POCUS for HF is Back
With an AI Twist

Dr Sabe De, MD FRCPC FASE & Dr Ryan Davey MD FRCPC FACC

HF Update 2022

May 13, 2022

Schulich MEDICINE & DENTISTRY

Western

Disclosures

Relationships with commercial interests:

- Grants/Research Support: **Theracos, AstraZeneca, Amgen, GE and Novartis, Ionis**
- Speakers Bureau/Honoraria: **Servier, Novartis, Bayer, Pfizer, Medtronic, Alnylam**

CLINICAL PERSPECTIVES

Bedside Focused Cardiac Ultrasound in COVID-19 from the Wuhan Epicenter: The Role of Cardiac Point-of-Care Ultrasound, Limited Transthoracic Echocardiography, and Critical Care Echocardiography

Li Zhang, MD, PhD, Bin Wang, MD, Jianhua Zhou, PhD, James Kirkpatrick, MD, FASE, Mingxing Xie, MD, PhD, FAHA, FASE, and Amer M. Johri, MD, MSc, FRCPC, FASE, *Wuhan and Guangzhou, China; Seattle, Washington; and Kingston, Ontario, Canada*

Zhang et al. JASE June 2020

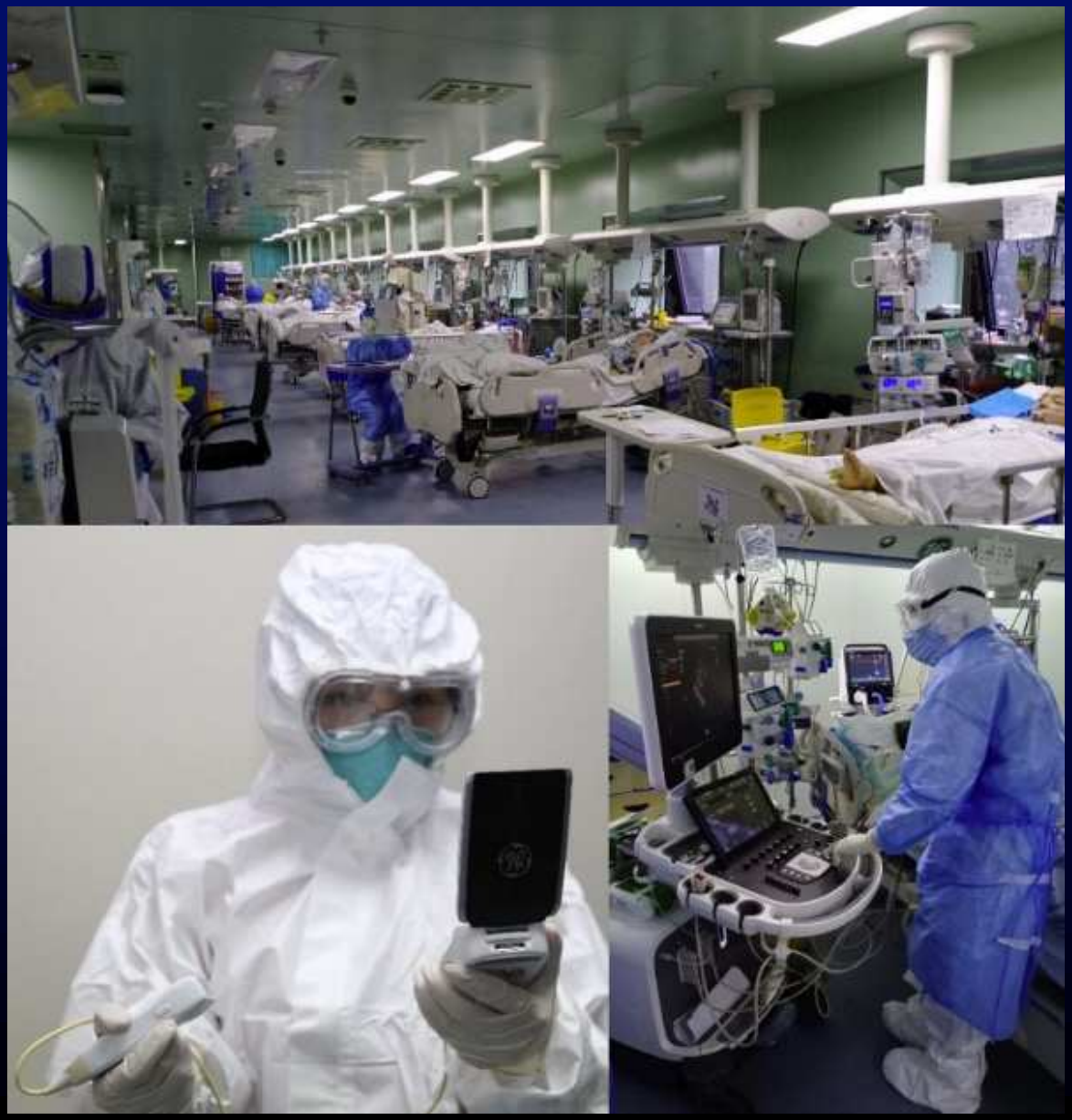


Table 1. ASE POCUS Protocol in Suspected or Confirmed COVID-19 Infection. A modified POCUS protocol to assist in the assessment of COVID-19 patients includes heart, chest and vessel views.

COVID19 POCUS Protocol	Structure Imaged	Assessment	Disease Associations
Cardiac 	**Left Ventricle**	Size, Global and Regional Function	Myocarditis ACS Cardiomyopathy Shock
	**Right Ventricle**	Size and Function; TR for PASP if available	PE Cardiomyopathy
	**Pericardium**	Effusion	Tamponade
	**Valves**	Gross Regurgitation or stenosis	Pre-existing CV disease
Lung 	**8 or 12 point exam**	B Lines (A lines, pleural sliding are normal)	Edema or Pneumonia
		Sub-pleural Consolidation Thickened Pleura	Pneumonia ARDS
		Lobar consolidation with air Bronchograms	Pneumonia ARDS
		Effusion	CHF
Vascular 	**JVP or Subcostal IVC**	Fluid Status	CHF, hypovolemia
	**+/- Leg Veins***	2 point compression*	DVT

*Leg veins may be assessed if the operator has training in this technique, clinical suspicion exists, and the sonographer is not available.
ACS, acute coronary syndrome; TR, tricuspid regurgitation; PASP, pulmonary artery systolic pressure; PE, pulmonary embolism; CV, cardiovascular; ARDS, acute respiratory distress syndrome; JVP, jugular venous pulsation; IVC, inferior vena cava. CHF, congestive heart failure; DVT, deep vein thrombosis.

Journal of the American Society of Echocardiography 2020 33670-673DOI: (10.1016/j.echo.2020.04.017)

POCUS GOALS

- POCUS aims to gather sufficient information to assess physiologic status and essential differential diagnoses.
- POCUS is carried out to facilitate decision making mainly in a binary (yes or no) fashion.
- POCUS should be performed by appropriately trained clinicians treating the patient.

Via et al. JASE 2014;27:683.e1-e33.

Table 1 Comparison of POCUS and traditional TTE, with a brief overview of technological capabilities and limitations, indications for techniques, and operators

	POCUS	TTE
Operators	Typically • Nonsonographer • Nonradiologist • May be conducted by traditional expert (ePOCUS)	• Level II, level III echocardiographer (physician)[1] • ARDMS (sonographer) • Credentialing laboratory
Indications	Assessment of • Valvular function (gross) • Pericardial effusion/tamponade • LV function/thickness • RV function • IVC • Expert consensus available[2]	• Wide spectrum • See available published guidelines*
Technological capabilities	• Usually portable (<15 lb) • 2D imaging • Color Doppler	• Full-service machine • 2D imaging • Color Doppler • 3D imaging • Strain • Pulsed-wave Doppler • Continuous-wave Doppler • Telemetry signal • Contrast can be applied
Advantages	• Portability • Accessibility • Relatively inexpensive compared to traditional TTE machines • Immediacy of results	• "Gold standard" • High-quality images • Standardized guidelines for examination and reporting • Multiple techniques available (3D, strain, contrast) • Archiving of imaging studies
Limitations	• Lack of formal training benchmarks • Paucity of guidelines • Technological limitations	• Portability • Access • Cost of machines greatly exceeds that of portable units

2D, Two-dimensional; *3D*, three-dimensional; *ARDMS*, American Registry for Diagnostic Medical Sonography; *IVC*, inferior vena cava; *LV*, left ventricular; *RV*, right ventricular.

*A list of published ASE guidelines is available at http://asecho.org/ase-guidelines-by-publication-date/.

POCUS in Heart Failure

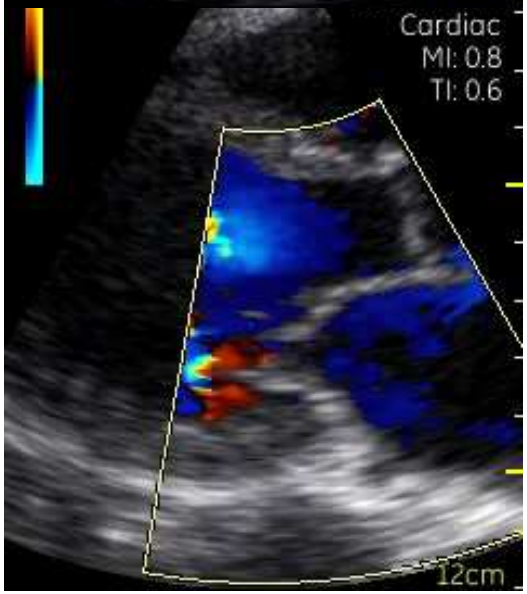
Case : 32F worsening SOB post-COVID

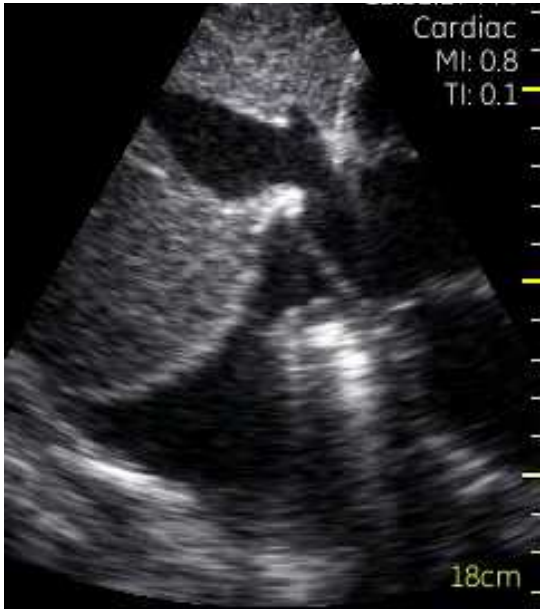
- Presents to ED
- She had been diagnosed with a mild case of COVID-19 approximately 3 weeks earlier
- Physical exam:
  - BP 90/50, HR 120, RR 20, T 36.8, JVP 10-12cm, O2 sat 92% on 6L;
  - Chest: diffuse crackles; Cardiac: Gr2/6 holosystolic murmur
  - Extremities: cool
- Investigations:
  - Lactate 3.5, WBC 7.2, ABG: pH 7.35, PaO2 85
  - ECG: sinus tachycardia
  - Chest x -ray shows diffuse interstitial pattern

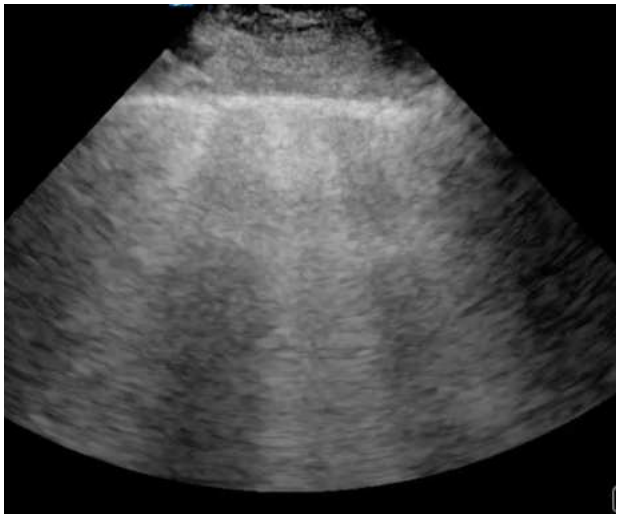
Case


Cardiac
MI: 0.8
TI: 0.1
12cm

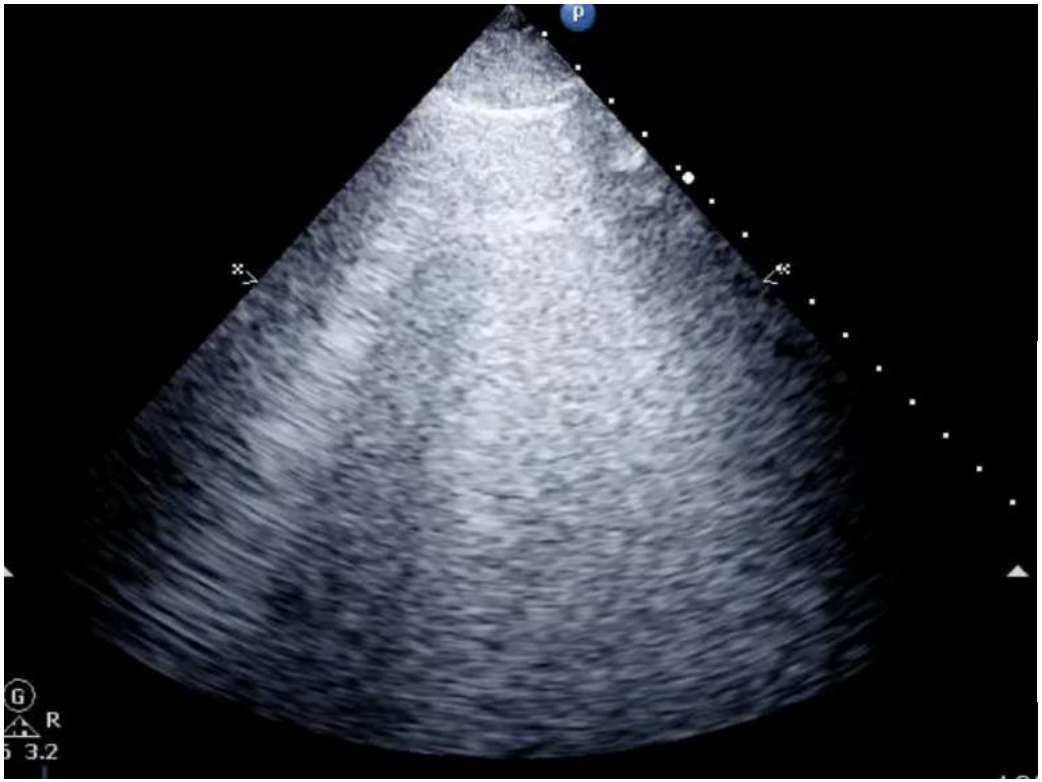

Cardiac
MI: 0.8
TI: 0.1
12cm


Cardiac
MI: 0.8
TI: 0.6
12cm


Cardiac
MI: 0.8
TI: 0.1
18cm



Lung US for Pulmonary Edema



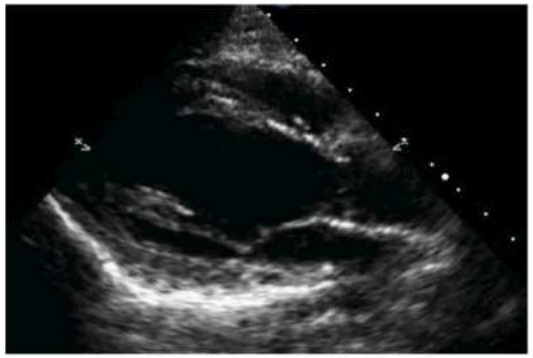
88% sensitivity
90% specificity

Outperforms CXR

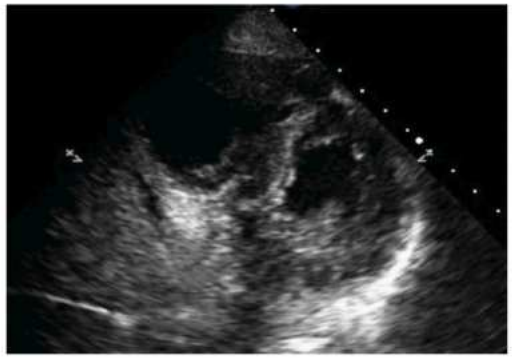
Lichtenstein AJRCCM 1997; Agricola Chest 2005;Lichtenstein Chest 2015; Enghard Crit Care 2015;

Wooten *J Ultrasound Med 2019; 38:967–973*. Garibyan *J UltrasoundMed 2018; 37:1641–1648*

Basic Point of Care Echocardiography for Heart Failure

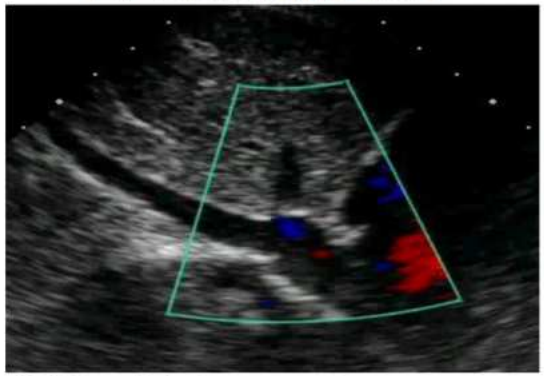


LV size/function



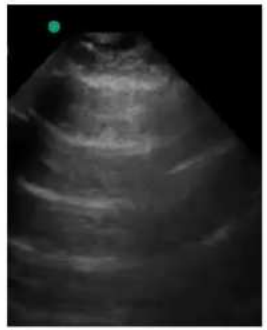
RV size/function

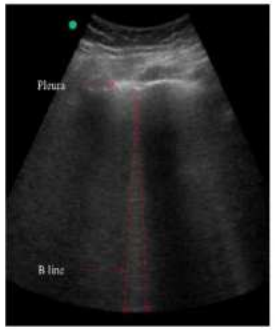
Pericardial Effusion



IVC - Volume Status

Significant Valvulopathy





A-lines B-lines

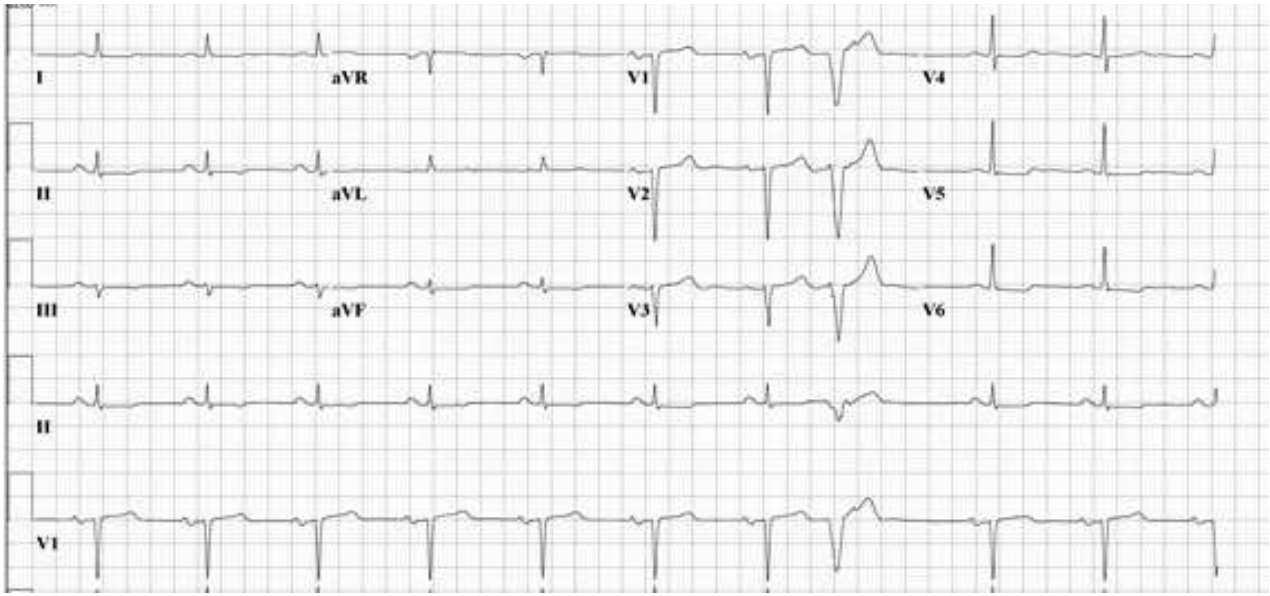
Lung Exam

Uses of POCUS in Heart Failure

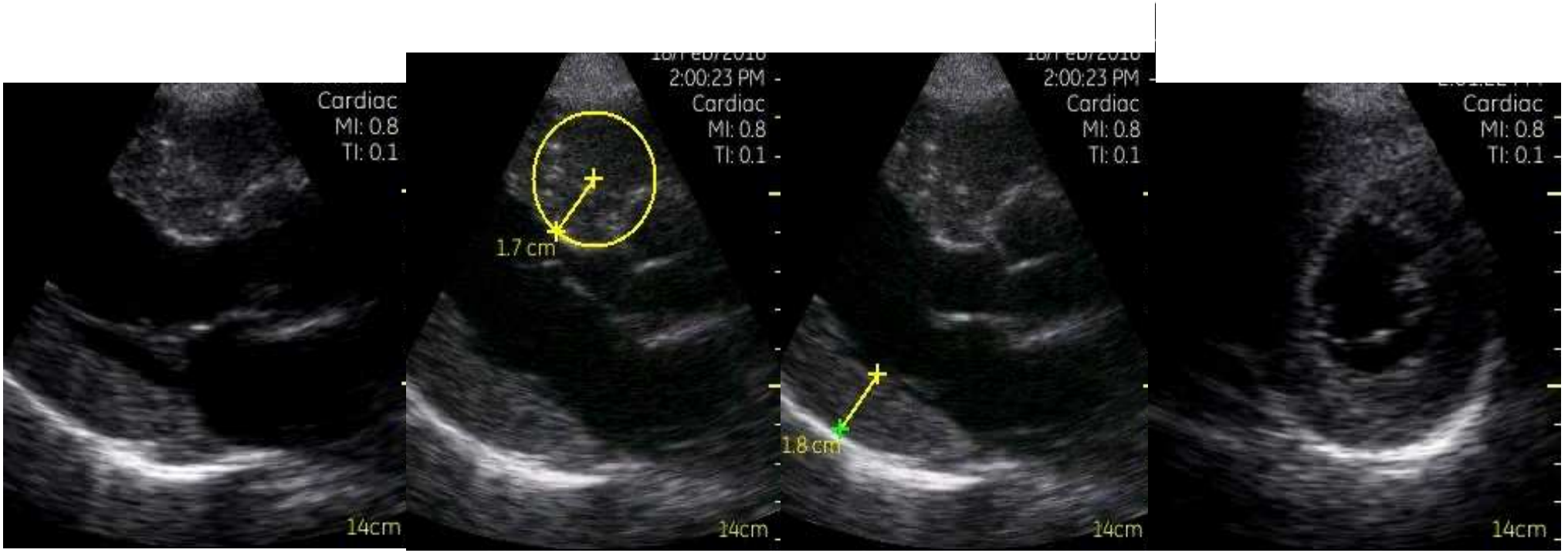
- Assessment of volume status
- Determination of LV function – HFrEF vs HFpEF
- RV size/function
- Valvular heart disease
- To gauge LV remodeling
- Advanced heart failure – use it for whatever you wish

Case :62M mild SOBOE and mild peripheral edema

- Referred to cardiology clinic
- PMHx: spinal stenosis, carpal tunnel syndrome
- Physical examination:
  - JVP 8-10cm ASA, 1+ pitting edema to the shins bilaterally
- Investigations: nt-proBNP 1200 pg/mL
  - ECG:



Case #3: 62M mild SOBOE and mild peripheral edema



EXPERT CONSENSUS STATEMENT

Focused Cardiac Ultrasound: Recommendations from the American Society of Echocardiography

Kirk T. Spencer, MD, FASE, Bruce J. Kimura, MD, Claudia E. Korcarz, DVM, RDCS, FASE, Patricia A. Pellikka, MD, FASE, Peter S. Rahko, MD, FASE, and Robert J. Siegel, MD, FASE, *Chicago, Illinois; San Diego and Los Angeles, California; Madison, Wisconsin; Rochester, Minnesota*

(J Am Soc Echocardiogr 2013;26:567-81.)

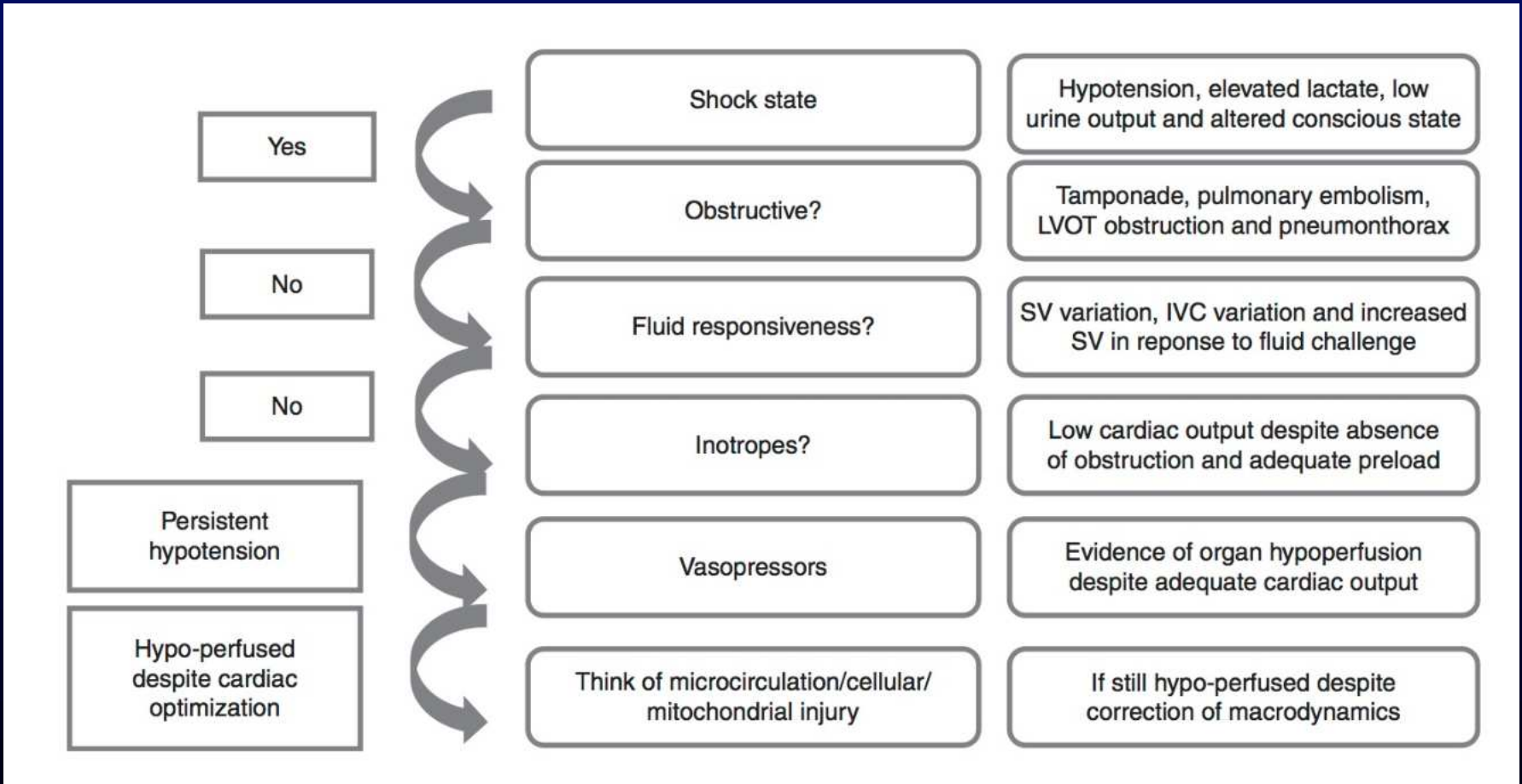
Keywords: Cardiac ultrasound, Guideline, Point-of-care

Suggested Targets of the POCUS examination

- LV dimension, systolic function
- RV systolic function
- Volume Status
- Pericardial effusion, tamponade physiology
- Gross signs of chronic heart disease
- Gross valvular abnormalities
- Large intracardiac masses

POCUS for Undifferentiated Shock

Stepwise Approach to Hemodynamic Compromise using POCUS



Roshdy et al. Echo Res Pract. **2014 Sep 1;1(1):D1-8.**

[2] ACUTE RV SYSTOLIC DYSFUNCTION

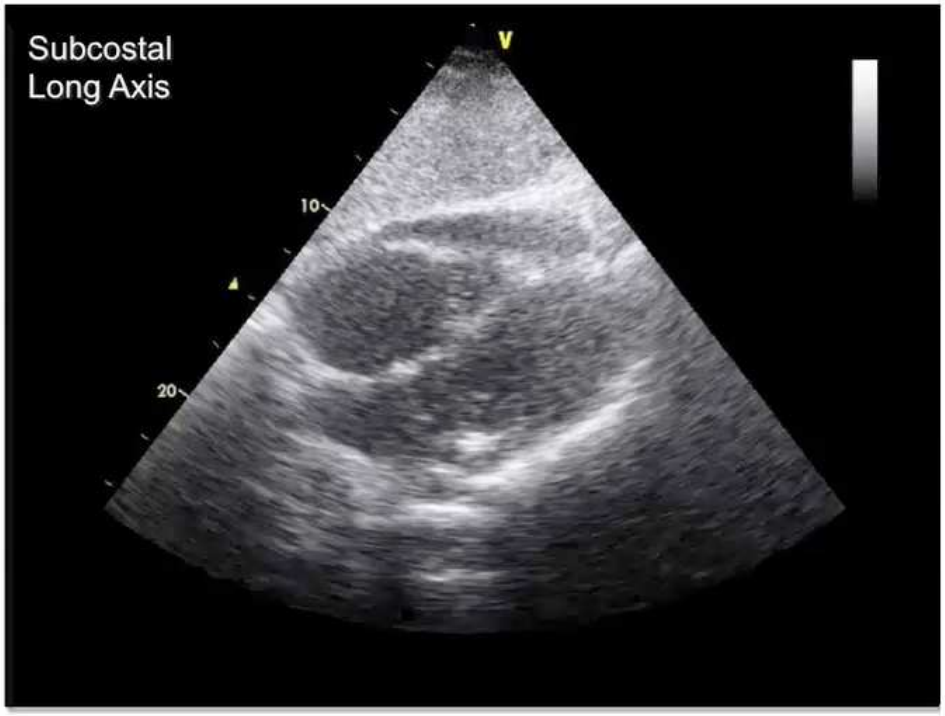
FoCUS FINDINGS

- RV DILATATION
- RV HYPOKINESIA (visual + reduced TAPSE)
- NO SIGNS OF CHRONIC RV DISEASE
- ± SYSTOLIC SEPTAL DYSKINESIA (pressure overload)

  ± DIASTOLIC SEPTAL DYSKINESIA (volume overload)

Via et al. JASE 2014;27:683.e1-e33.

[5] PERICARDIAL EFFUSION



FoCUS FINDINGS

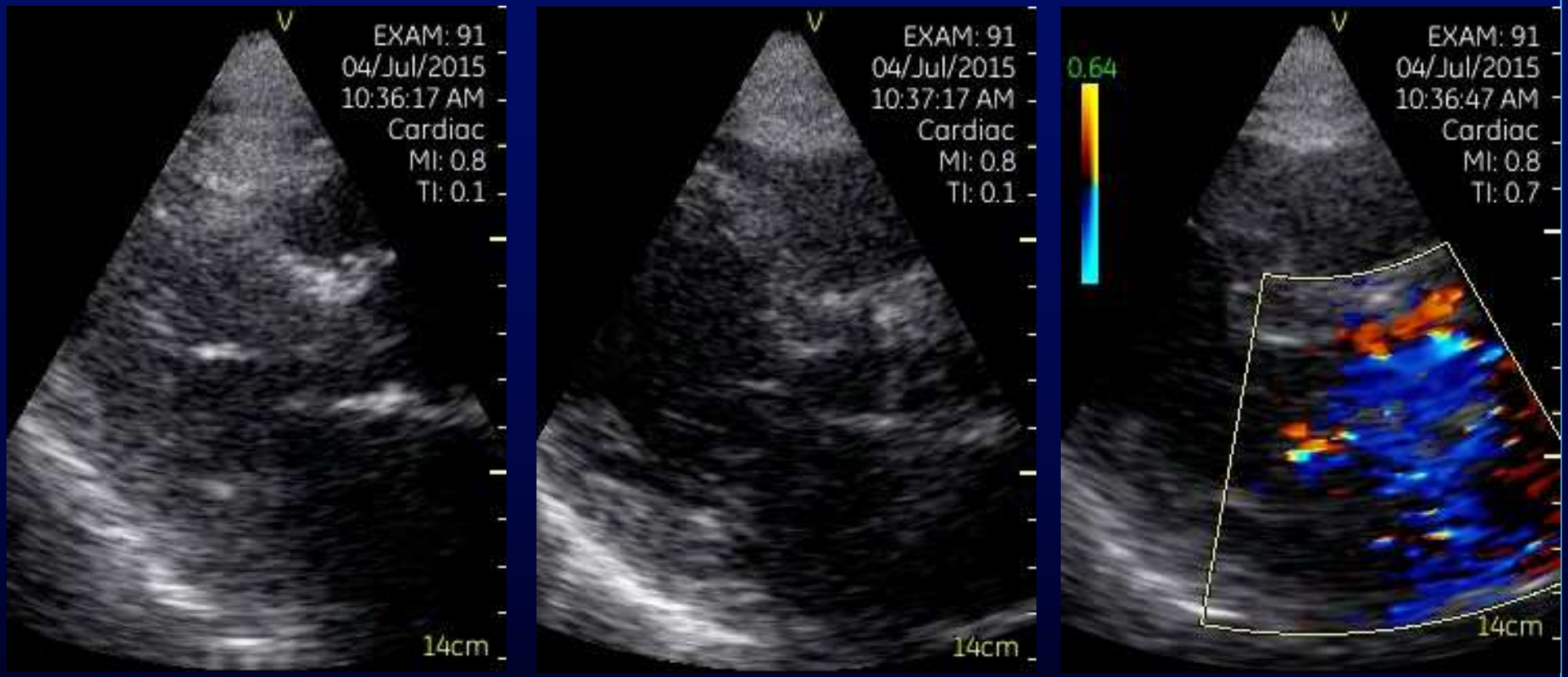
- ANECHOIC/ HYPO-ECHOIC PERICARDIAL FREE SPACE
- NO SIGNS OF COMPRESSION ON "LOW-PRESSURE CAVITIES

Via et al. JASE 2014;27:683.e1-e33.

POCUS compared with Physical Exam

- More accurate for determination of LV systolic function
- More accurate for determination of valvular disease
- POCUS with current ultrasound machines for detection of cardiac abnormalities is superior to physical exam alone
- Can be used as a screening tool in patients at risk

Via et al. JASE 2014;27:683.e1-e33.



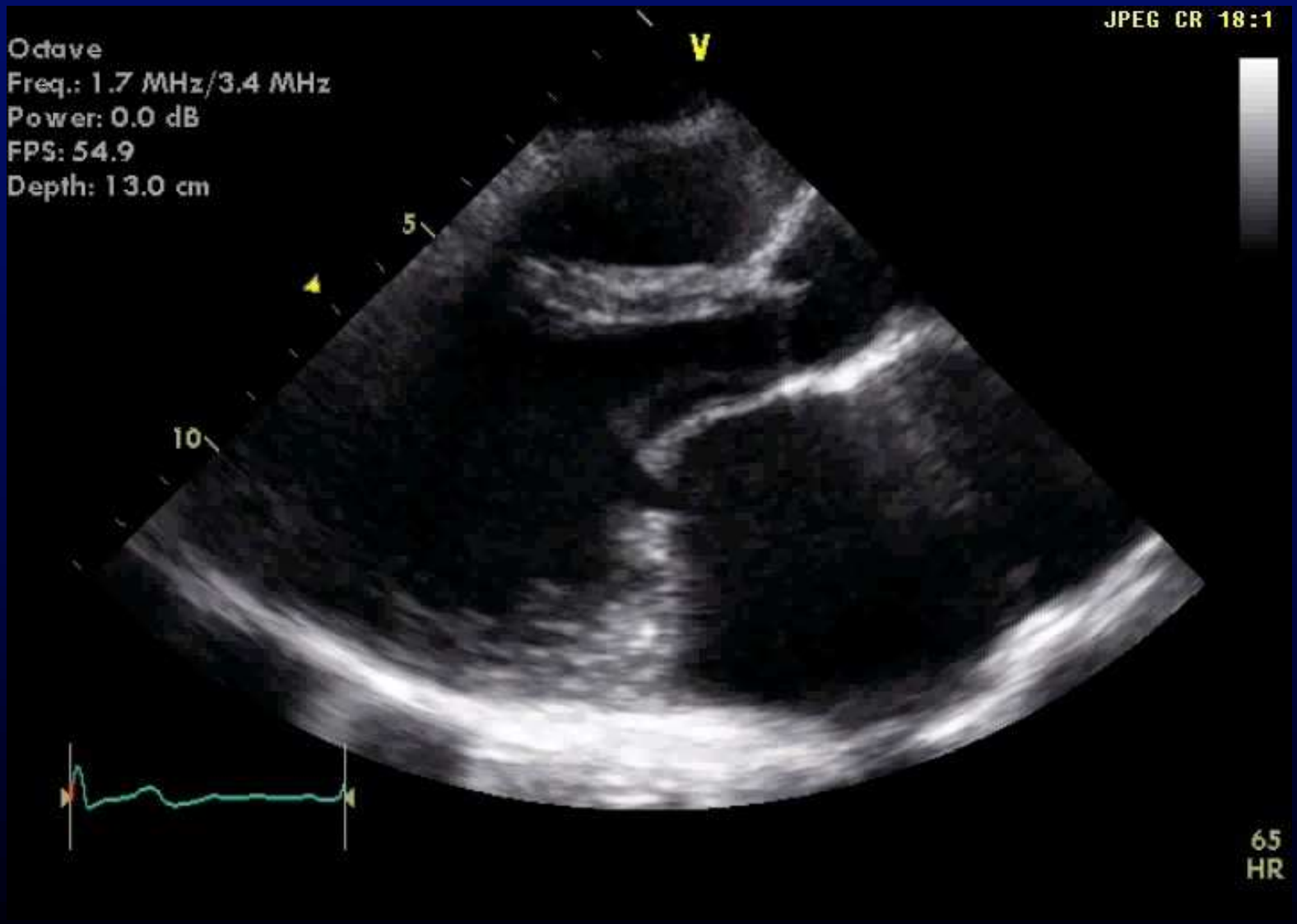
52 yo male with Click/Murmur

62 year old male with SEM

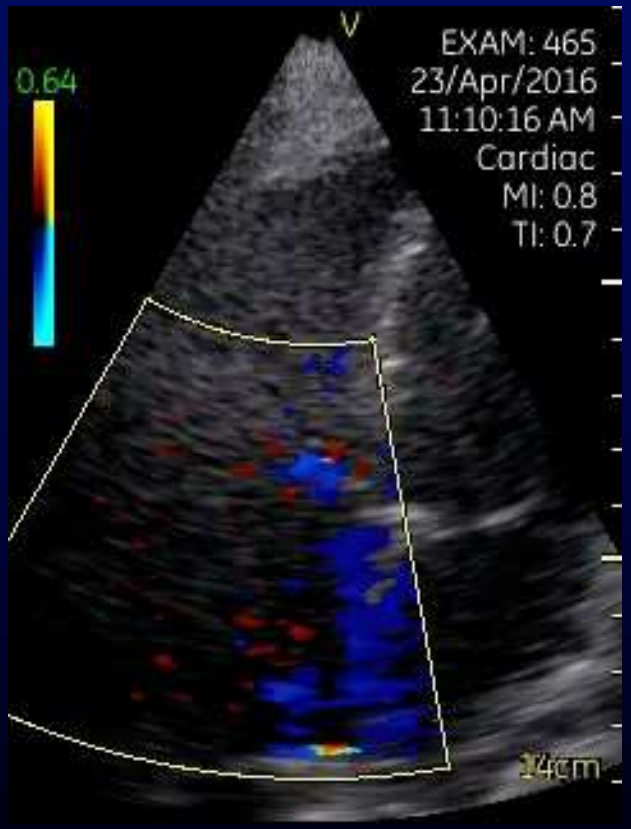
NEWS | FEBRUARY 16, 2012

Medical Outreach Brings Pocket Ultrasound to Underserved in India

February 16, 2012 — A partnership between the American Society of Echocardiography (ASE) and GE Healthcare used technological innovations in the field to bring **cardiovascular ultrasound** to an underserved population in rural India. Sponsored by ASE, nine United States-based cardiovascular sonographers traveled to a remote location in northwest India, where an estimated 12 million people had gathered for a meditation camp, in late January. The sonographers and their India-based physician counterparts from Medanta, the Medicity, in Gurgaon, part of India's National Capital Region, used technology to provide education to local clinicians and free imaging services to 1,030 pre-identified


Octave
Freq.: 1.7 MHz/3.4 MHz
Power: 0.0 dB
FPS: 54.9
Depth: 13.0 cm
JPEG CR 18:1
V
5
10
65
HR

70 year old female with high JVP



IVC assessment using POCUS

Variable	Normal (0-5 [3] mm Hg)	Intermediate (5-10 [8] mm Hg)		High (15 mm Hg)
IVC diameter	≤2.1 cm	≤2.1 cm	>2.1 cm	>2.1 cm
Collapse with sniff	>50%	<50%	>50%	<50%
Secondary indices of elevated RA pressure				• Restrictive filling • Tricuspid E/E′ > 6 • Diastolic flow predominance in hepatic veins (systolic filling fraction < 55%)

Ranges are provided for low and intermediate categories, but for simplicity, midrange values of 3 mm Hg for normal and 8 mm Hg for intermediate are suggested. Intermediate (8 mm Hg) RA pressures may be downgraded to normal (3 mm Hg) if no secondary indices of elevated RA pressure are present, upgraded to high if minimal collapse with sniff (<35%) and secondary indices of elevated RA pressure are present, or left at 8 mm Hg if uncertain.
IVC, Inferior vena cava; *RA*, right atrial.

Rudski et al. JASE 2010

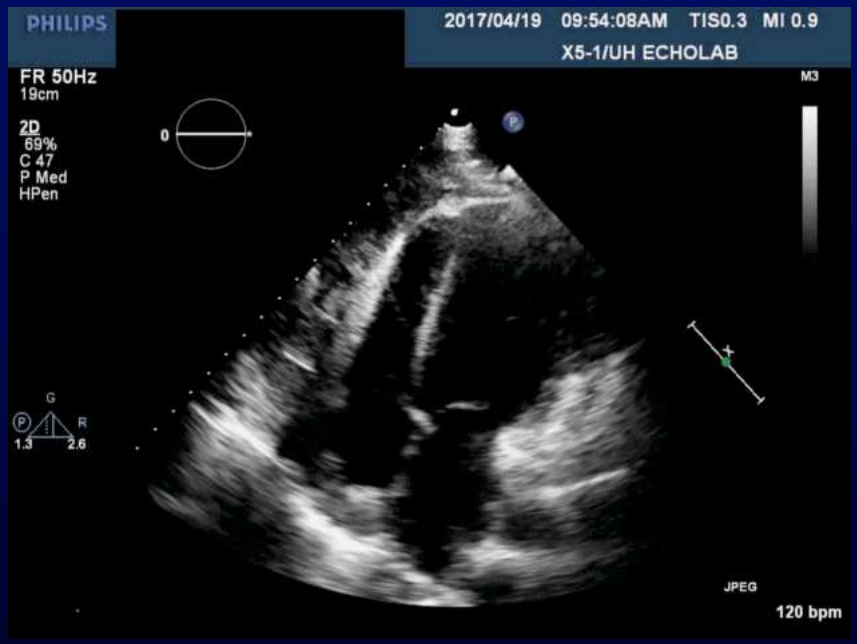
Pitfalls of IVC assessment

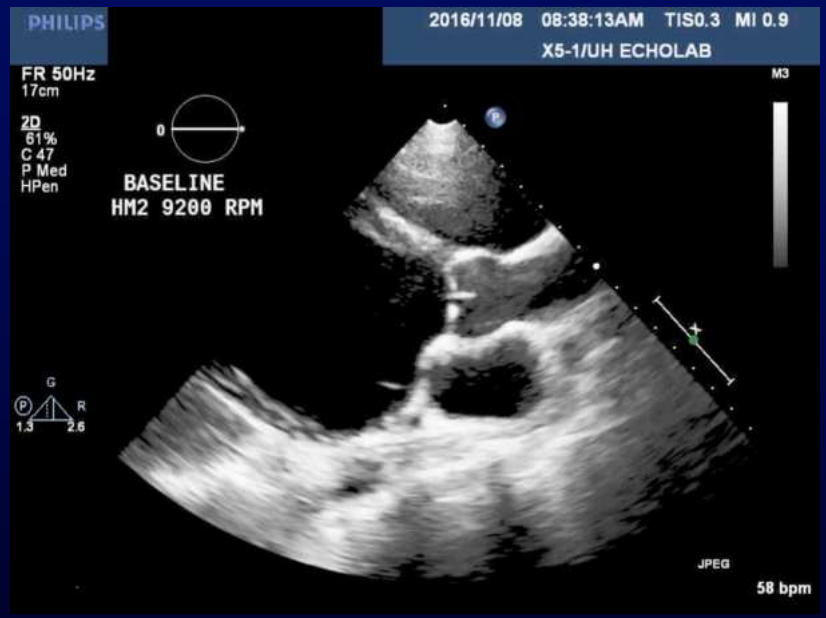
- Since IVC size and collapsibility are used as the surrogates for RA pressure, anything that can affect this interaction may yield an erroneous interpretation.

Conditions that may cause UNDERestimation of RAP by IVC POCUS	Conditions that may cause OVERestimation of RAP by IVC POCUS
Obesity	Tamponade
High Positive Pressure Ventilation	Severe tricuspid regurgitation
COPD/Asthma exacerbation	Pericardial constriction

Blanco and Volpicelli *Crit Ultrasound J (2016) 8:15*

18 year old male post transplant





5 months prior

POCUS – LVAD assessment


V
EXAM: 637
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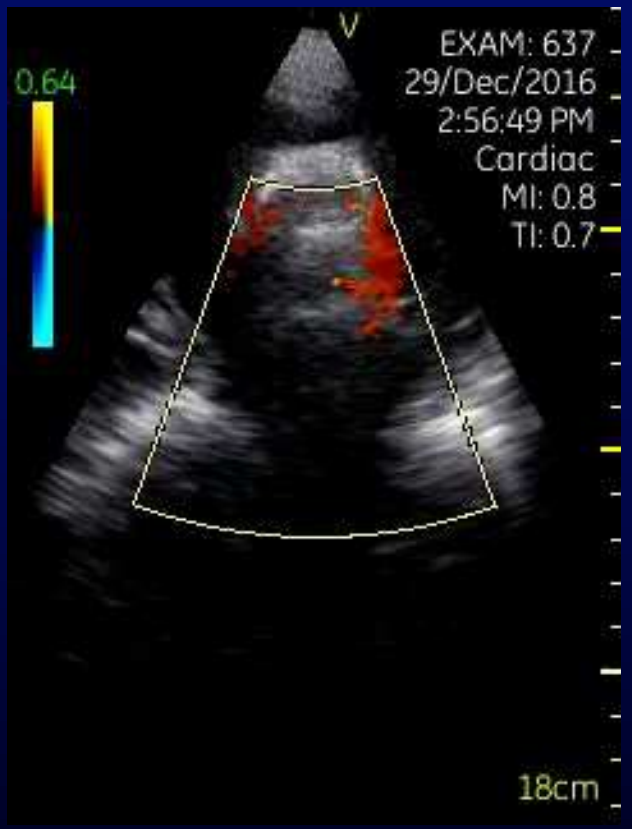
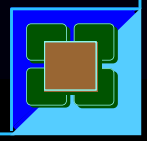
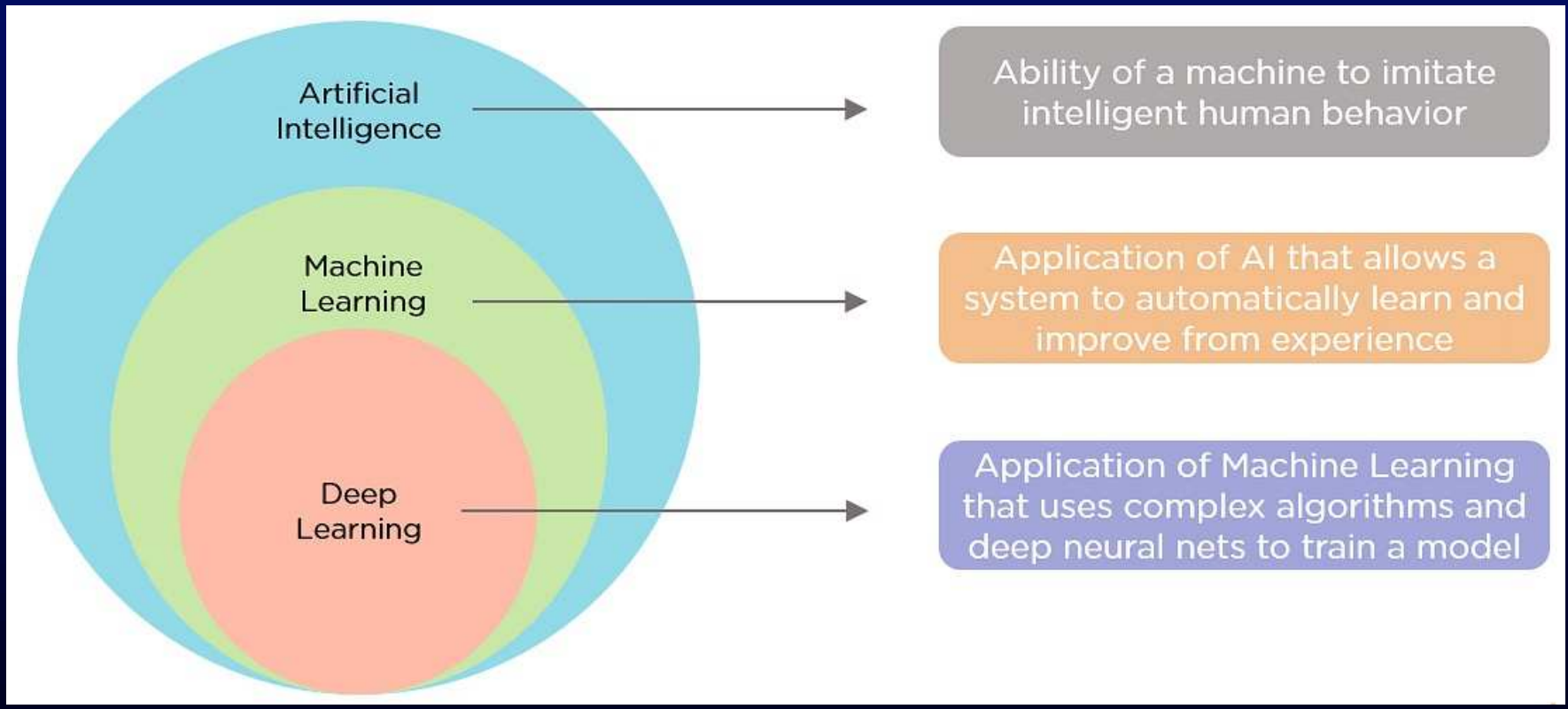
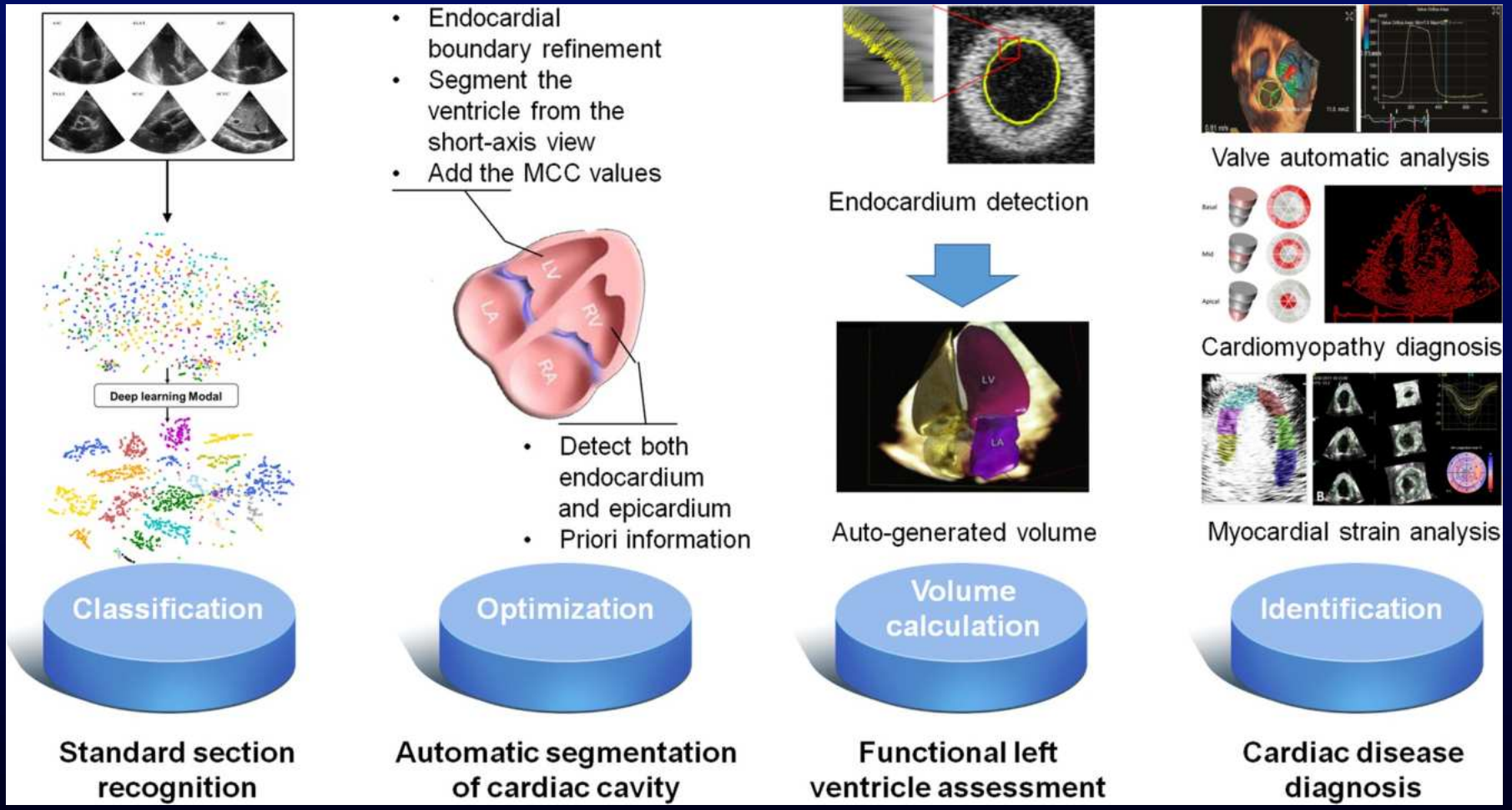
2:56:36 PM
Cardiac
MI: 0.8
TI: 0.1
18cm


V
0.64
EXAM: 637
29/Dec/2016
2:56:49 PM
Cardiac
MI: 0.8
TI: 0.7
18cm

Artificial Intelligence and POCUS




Artificial Intelligence
Machine Learning
Deep Learning
Ability of a machine to imitate intelligent human behavior
Application of AI that allows a system to automatically learn and improve from experience
Application of Machine Learning that uses complex algorithms and deep neural nets to train a model



Zhou, J., Du, M., Chang, S. *et al. Cardiovasc Ultrasound* 19, 29 (2021).

MINI-FOCUS ISSUE: IMAGING

BEGINNER

CASE REPORT: TECHNICAL CORNER

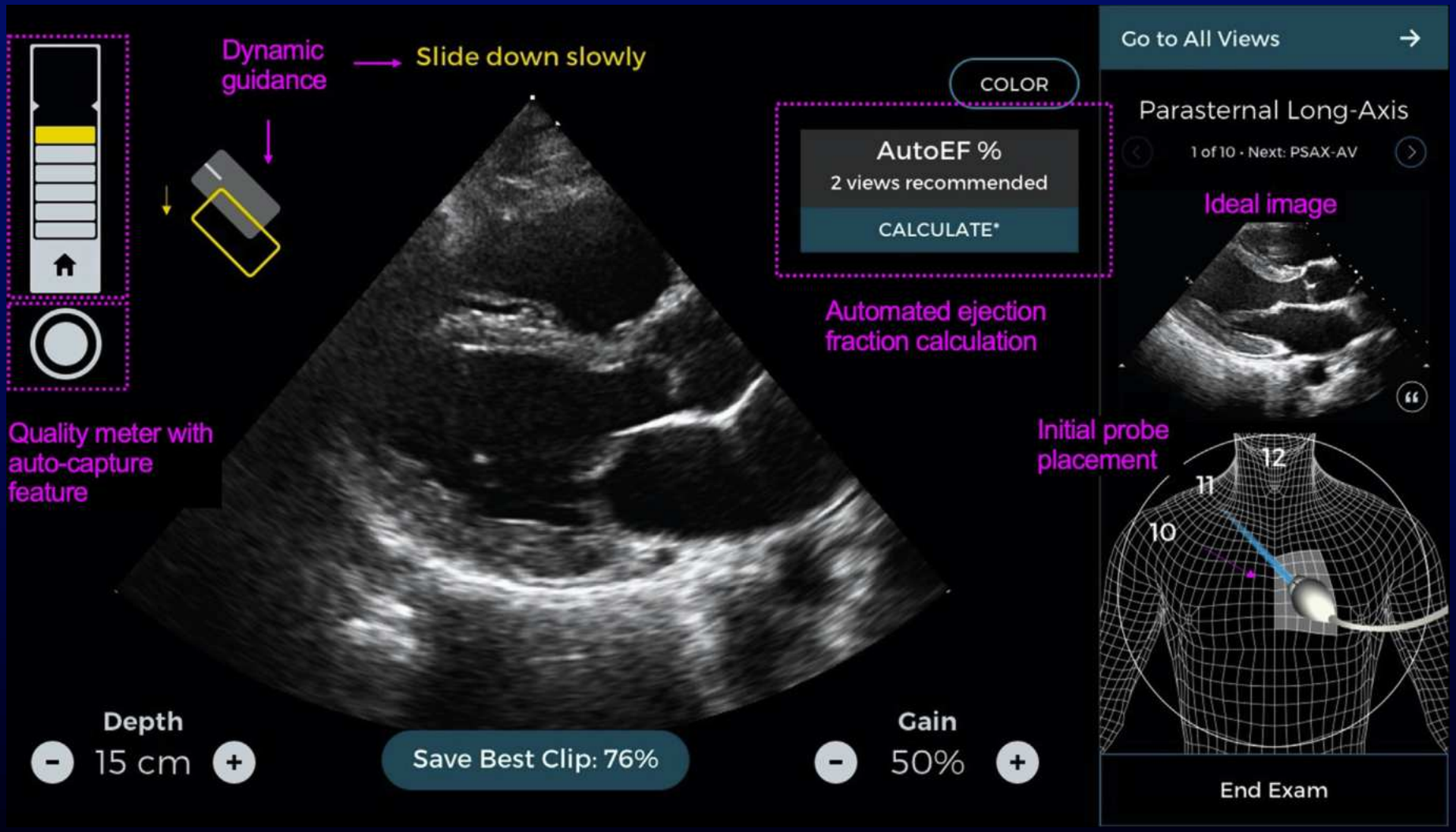
Artificial Intelligence–Enabled POCUS in the COVID-19 ICU

A New Spin on Cardiac Ultrasound

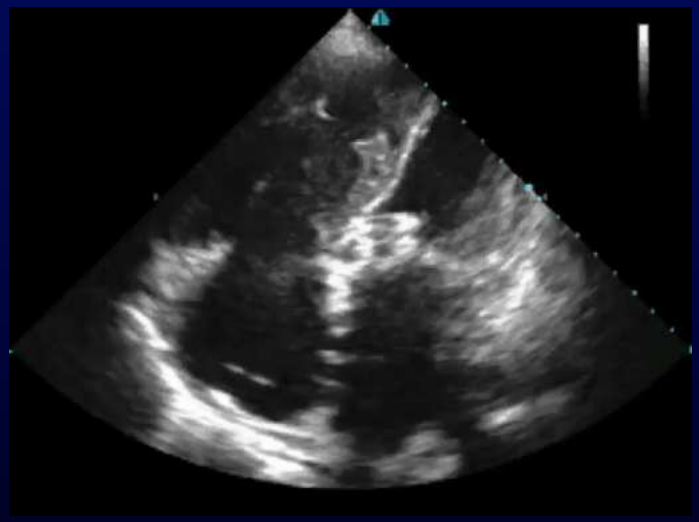
Baljash S. Cheema, MD, MSCI,[a] James Walter, MD,[b] Akhil Narang, MD,[a] James D. Thomas, MD[a]

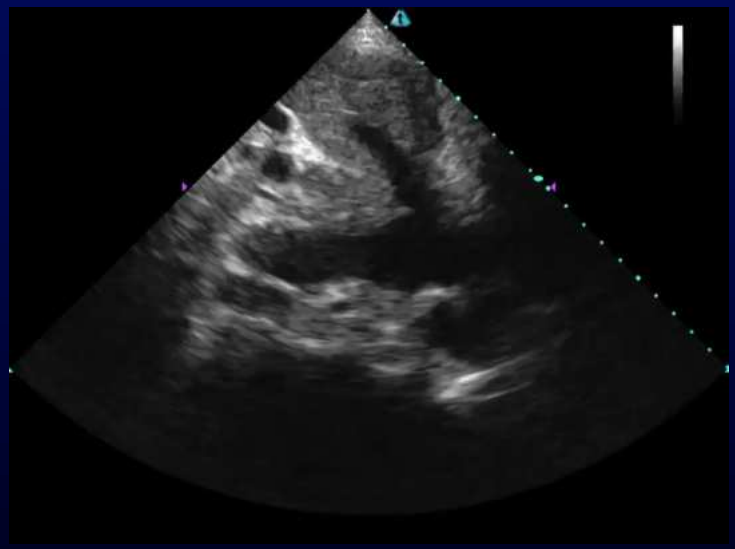
ABSTRACT

We present the novel use of a deep learning–derived technology trained on the skilled hand movements of cardiac sonographers that guides novice users to acquire high-quality bedside cardiac ultrasound images. We illustrate its use at the point of care through a series of patient encounters in the COVID-19 intensive care unit. (**Level of Difficulty: Beginner.**) (J Am Coll Cardiol Case Rep 2021;3:258–63)

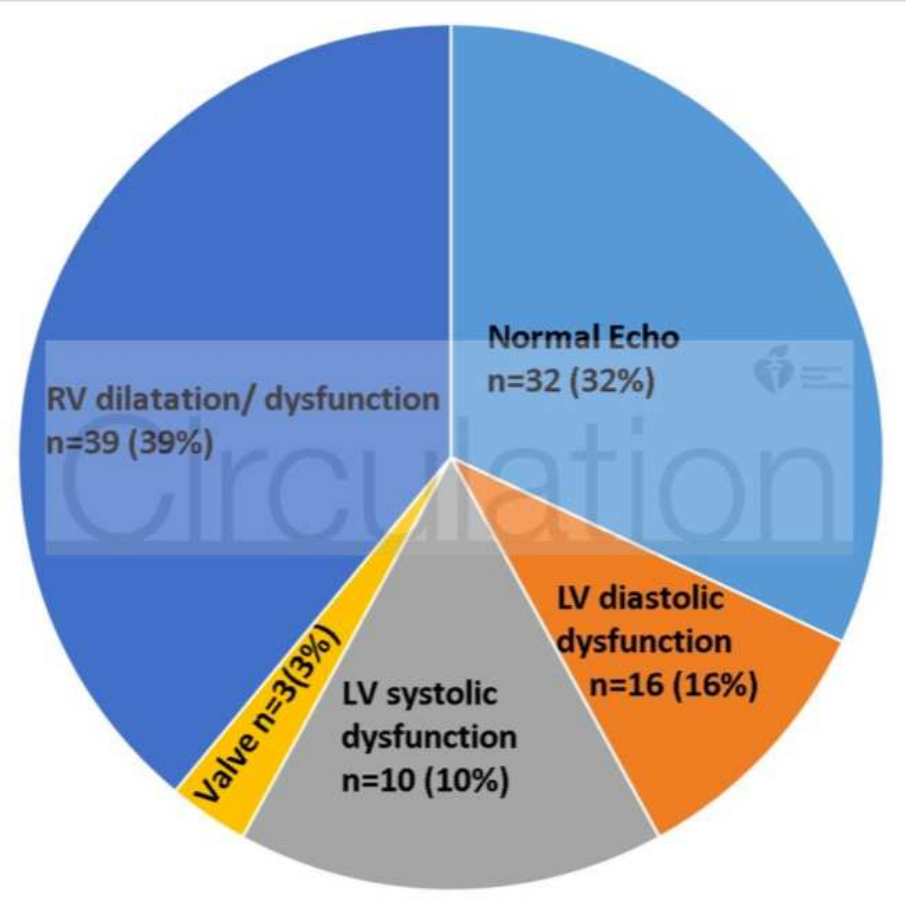

Dynamic guidance
Slide down slowly
COLOR
AutoEF %
2 views recommended
CALCULATE*
Automated ejection fraction calculation
Go to All Views
Parasternal Long-Axis
1 of 10 · Next: PSAX-AV
Ideal image
Quality meter with auto-capture feature
Initial probe placement
12
11
10
Depth
15 cm
Save Best Clip: 76%
Gain
50%
End Exam

65 yo female with hypoxic respiratory failure with RV failure/PH





Echocardiographic Findings in COVID-19



Szekly et al. Circulation 2020

Pulmonary hypertension findings on POCUS

- Although Doppler CW analysis of tricuspid regurgitant jet is most helpful echo technique for detection of pulmonary hypertension, it is difficult to perform on many POCUS machines
- Other qualitative measures include:
  - RV size assessment
    - Is RV > LV in PLAX or 4C views?
    - Does RV overtake the apex?
  - RV structural assessment
    - Is RV D-shaped or show septal flattening in PSAX view?
  - RA size assessment
    - Is RA > LA in 4C view?
  - Is RV free wall thickened?

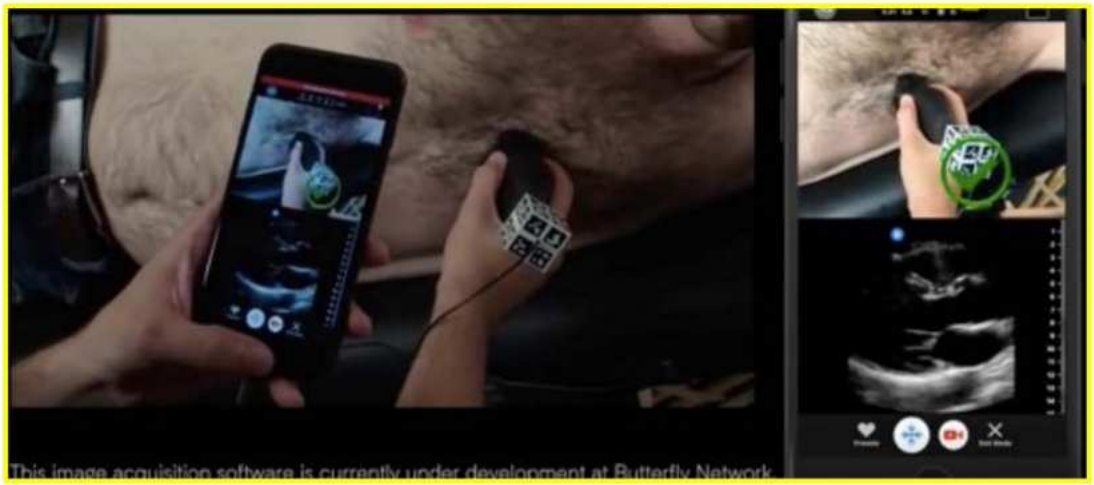
Adapted from: Rudski et al, JASE 2010.

POCUS:
CLOUD-BASED LEARNING, AI & Augmented Reality

- **Lumify: REACTS-** integrated "tele-ultrasound"
- **Butterfly: Augmented Reality Telemedicine Technology "**Tele-Guidance technology"

https://www.usa.philips.com

https://www.youtube.com/watch?v=GpJYzfn1J5Y



www.butterflynetwork.com

https://www.youtube.com/watch?v=dIIOTFyKMVU

Hub and Spoke Model

- **Accelerated Remote Cardiopulmonary Tele-Pocus In COVID-19 Assessment (ARCTICA)**

- Geographically remote regions virtually connected to experts
- Live-streamed images
- Digital rapport creation

PI- A. Johri, Queen's University

Summary and Conclusions

- POCUS may be used in a variety of settings particularly when echo is not readily available
- Best used to make Binary Decisions
- Artificial Intelligence is making POCUS far more accessible to all practitioners

Thank-you