MASSACHUSETTS GENERAL HOSPITAL
HEART CENTER

Echocardiography to Manage Acute Submassive PE

David M. Dudzinski MD, FAHA, FACC, FASE
Tuesday, November 19, 2024

@criticalecho

A Teaching Affiliate of Harvard Medical School

NO DISCLOSURES

MASSACHUSETTS GENERAL HOSPITAL
HEART CENTER

Appropriate Use Criteria from AHA/ACC/ASE

- **Suspected** [acute] PE in order to **establish** diagnosis
- **Known** acute PE to **guide** therapy (eg, thrombectomy and thrombolytics)

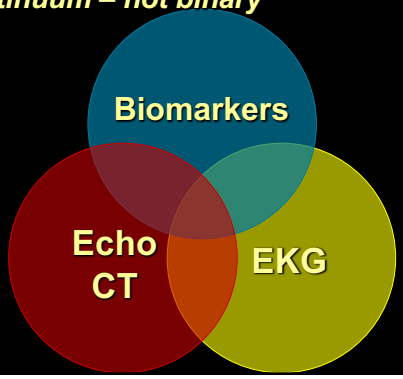
"Rarely appropriate" ***"Appropriate"***

In patients without haemodynamic instability, use of clinical prediction rules integrating PE severity and comorbidity, preferably the PESI or sPESI, should be considered for risk assessment in the acute phase of PE.[178,216,229]	IIa	B
Assessment of the RV by imaging methods[c] or laboratory biomarkers[d] should be considered, even in the presence of a low PESI or a negative sPESI.[229]	IIa	B

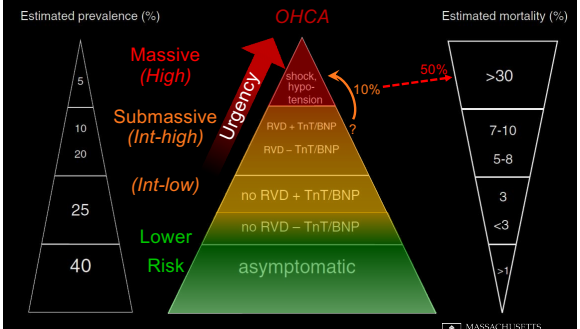
JASE 2011;24:229. *EHJ* 2020;41:543. *JASE* 2023;36:906.
PLoS One 2022;17:e0276202 (multiorgan POCUS, 96% Sp, but 50% Sn)

MASSACHUSETTS GENERAL HOSPITAL
HEART CENTER

- ***Integrative assessment of severity***
- ***Continuum – not binary***



Risk Stratification



Insights Imaging 2011;2:705; *EHJ* 2014;35:3033.
Thromb Haemost. 2008;100:747.
Circulation 2000;101:2817 & 2011;123:1788

MASSACHUSETTS GENERAL HOSPITAL
HEART CENTER

CT in PE Prognosis

- *Size Measures*
  - ✓ RV (RV/LV)
  - ± RA
  - ± IVC
  - ± PA
- *Functional Measures*
  - ? RV systolic function
  - ? Right heart pressures
  - ✗ McConnell sign; Doppler
  - ± Septal geometry

Dudzinski DM, et al. *Acad Emerg Med* 2017;3:337.

MASSACHUSETTS GENERAL HOSPITAL
HEART CENTER

Echo in PE Prognosis ("RVS")

- ***Size Measures***
  - RV (RV/LV)
  - RA
  - IVC
  - PA

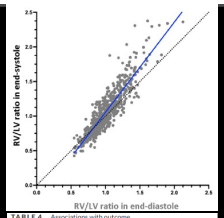


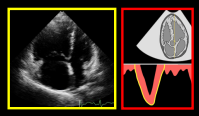
TABLE 4 Associations with outcome.

Variable	Odds ratio	95% CI	p
Primary outcome (univariate)			
RV/LV in diastole	9.31	4.10–21.48	<.0001
RV/LV in systole	3.97	2.29–6.88	<.0001
FAC	.95	.93–.096	<.0001
Primary outcome (multivariate)			
RV/LV in diastole	9.48	4.12–21.65	<.0001
RV/LV in systole	3.88	2.23–6.76	<.0001

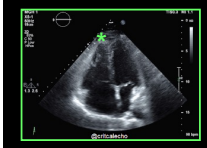
Lyhne MD, Dudzinski DM…Kabrhel C. *Echocardiography* 2023;40:925.

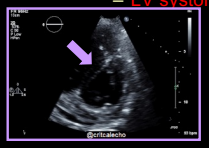
Echo in PE Prognosis ("RVS")

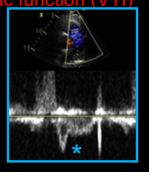
- ***Size Measures***
  - RV (RV/LV)
  - RA
  - IVC
  - PA



- ***Functional Measures***
  - Right heart pressures
  - RV systolic function
  - McConnell sign
  - Septal geometry
  - Pulmonary artery Doppler
  - LV systolic function (VTI)







Bernard S, Dudzinski DM. *JASE* 2019;32:807. *JASE* 2023;36:906 & 933.
Murphy SP, Urbut SA, Dudzinski DM. *JASE* 2023;36:941.

CT v. TTE for Submassive PE

- n=298, age 59 ±17, 49% ♀, 90% White
- 104 had CT and TTE; 14 had composite outcome

	(-) RVS on CT	5 Day Event	(+) RVS on CT	5 Day Event	Subtotal	
(-) RVS on TTE	25 (24%)	4%	37 (36%)	3%	62 (60%)	3%
(+) RVS on TTE	5 (5%)	20%	37 (36%)	30%	42 (40%)	29%
Subtotal	30 (29%)	7%	74 (71%)	16%	104	

Dudzinski DM, et al. *Acad Emerg Med* 2017;3:337.

CT v. TTE for Submassive PE

- n=298, age 59 ±17, 49% ♀, 90% White
- 104 had CT and TTE; 14 had composite outcome

	(-) RVS on CT	5 Day Event	(+) RVS on CT	5 Day Event	Subtotal	
(-) RVS on TTE	25 (24%)	4%	37 (36%)	3%	62 (60%)	3%
(+) RVS on TTE	5 (5%)	20%	37 (36%)	30%	42 (40%)	29%
Subtotal	30 (29%)	7%	74 (71%)	16%	104	

Dudzinski DM, et al. *Acad Emerg Med* 2017;3:337.

CT in PE Prognosis

- *Size Measures*
  - ✓ RV (RV/LV)
  - ± RA
  - ± IVC
  - ± PA
- *Functional Measures*
  - ✗ RV systolic function
  - ± Right heart pressures
  - ✗ McConnell sign; Doppler
  - ± Septal geometry

Among patients with PE and RV strain by CT, positive versus negative TTE predicted 10x greater risk of clinical deterioration.

Dudzinski DM, et al. *Acad Emerg Med* 2017;3:337.

CT v. TTE for Submassive PE *Update*

- **2014-2017, PERT patients, > 64 slice CT**
- n=554 with both CT and TTE

	(-) RVS on CT	(+) RVS on CT	Subtotal
(-) RVS on TTE	9 (2%)	203 (37%) *discordance*	212 (38%)
(+) RVS on TTE	18 (3%)	324 (58%) *concordance*	342 (62%)
Subtotal	27 (5%)	527 (95%)	554

Lyhne MD, Dudzinski DM…Kabrhel C. *Emerg Radiol* 2023;30:325.

CT v. TTE for Submassive PE *Update*

- **2014-2017, PERT patients, > 64 slice CT**
- n=554 with both CT and TTE

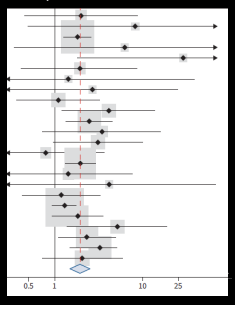
	(-) RVS on CT	(+) RVS on CT	Subtotal
(-) RVS on TTE	9 (2%)	203 (37%) *discordance*	**212 (38%)** Sp 4%
(+) RVS on TTE	18 (3%)	324 (58%) *concordance*	**342 (62%)** Sn 95%
Subtotal	**27 (5%)**	**527 (95%)**	**554**

MASSACHUSETTS GENERAL HOSPITAL HEART CENTER

Lyhne MD, Dudzinski DM...Kabrhel C. *Emerg Radiol* 2023;30:325.

Meta-Analysis of Echocardiographic RV Dysfunction in Normotensive PE

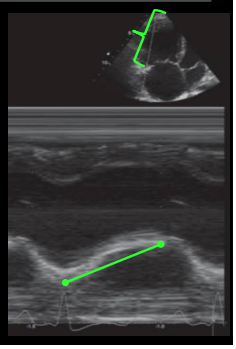
- N=55 (4394 excluded), n=17090, 37.8% RVS
- Odds Ratios:
  - Combined AE 3.29
  - All cause Mortality 2.00
  - PE Mortality 4.01



Eur Resp Rev 2022;31:220120.

Tricuspid Annular Plane Systolic Excursion

- Measure of longitudinal shortening; *assumes*
  - Local ≈ global function
  - Base reflective of free wall and apex (specifically may *not* be true in disease)
- ↓ TAPSE in acute PE but also RVMI, PAH, CTEPH
- Operator/image dependent but has prognostic info



Am J Respir Crit Care Med 2006;174:1034.
J Cardiovasc Ultrasound 2012;20:181.
Eur Respir Rev 2010;19:288.

Echo: TAPSE in Normotensive Submassive PE Patients

- 411 PE pts
  - Age 64 ± 18
  - 58% submass, 41% low risk
  - 2% lytic
- Hours to TTE
  - Admit: 193
  - <24h: 159
  - <72h: 59
- TAPSE ≤ 15
  - 20 % PPV
  - 99 % NPV

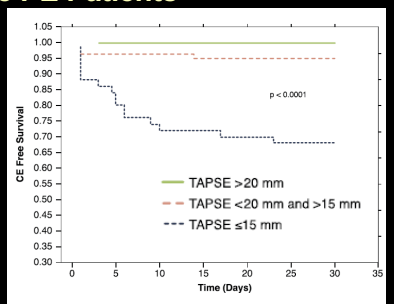
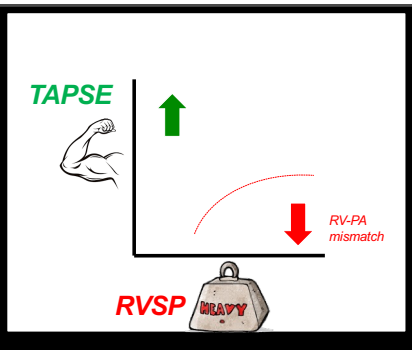


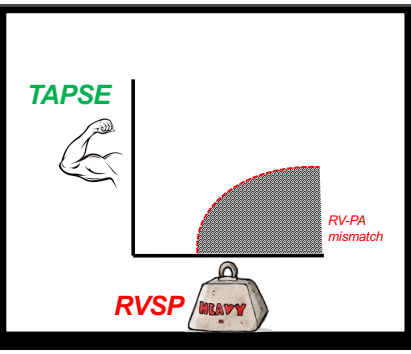
Figure 3. Kaplan-Meier Survival Analysis According to TAPSE in 411 Initially Normotensive Patients With APE

JACC Imaging 2014;7:553

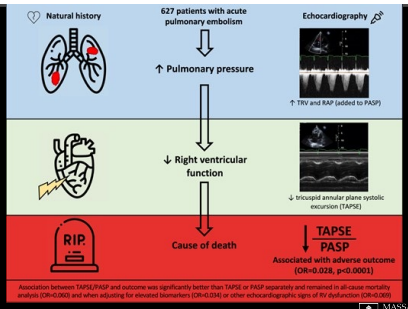
Echo: RV-PA Coupling



Echo: RV-PA Coupling



RV-PA Coupling: TAPSE/PASP Ratio



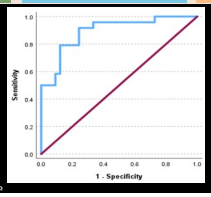
Lyhne M, Kabrhel C…Dudzinski DM. *EHJ: CV Imaging* 2021;22:285. *EHJ Open* 2022;2:oeac007.

MASSACHUSETTS GENERAL HOSPITAL HEART CENTER

Putting it All Together ?

Table 5 Multivariable models relating various clinical and echocardiographic variables to the primary outcome in patients with PE

Models	AUC
Admission TnI + BNP	0.73
Echo RVFWS + RV S' + TAPSE/RVSP	0.769
CT RV/LV + thrombus burden + septal bowing	0.796
CT RV/LV + thrombus burden + RVFWS + RV S'+ TnI + BNP	0.857
CT RV/LV + thrombus burden + RVFWS + RV S'+ TAPSE/RVSP + TnI + BNP	0.893



JASE 2022;36:906.e4 923

MASSACHUSETTS GENERAL HOSPITAL HEART CENTER

Summary: Echo in Submassive PE

- **Prognostics:** ***Echocardiography in PE adds***
  - **↑ Sn for RVS: NPV for adverse events**
  - **↑↑ Sp for RVS: PPV to appropriately target invasive interventions prospectively (risk-benefit calculations)**
    - You need echocardiography if possibly considering an intervention .
    - ***which means most intermediate-high risk PE***
- Remember, Echocardiography also:
  - Informs differential (cancer, RVMI, shunting) and chronicity
  - Establishes baseline (to assess impact of intervention)
  - Assists with procedural planning and guidance (chamber size/navigation, anatomy, clot-in-transit)
  - Help if need to consider MCS

MASSACHUSETTS GENERAL HOSPITAL HEART CENTER

MASSACHUSETTS GENERAL HOSPITAL HEART CENTER

Echocardiography to Manage Acute Submassive PE

David M. Dudzinski MD, FAHA, FACC, FASE
@criticalecho

A Teaching Affiliate of Harvard Medical School