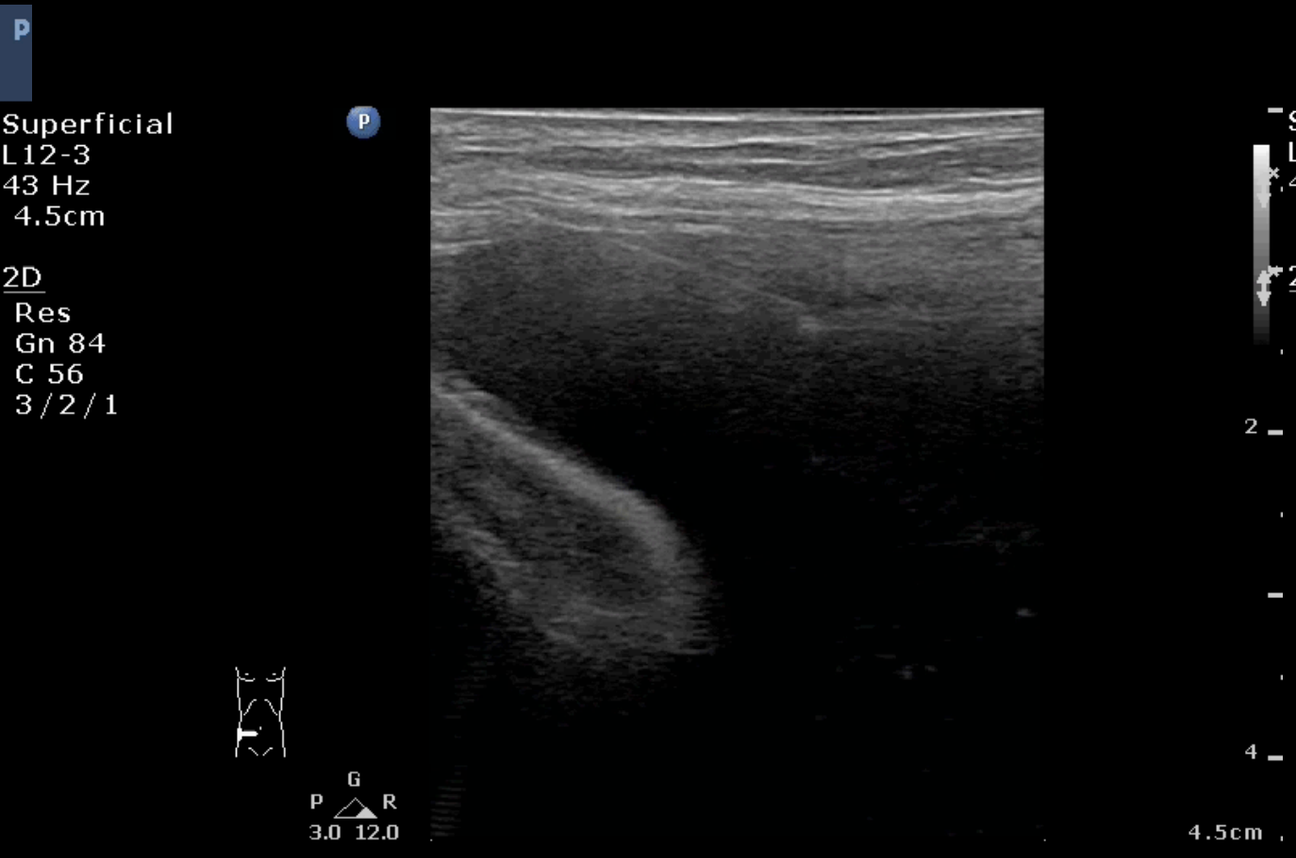


Table 1 Maximal IVC and IJV diameter during the three phases of sonographic scanning

	Spontaneous breathing	*p*	Positive pressure ventilation	*p*	Increased intra-abdominal pressure[a]	*p*
IVC max diameter (mm ± SD)	20.6 (±4.8)	0.04**	21.8 (±5.6)	0.01**	16.5 (±4.9)	Reference point
IJV max diameter (mm ± SD)	10.1 (±3.4)	0.2	12 (5.2)	0.46	13.2 (4.9)	Reference point

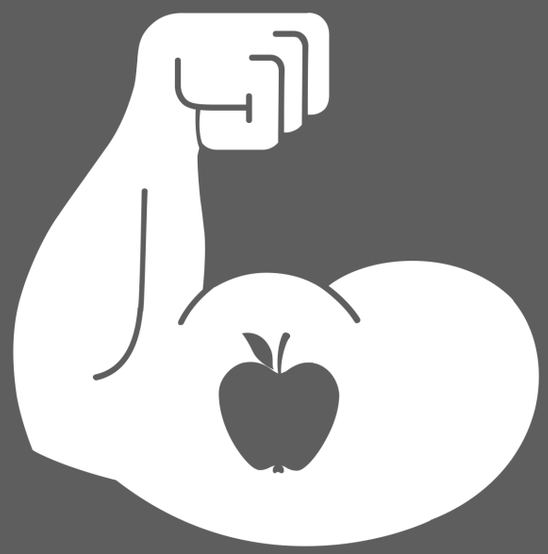
Table 2 Correlation analysis between the Inferior Vena Cava and Internal Jugular Vein Collapsibility in the 3 Different Phases

3 different phases	CORR procedure (r^2)	*p*
Spontaneous breathing	0.86	0.01*
Positive pressure ventilation	0.21	0.52
Increased intra-abdominal pressure	0.26	0.42

Effect of IAH on IVC & IJV

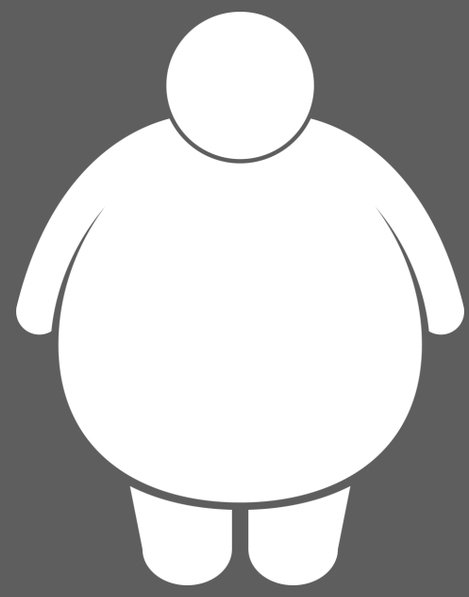
J Ultrasound (2015) 18:343 – 348

Nutrition



MT@1/3 thigh

ACS



NGT position
Bowel content
ABD content
Hemodynamics

POCUS Academy

Point-of-care ultrasound is the visual stethoscope in the 21st century

The only limitation is your imagination

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FB: Emergency Ultrasound Training Center