

ATRIAL MEASUREMENTS:

CAN THEY PREDICT ADVERSE EVENTS IN PATIENTS WITH ACUTE PE?

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Disclosures

None

Background: Existing data

- **Reduced left atrial volume (<62 mls) and increased atrial volume ratio (>1.2)** is associated with a significantly higher 30-day all-cause mortality⁽¹⁾
- **Increased risk of adverse events** (30-day PE-related mortality or the need for advanced therapy) when there is evidence of right heart strain on **ECHO, ECG and CTA** together⁽²⁾
- **Septal bowing** and increasing **pulmonary artery diameter** are associated with **5-day adverse outcomes** (all-cause mortality, acute decompensation, or need for emergent treatment)⁽³⁾

¹. G Aviram *et al* (2016); ². B Carroll *et al* (2018); ³. M Lyhne *et al* (2019)

Aims

- Determine **which atrial measurement(s)** (volume, area, diameter) is/are associated with **30-day PE-related adverse events** in patients with acute PE
- Determine **if any atrial measurement(s)** is/are a better predictor of **30-day PE-related adverse events** compared to the combination of ECHO, ECG, and CTA
- Determine whether increasing **pulmonary artery diameter , septal bowing, or reflux of contrast into the IVC** are associated with **30-day PE-related adverse events**

Methods

501 patients diagnosed with acute PE between 2007 – 2014

1. Clinical records:

- Adverse events recorded: 30-day PE-related mortality or the need for advanced therapy i.e. thrombolysis, thrombectomy, vasopressors

2. Tests:

- Tricuspid annular plane systolic excursion (TAPSE) measurement from the echo report
 - performed 24hrs before or 48hrs after the diagnostic CT scan
 - classed as abnormal if $<16\text{mm}$
- ECG result recorded where available

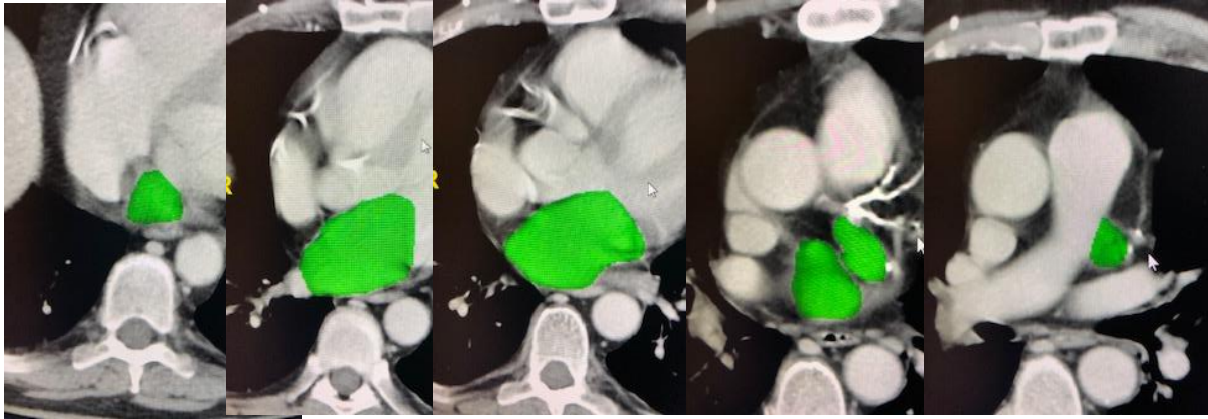
Methods

3. CT measurements (Gated and non-gated chest CTAs) using TeraRecon:

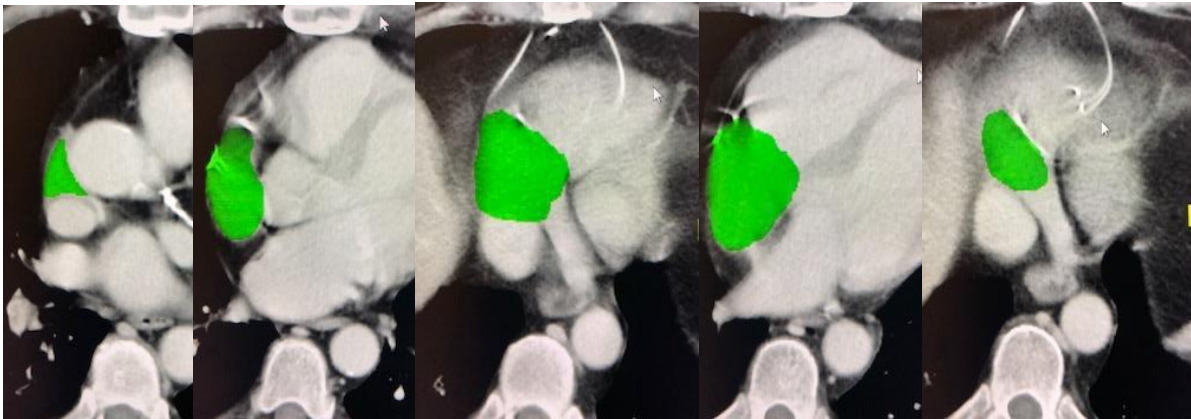
- Right and left atrial volume, area, and diameters
- Main PA diameter
- Ascending aorta diameter
- RV/LV diameter ratio
- Ventricular septal bowing
- Reflux of contrast into the IVC (into hepatic veins)

Methods: Atrial Volume

Left atrium (including appendage):



Right atrium (including appendage):



Measurements

Left atrial volume

Right atrial volume

RA/LA volume ratio

Left atrial area

Right atrial area

RA/LA area ratio

Left atrial short-axis diameter

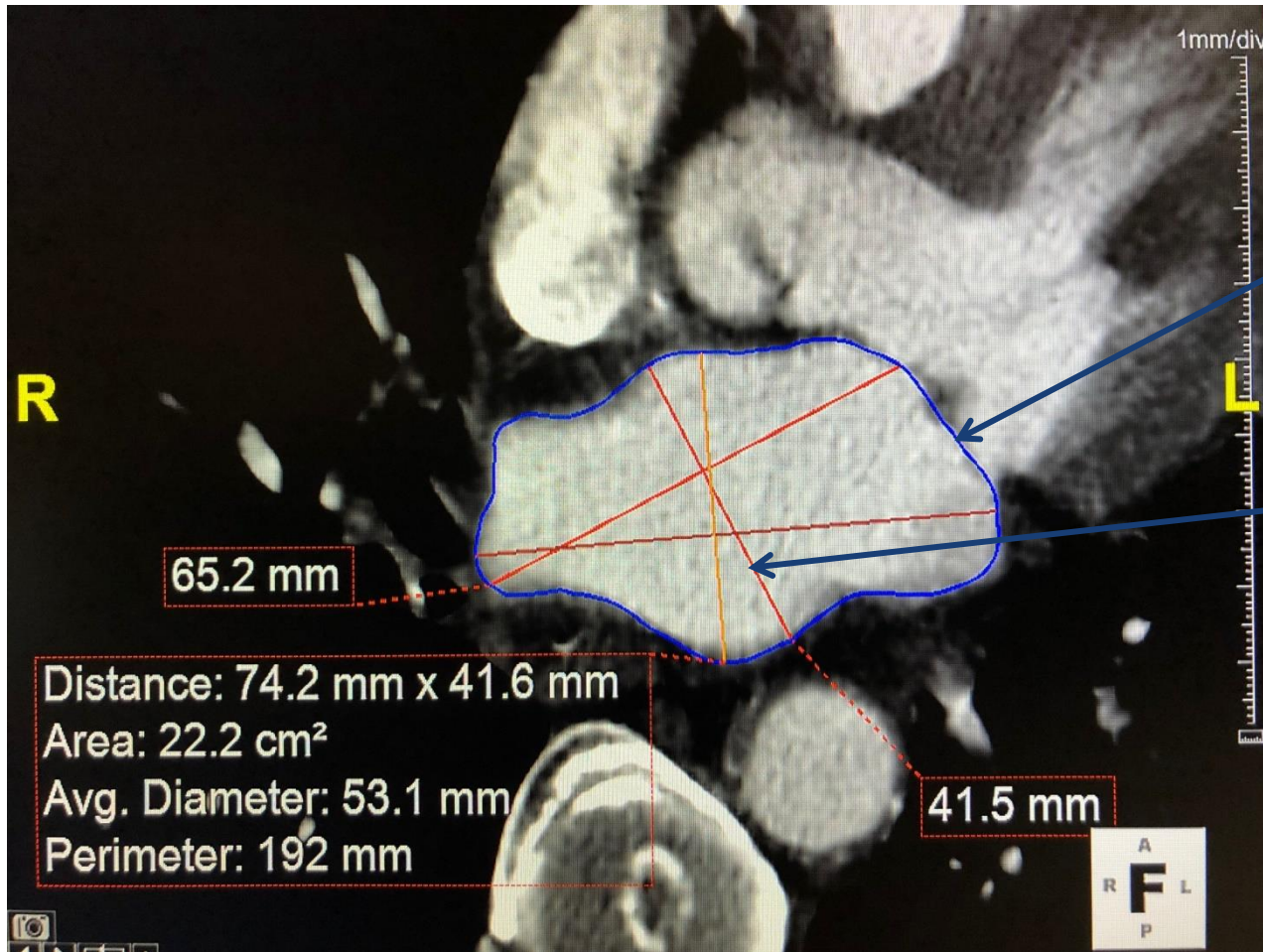
Right atrial short-axis diameter

RA/LA short-axis diameter ratio

PA diameter

RV/LV diameter ratio

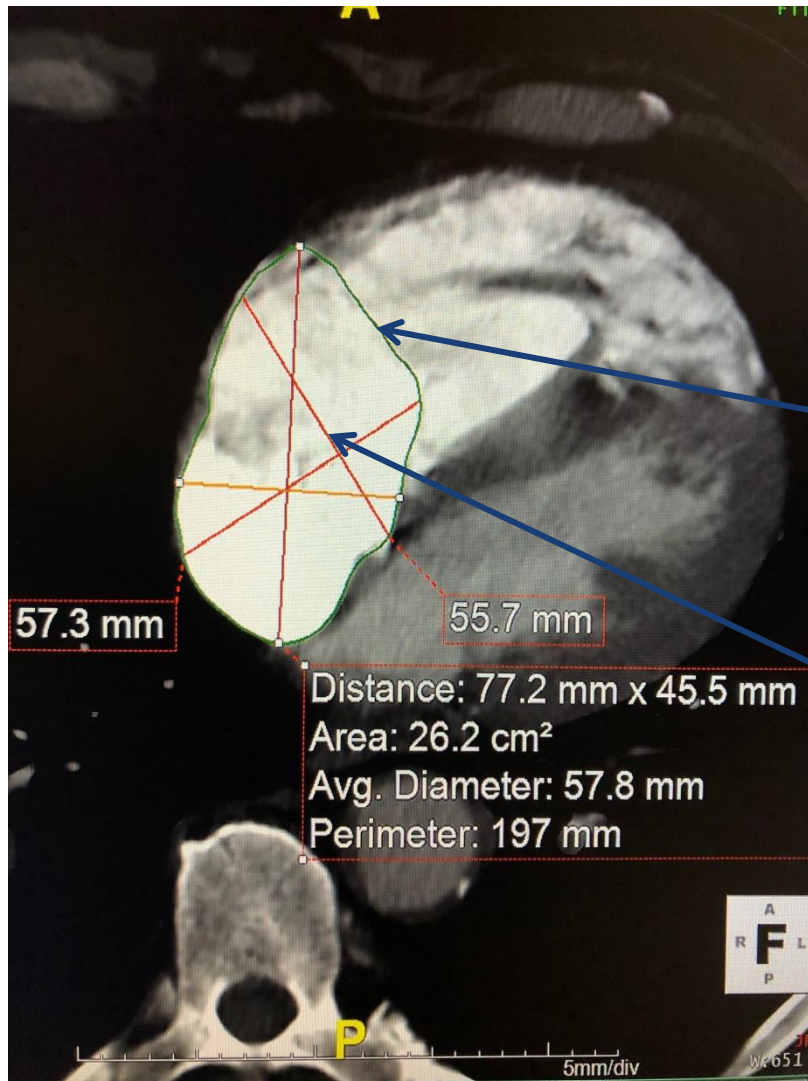
Methods: Left atrial area and diameter



Measurements

Left atrial volume
Right atrial volume
RA/LA volume ratio
Left atrial area
Right atrial area
RA/LA area ratio
Left atrial short-axis diameter
Right atrial short-axis diameter
RA/LA short-axis diameter ratio
PA diameter
RV/LV diameter ratio

Methods: Right atrial area and diameter



Measurements

Left atrial volume

Right atrial volume

RA/LA volume ratio

Left atrial area

Right atrial area

RA/LA area ratio

Left atrial short-axis diameter

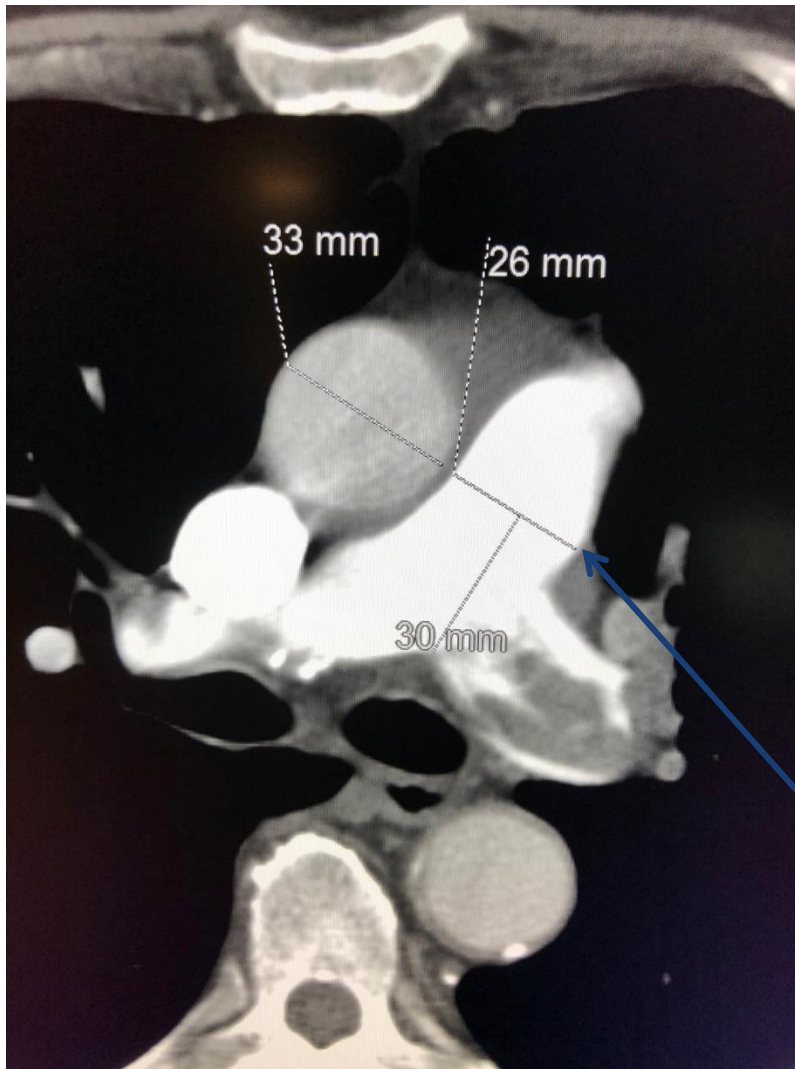
Right atrial short-axis diameter

RA/LA short-axis diameter ratio

PA diameter

RV/LV diameter ratio

Methods: Pulmonary artery



Measurements

Left atrial volume

Right atrial volume

RA/LA volume ratio

Left atrial area

Right atrial area

RA/LA area ratio

Left atrial short-axis diameter

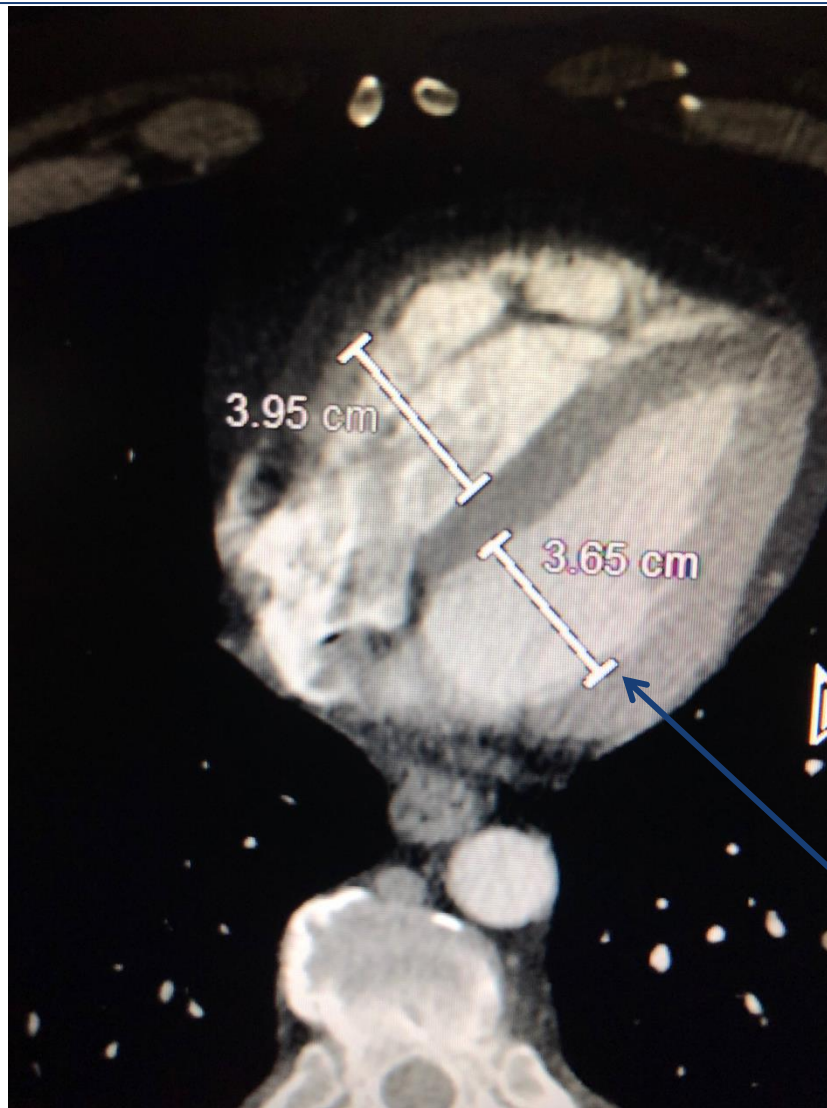
Right atrial short-axis diameter

RA/LA short-axis diameter ratio

PA diameter

RV/LV diameter ratio

Methods: Ventricular diameters



Measurements

Left atrial volume

Right atrial volume

RA/LA volume ratio

Left atrial area

Right atrial area

RA/LA area ratio

Left atrial short-axis
diameter

Right atrial short-axis
diameter

RA/LA short-axis
diameter ratio

PA diameter

RV/LV diameter ratio

Statistical Analysis

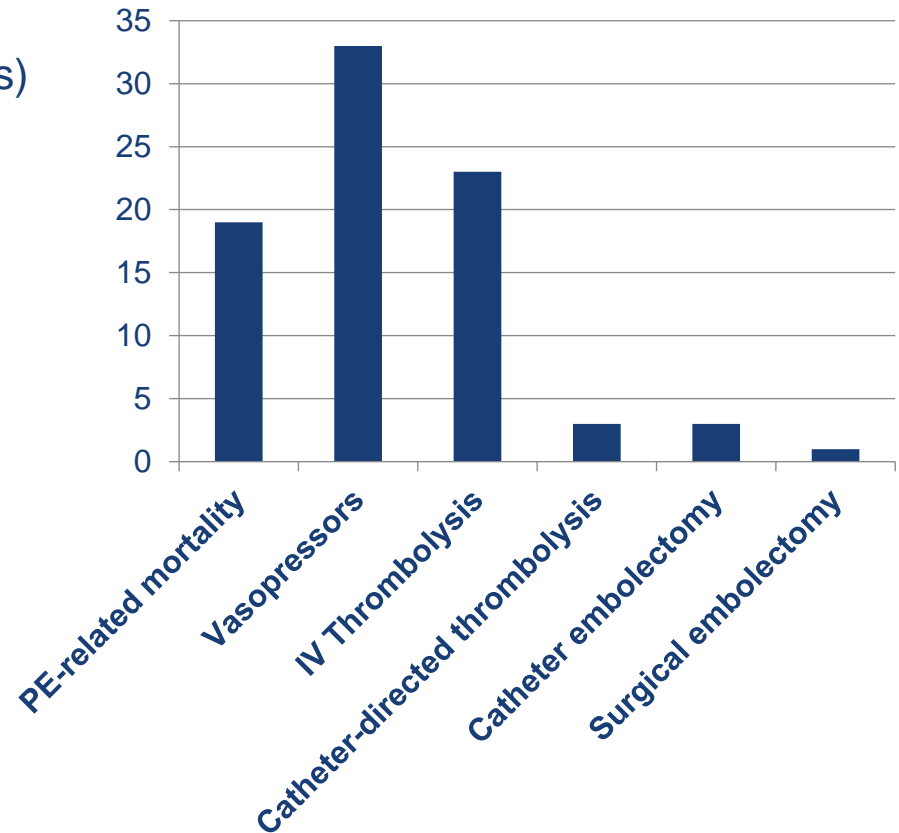
- Comparison of subsets (with and without adverse events) was done using **Mann-Whitney U** and **Chi-squared tests**
- Prediction analysis was done by calculating the **area under the curve (AUC)** for receiver operating characteristic (ROC) curves, and **Delong's test** was used to compare AUC for paired ROC curves
- **Multivariate logistic regression** was performed to determine the best predictors of adverse outcomes

Results

Demographics

- N = 493 pts
(8 excluded - incomplete/unavailable images)
- Adverse events = 62/493 pts (12.6%)
- Mean age = 63±16 years (p=0.2)
- Male 48%; Female 52% (p=0.6)

Number of patients with 30-day adverse events

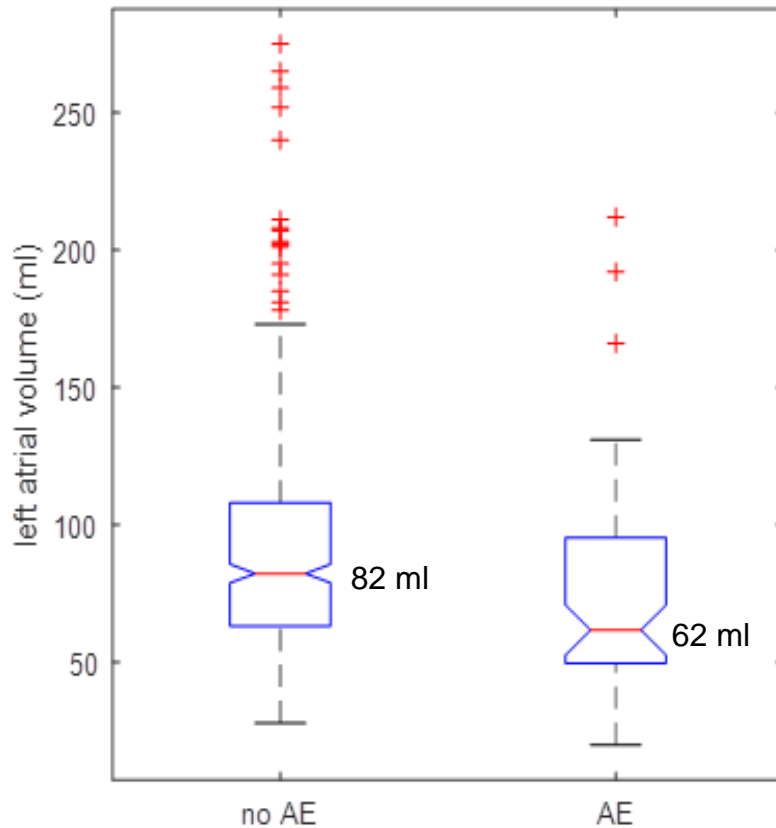


Results: Association between measurements and adverse events

Measurements	No Adverse Event (Median)	Adverse Event (Median)	p-value
Left atrial volume	82 mls	62 mls	<0.001
RA/LA volume ratio	1.15	1.46	<0.001
Left atrial area	21 cm ²	18 cm ²	0.001
RA/LA area ratio	1.19	1.45	<0.001
Left atrial short-axis diameter	42 mm	37 mm	0.001
RA/LA short-axis diameter ratio	1.41	1.62	<0.001
RV/LV diameter ratio	1.0	1.21	<0.001

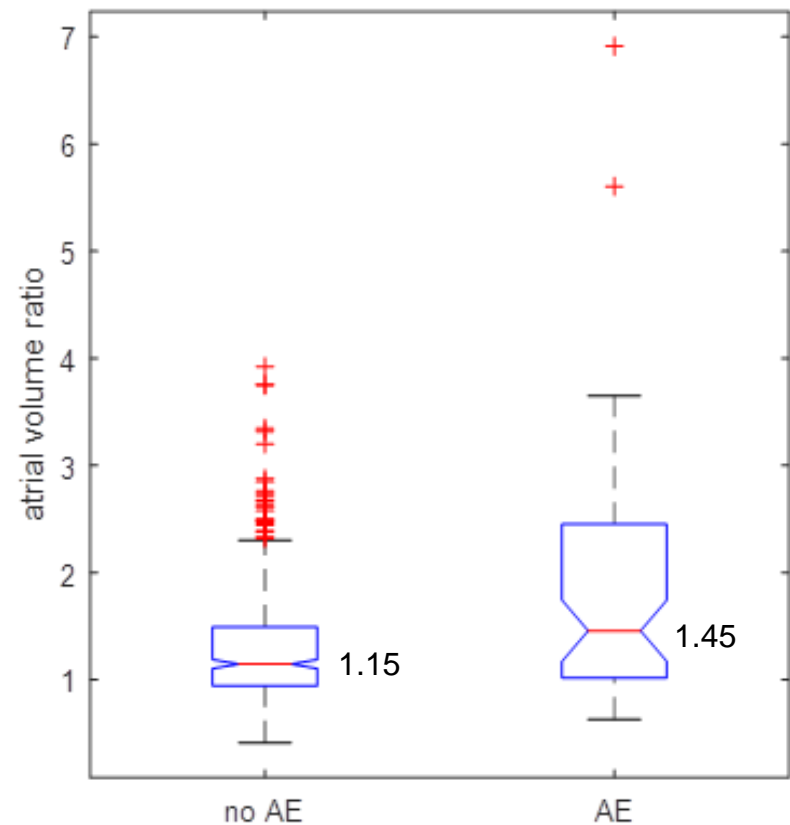
Results: Left atrial volume

LA volume in patients with and without adverse events (AE)



$P < 0.001$

RA/LA volume ratio in patients with and without adverse events (AE)



$P < 0.001$

Results: Association between measurements and adverse events

Measurements	No Adverse Event Median (N = 431)	Adverse Event Median (N = 62)	P-value
TAPSE	18 mm	14.5 mm	<0.001
PA diameter	30 mm	30 mm	0.88

Measurements	No Adverse Event (% of group)	Adverse Event (% of group)	P-value
ECG	40%	55%	0.02
Septal Bowing	3%	10%	0.01
Reflux of contrast into IVC	26%	50%	<0.001

Results: Prediction of adverse events

Measurements	AUC
Left atrial volume	0.67
TAPSE+ECG+(RV/LV)	0.71

No sig difference between them ($P>0.07$)

Limitations

- **Retrospective study**
- **Selection bias:**
 - Acute PE only
 - Original database only included patients with an echo performed
- Slightly **limited precision** of measurements due to:
 - Motion artefact
 - Varying quality of contrast opacification in atria
 - Streak artefact from contrast/lines in the right atrium
- Mostly **Non-ECG gated** studies therefore unable to account for systole/diastole

Conclusions

- **LA measurements** are associated with 30-day PE-related adverse events in patients with acute PE
- **LA volume** is an equivalent predictor of 30-day PE-related adverse events compared to the combination of modalities (TAPSE, ECG, and RV/LV diameter ratio)
- **Reflux of contrast into the IVC** and **septal bowing** are associated with 30-day PE-related adverse events, however **PA diameter** is not

Ongoing and Future Work

- Assess **inter-rater variability** with a randomly selected subset
- Assess the association of atrial measurements with **90-day and 1-year mortality**
- Repeat the measurements using the same **automatic software** as Aviram *et al* (2016) for our cohort to see if our results are reproducible

References

Carroll, B. J., Heidinger, B. H., Dabreo, D. C., Matos, J. D., Mohebali, D., Feldman, S. A., McCormick, I., Litmanovich, D., Manning, W. J. (2018). Multimodality Assessment of Right Ventricular Strain in Patients With Acute Pulmonary Embolism. *American Journal of Cardiology*, 122(1), 175–181.

Galit Aviram, MD; Eugene Soikher, MD; Achiude Bendet, MD; Hezzy Shmueli, MD; Tomer Ziv-Baran, P., & Yoav Amitai, MD; Limor Friedensohn, MD; Shlomo Berliner, MD, PhD; Ahuava Meilik, PhD; and Yan Topilsky, M. (2016). Prediction of Mortality in Pulmonary Embolism Based on Left Atrial Volume Measured on CT Pulmonary Angiography. *Chest*, 149(3), 667–675.

Lyhne, MD., Schultz, JG., MacMahon, PJ., Haddad, F., Kalra, M., Tso, DM., Muzikansky, A., Lev, MH., Kabrhel, C. (2019). Septal bowing and pulmonary artery diameter on computed tomography pulmonary angiography are associated with short-term outcomes in patients with acute pulmonary embolism. *Emergency Radiology*. <https://doi.org/10.1007/s10140-019-01709-9>

Aujesky, D., Hughes, R., Jimenez, D. (2009). Short-term prognosis of pulmonary embolism. *Journal of Thrombosis and Haemostasis*. 7 (suppl. 1):318-21

Schmid, E., Hilberath, JN., Blumenstock, G., Shekar, P., Kling, S., Sherman, SK., Rosenberger, P., Nowak-Machen, M. (2015). Tricuspid annular plane systolic excursion (TAPSE) predicts poor outcome in patients undergoing acute pulmonary embolectomy. *Heart Lung Vessel*. 7(2): 151–158.

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