

Performance and Interoperability of a Vectorcardiogram Deep Learning Algorithm to Detect Atrial Flutter Compared to Electrocardiogram Analysis By Electrophysiologists

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HEART RHYTHM

BRINGING THE WORLD OF EP TOGETHER

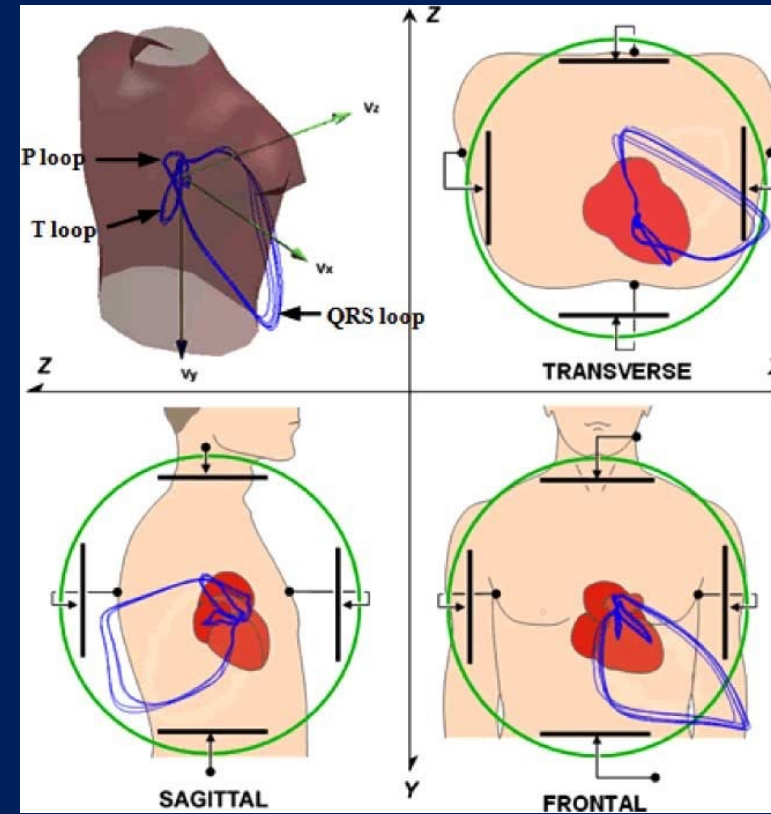
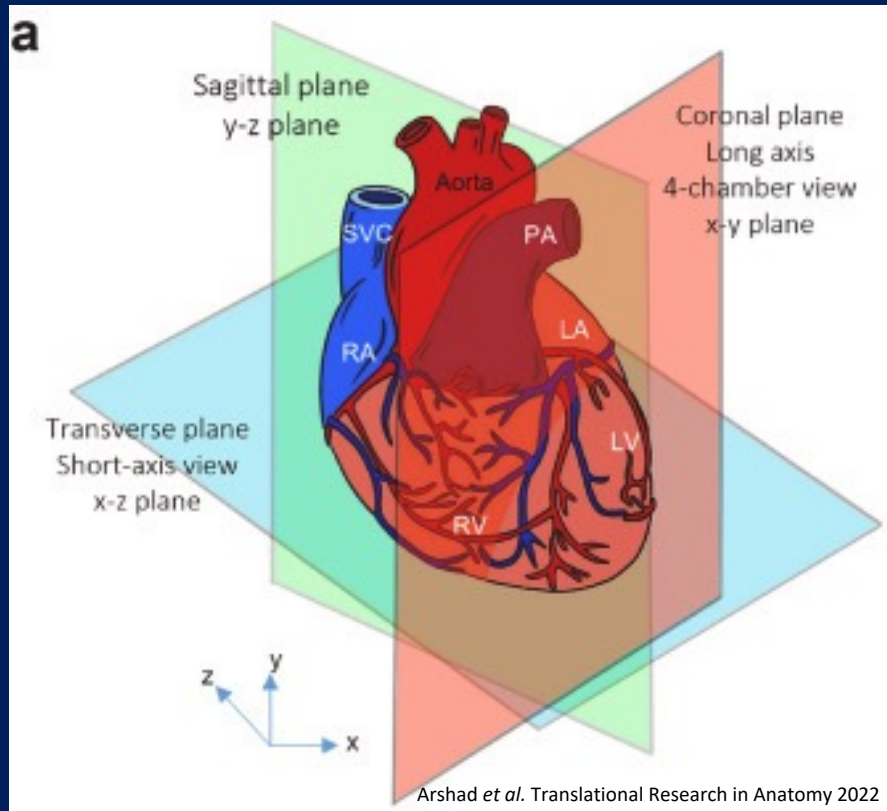
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Background



- VCG represents instantaneous changes in direction and magnitude of electrical activity in 3 planes
- Acquired directly or transformed from 12-lead ECG

Background: Back to the Future

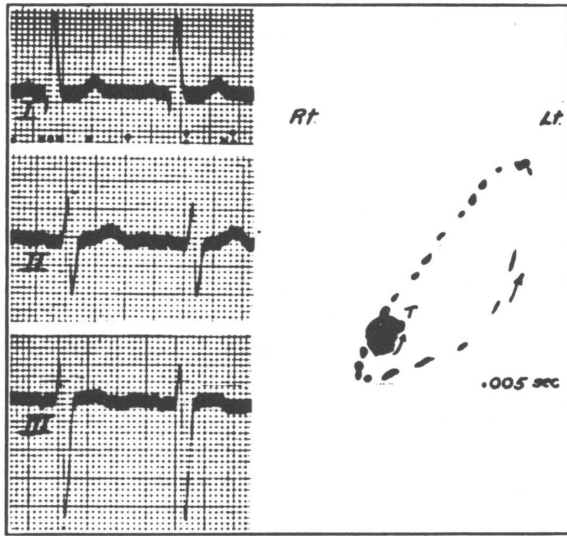


Figure 19. Actual recordings of the electrocardiogram and vectorcardiogram reported by Wilson and Johnston. These apparently are the same tracings as those shown diagrammatically in figure 18. (From Frank N. Wilson and Franklin D. Johnston, *Am. Heart J.*, 1938, 16: 14-28.)

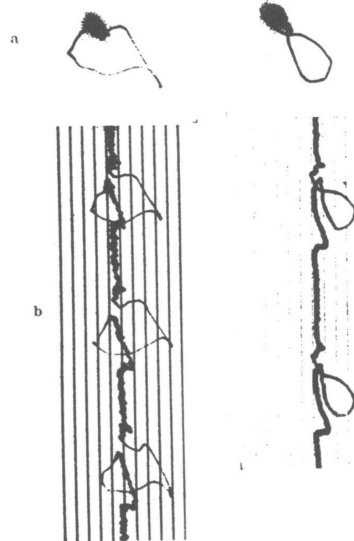


Figure 22. The "scroll" (continuous vectorcardiogram) as recorded first by Hollmann and Hollmann using the cathode ray oscilloscope. Mann had also recorded the "scroll" by 1938 using his mirror-type vectorcardiograph. (From H.E. Hollmann and W. Hollmann, *Zt. klin. Med.*, 1938, 154: 732-753.)

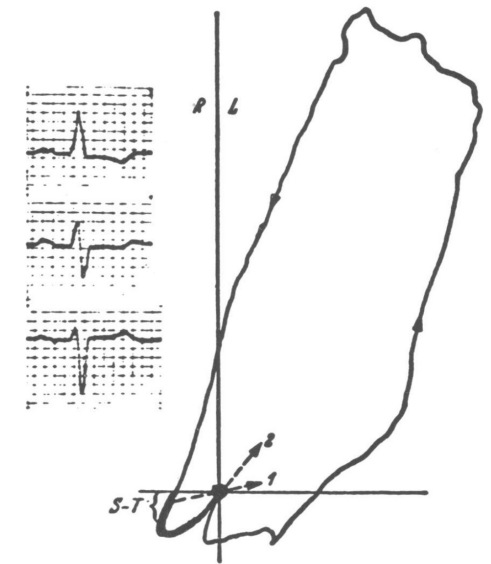


Figure 23. The vectorcardiogram of a patient with left ventricular hypertrophy reported by Schellong in 1936. (From F. Schellong, *Verhandl. Dt. Gesell. inn. Med.*, 1936, 48: 288-310.)

- VCG is not new
- Early recordings derived from bipolar leads I, II, III
- Relegated to research applications in favor of ECG for clinical use
- Resurgence of interest with novel acquisition technologies

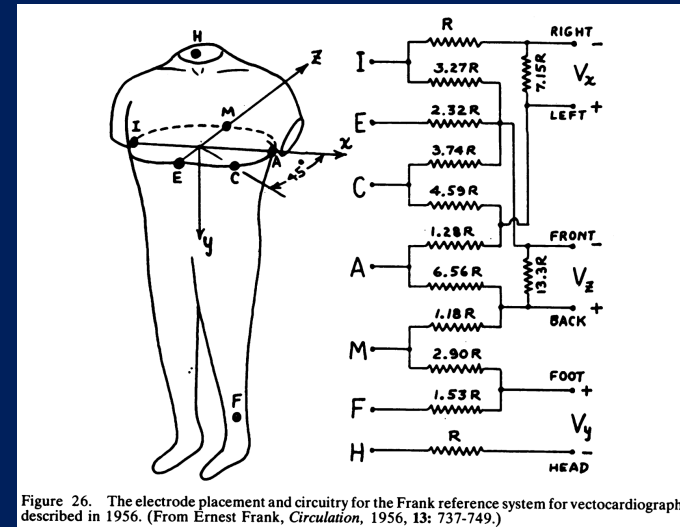
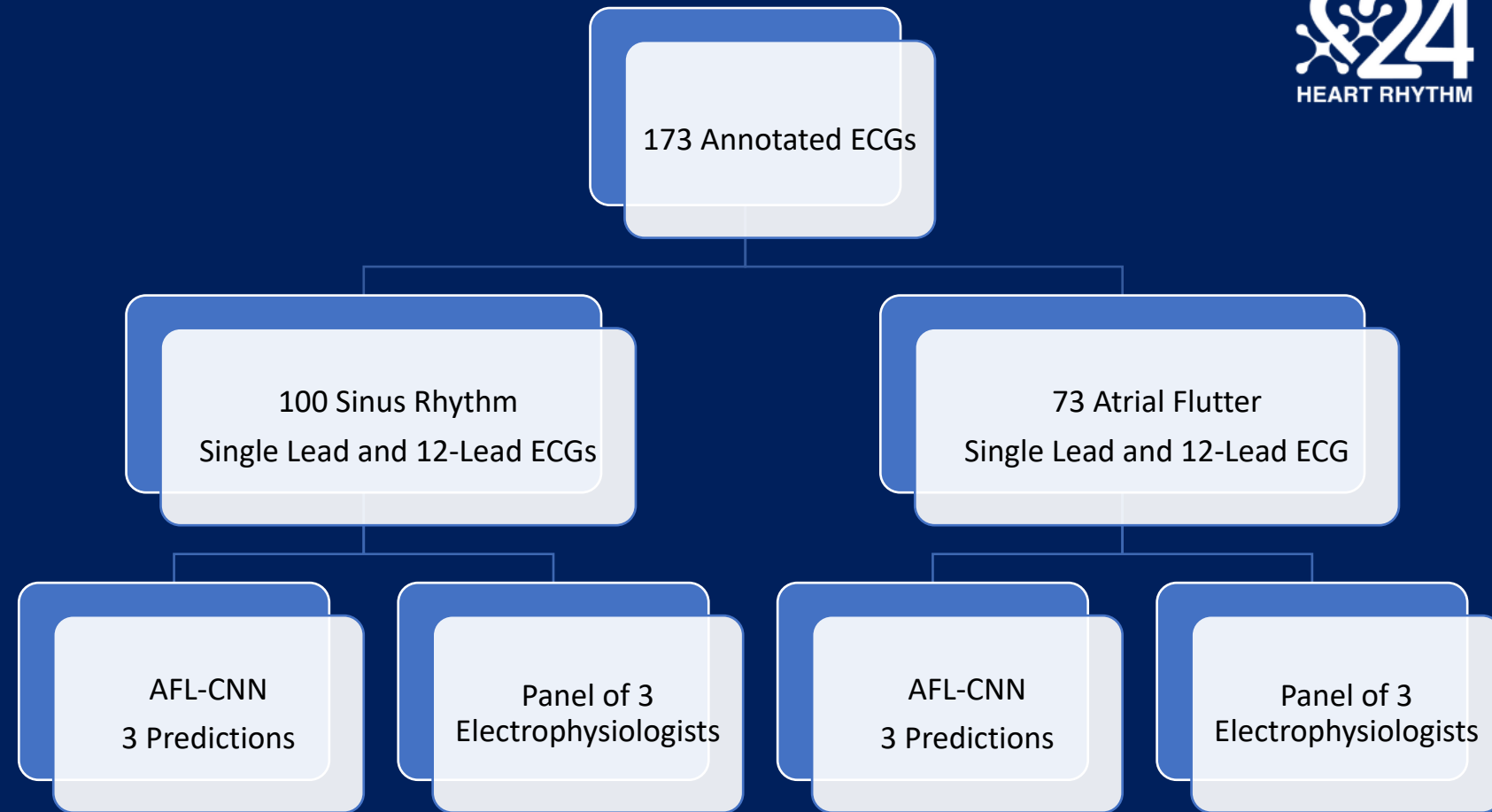


Figure 26. The electrode placement and circuitry for the Frank reference system for vectocardiography described in 1956. (From Ernest Frank, *Circulation*, 1956, 13: 737-749.)

Methods

- CNN developed on 6,000 ECGs with 2,000 each of AF/AFL/Sinus
- External validation on database of 2,238 ECGs
- Training included 12-Lead ECG, Lead I, and VCG
- VCG: Kors Transformation



- Kappa statistic to evaluate interobserver variability in classifying ECG as AFL or Sinus Rhythm

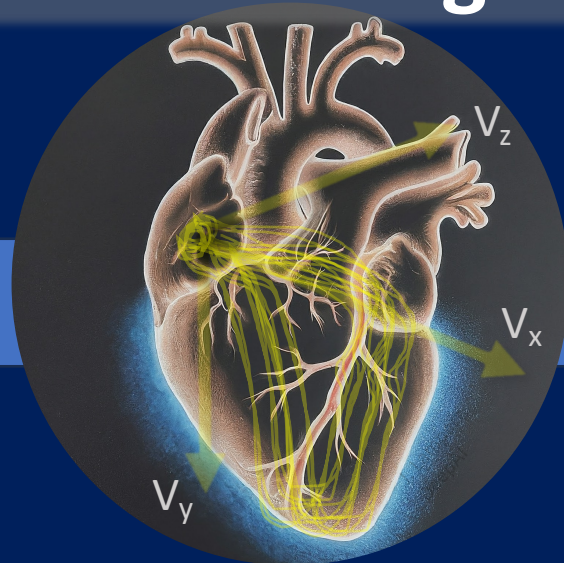
Single Lead ECG

Vectorcardiogram

12 Lead ECG



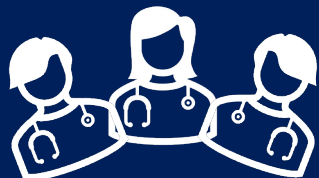
Lead I from
12-Lead ECG



Kors
Transformation



Kappa= 1.0



Kappa= 0.586



Kappa= 1.0



Kappa= 1.0



Kappa= 0.799

	AFL-CNN	EP Panel
Sens	94.1% (90.2-97.5)	69.4% (66.1-72.6)
Spec	98.0% (96.4-99.1)	92.9% (91.9-93.9)
PPV	98.5% (96.5-1.00)	98.7% (97.6-99.5)
NPV	96.9% (94.6-98.6)	91.8% (90.8-92.8)
F1	96.2% (93.6-98.4)	77.8% (74.2-80.9)

	AFL-CNN
Sens	97.3% (94.4-99.4)
Spec	99.2% (98.5-99.8)
PPV	100% (100.0-100.0)
NPV	98.7% (97.5-99.7)
F1	98.6% (97.0-99.7)

	AFL-CNN	EP Panel
Sens	97.2% (94.3-99.3)	91.1% (88.4-93.6)
Spec	99.2% (98.4-99.8)	98.0% (97.4-98.6)
PPV	100% (100.0-100.0)	99.8 (99.5-100.0)
NPV	98.7% (97.5-99.7)	96.9% (96.0-97.7)
F1	98.5% (97.0-99.7)	95.1% (93.3-96.5)

Conclusions

- AFL-CNN applied to the VCG performed comparably as well to the AFL-CNN as applied to the gold-standard 12-lead ECG for discrimination of AFL from sinus rhythm.
- AFL-CNN outperformed electrophysiologists in AFL diagnosis
- There was notable variability in electrophysiologist agreement on whether atrial flutter was present
 - a discrepancy more pronounced on single-lead ECG analysis
- AFL-CNN had perfect agreement with repeated applications in rhythm classification of atrial flutter
- Further investigation is needed to assess applications to both directly acquired VCGs and to disease states beyond atrial arrhythmias



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Thank You



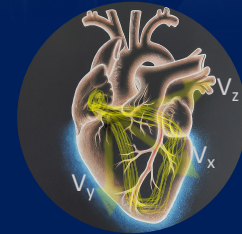
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