Assimilated LVEF: Combining Human Intuition with Machine Measurement for Sharper Estimates of Left Ventricular Ejection Fraction and Stronger Association With Outcomes

T McAndrew, B Redfors, A Crowley, Y Zhang, MC Alu, MT Finn, A Furer, S Chen, G Ong, D Burkhoff, O Ben-Yehuda, WA Jaber, RT Hahn, MB Leon

The PARTNER Publications Office

On behalf of the PARTNER II Investigators and PARTNER Publications Office

The PARTNER II Trial

Background

- Variability in the measurement of left ventricular ejection fraction (LVEF) can complicate the reproducibility of statistical finding between clinical trials
- Measurement error can also lead to the misclassification of patients, resulting in suboptimal treatment decisions, and obscuring correlations with clinical outcomes.
- We propose a method to reduce measurement variability and improve reproducibility by fusing cardiologists' visual estimates with Simpson's biplane method

Methods

- Study Population: 1366 patients with severe symptomatic aortic stenosis enrolled in the PARTNER 2A Trial (Tb1.)
- A single echocardiographic core laboratory (C5 Research, Cleveland, OH) assessed LVEF by both Simpson's biplane method and visual estimation techniques
- For each patient, we combined the visual estimate (18.1% std.) with Simpson's biplane calculation (8.1% std.) creating a more precise EF estimate (Fig1.)
- We include LVEF uncertainty in our statistical models by
  - Sampling from each pt's LVEF distribution
  - Running a statistical model
  - Compiling the results
- The assimilated LVEF was tested in KM and Cox proportional hazards models, and compared to visual estimates and Simpson's method alone. (Fig2. & Fig3.)

Results

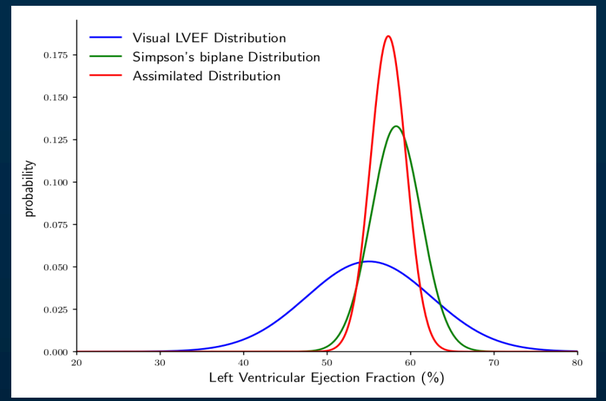


Fig1: Example combining visual and Simpson's biplane estimates. The assimilated LVEF takes advantage of Simpson's biplane accuracy and the echocardiographer's visual expertise.

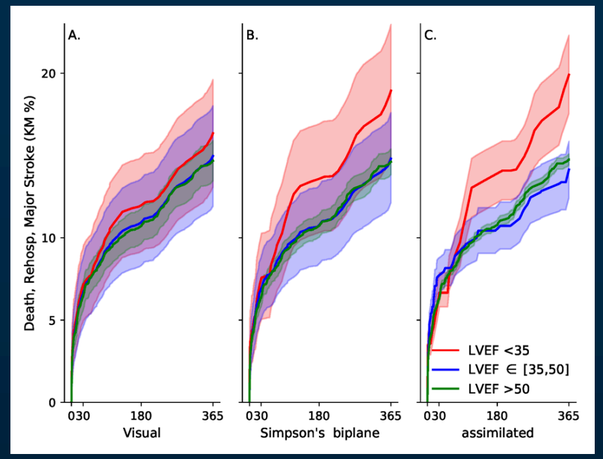
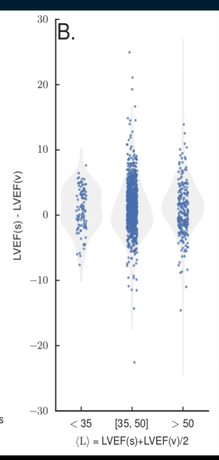


Fig2: Kaplan Meier estimates of 1yr Death, Rehospitilization, and Major stroke for visual LVEF, Simpson's biplane LVEF, and assimilated LVEF

F

A.	P2A
Number of patients analyzed*	(1366/2029)
Population characteristics	
Age (yrs)	82.14 (6.38)
BMI (kg/m^2)	27.60 (5.54)
BSA (m^2)	1.85 (0.23)
Diabetes	33.88 (453/1337)
Prior CABG	21.62 (289/1337)
Prior PCI	26.40 (353/1337)
Echocardiography	
LVEF	55.78 (11.37)
Visual (p)	54.45 (10.84)
Simpson's bi-plane (p)	55.78 (11.37)
Cardiac Output (L/min)	3.65 (1.16)
Stroke Volume (mL)	29.90 (8.34)
Heart Rate (bpm)	71.46 (12.57)
LV Mass index (g/m^2)	120.53 (32.89)
LAV Index*** (mL/m^2)	40.96 (13.38)
E/e' Medial	21.02 (9.82)
LV End Systolic Volume (mL)	48.41 (29.92)
LV End Diastolic Volume (mL)	103.89 (39.67)
LVOT Peak Velocity (cm/s)	93.47 (19.48)
Aortic Annulus Diameter (cm)	3.26 (0.39)
Mean Gradient (mmHg)	45.29 (12.87)
Aortic Valve Area (cm^2)	0.69 (0.18)

* We study patients with visual LVEF and Simpson's bi-plane LVEF measurements
** Left Ventricular Outflow Tract
*** Left Atrium Volume Index



Tb1:1366 PARTNER 2A patients with both visual and Simpson's biplane estimate, and the per-patient difference between visual and Simpson's biplane estimates

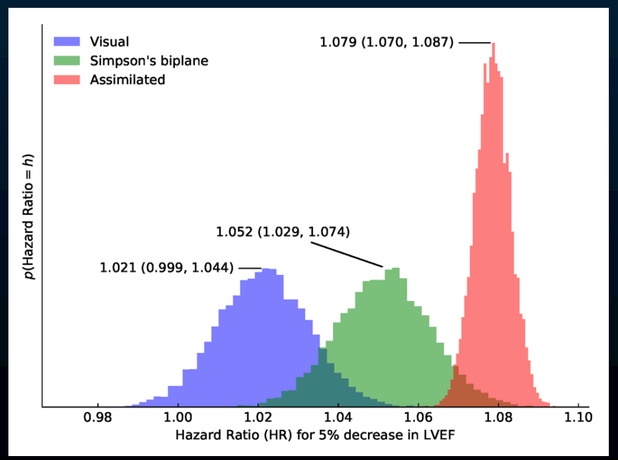


Fig3: Cox proportional hazards models for visual, Simpspon's biplane, and assimilated LVEF.

Conclusions & Clinical Implications

- Combining visual estimates and a machine guided LVEF (Simpson's biplane), we reduce reproducibility errors in LVEF measurement and improve the association between LVEF and a composite of death, stroke, and rehospitalization at 1 year.
- The assimilated LVEF directly incorporates expert echocardiographic expertise into statistical models.
- This assimilated LVEF may prove useful in the presence of poor echocardiographic images, where the cardiologist's visual estimate can more accurately judge LVEF.
- More work is needed to understand the uncertainty associated with visual estimation of LVEF and Simpson's biplane LVEF
- This study highlights the important role variability plays in reproducible research
- While human expertise and intuition can influence statistical models, future work will explore the the alternating influence between models and humans

Disclosures

Dr. McAndrew has nothing to disclose. Drs. Jaber and Hahn have echocardiographic core lab contracts with Edwards Lifesciences related to the PARTNER 2 Trial, from which they receive no direct compensation. Dr. Leon is a member of the PARTNER Trial Executive Committee, for which he receives no direct compensation. The other authors have nothing to disclose