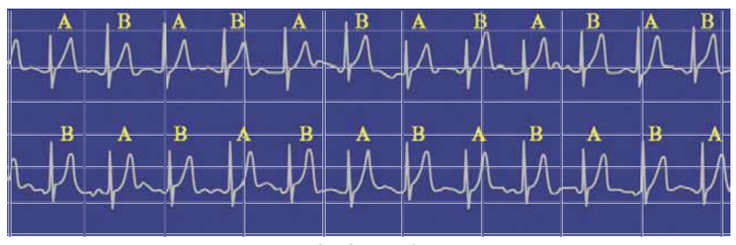
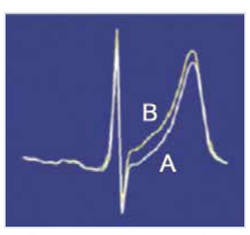
Recognition and quantification of T-Wave Alternans (TWA)

Risk stratification for Sudden Cardiac Death (SCD)

Definition of TWA



Rhythm Strip



Superimposed Beats

Definition: Repeating ABAB pattern in amplitude and shape of ST segment and T wave.

The TWA level shown in the QRS-aligned template (as left) is 124 microvolts. The recording is from a FINCAVAS patient who died of cardiovascular causes at ~ 1 year.

From: Minkkinen et al JCE 2009;20:408.

About T-Wave Alternans

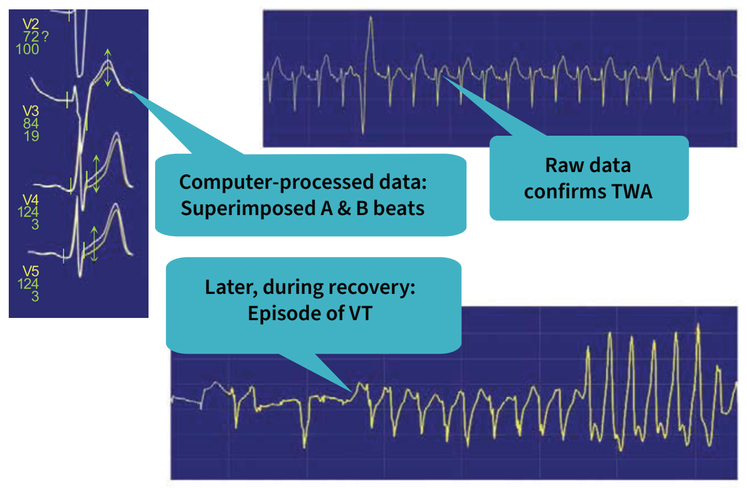
T-Wave Alternans (TWA) is an electrophysiological phenomenon that is evident in the ECG as an alternating pattern of ST/T-Wave morphologies on successive beats. Although the alternation can be present in both the ST segment and T-Wave, the entire pattern is simply referred to as TWA.

The Modified Moving Average T-Wave Alternan (TWA) algorithm measures and quantifies the alternations on beat-to-beat patterns, precisely detecting fluctuations in the ECG waveform. TWA enables physicians to identify an often-missed pattern variation that may indicate a high level of SCD risk and helps support earlier treatment decisions.

Performing a TWA test is useful for patients who have had an MI, family history of MI and/or SCD, on beta-blockers, using an antiarrhythmic drug, or will be using an antiarrhythmic drug. Not recommended for patients with atrial fibrillation.

Source:
T-Wave Alternans Physician's Guide, 2020044-067 Revision C,
© 2008–2009 General Electric Company.

TWA preceding VT During exercise test



Acquiring and processing the ECG signal

Test protocol and setup

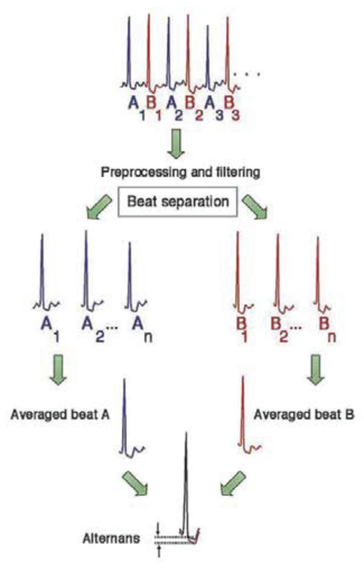
- T-Wave Alternans can be collected during a standard Holter or ECG exercise stress test.
- Use standard electrodes. See Skin Preparation and Electrode Placement, right.
- Maintain usual medications.
- No minimum heart rate is required.
- Heart rate limit = 125 beats/min.
- Update factor = 1/8.
- Noise limit = 20 µV.

Skin preparation and electrode placement

TWA is a regionally specific phenomenon. Use precordial leads whenever possible. Use of Frank X, Y, or Z leads is not recommended for TWA monitoring.

1 Ensure each electrode site is dry, clean, and free of excess hair.
2 Degrease each electrode site with a skin preparation cream.
3 Using a synthetic abrasive pad, clear away a layer of skin.
4 Apply standard electrodes on precordium and limbs
   - Precordial leads provide the most useful information for TWA testing.
   - Ideally, right and left parasternal electrodes should not be placed on pectoral muscles.
   - Allow slack in wires for movement.

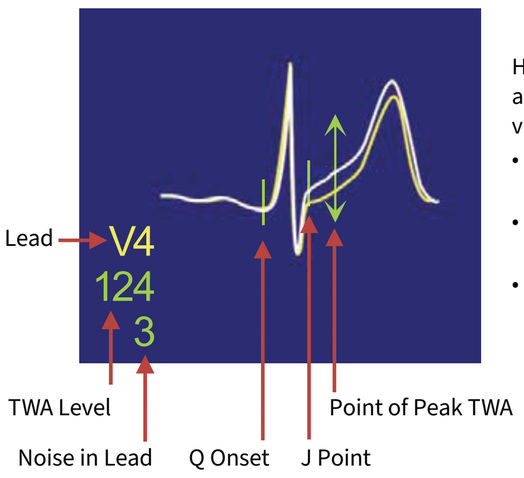
Modified moving average method (MMA)



- Analyzes TWA in time domain
- Continuously streams A and B forms
- Identifies peak alternation between consecutive beats in JT interval per 15 seconds
- Does not require fixed heart rate
- Uses standard electrodes
- Patients maintain medications
- 1-Microvolt resolution
- Full disclosure ECG available
- Provides TWA template for computer-aided waveform inspection

Reviewing TWA measurements and templates

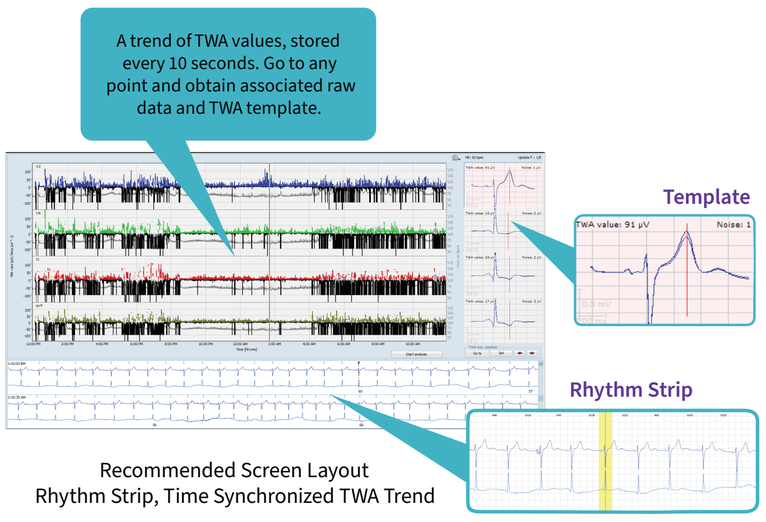
Templates and display information



High resolution ECGs are superimposed for visual inspection:

- Rule out waveforms not TWA
- P-wave and QRS should be aligned
- Confirm TWA visually down to 20 µV

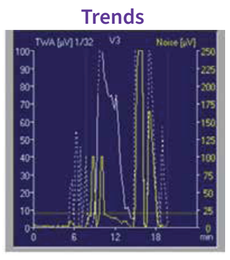
Visual confirmation - ambulatory ECGs



Recommended Screen Layout
Rhythm Strip, Time Synchronized TWA Trend

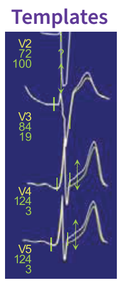
Visual confirmation - exercise ECGs

Trends



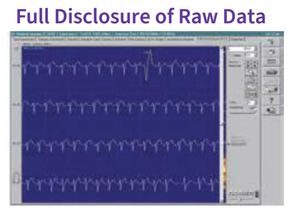
Positive TWA at 8 minutes.
Dashed trends of TWA values have noise values > 20µV.

Templates



QRS complex is aligned.
Noise value < 20µV

Full Disclosure of Raw Data



TWA pattern visible in full disclosure data at point of positive TWA measurement.

Time synchronized trends + Templates + Row data = Quick visual confirmation

Test interpretation

TWA test interpretation

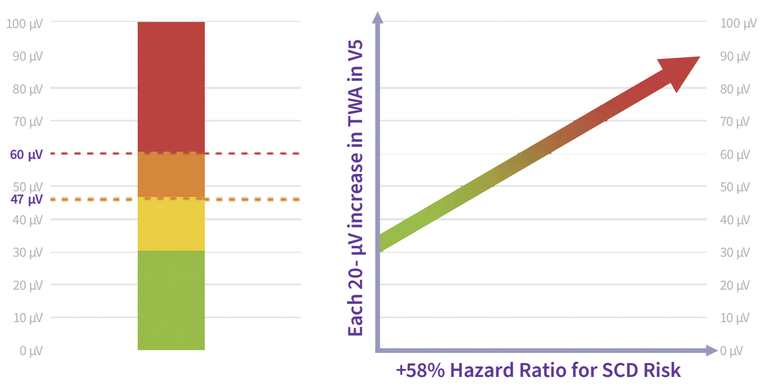
- Cutpoint for abnormal results: ≥ 47µV
  - Severely abnormal: ≥ 60 µV
  - Larger TWA = greater risk
- Hazard ratios for positive TWA test:

	CV Death		SCD	
		NPV		NPV
Ambulatory	2.9–17.1	97%	4.8–22.6	94%
Exercise	4.6	98%	4.4	99%

- Indeterminate tests (2-5%) may result from ventricular ectopy, technically poor readings.
- Not recommended: Assessment during AF, high-grade ectopy, supraventricular arrhythmias, or conduction block.
- **CAVEAT:** Results of TWA tests should be used as an adjunct to clinical history, symptoms, and the results of other noninvasive and invasive tests.

Microvolt TWA Consensus Guideline, *JACC 2011; 44:1309–1324*

Higher TWA = higher risk of SCD



TWA ≥ 47 µV = risk of SCD.
TWA ≥ 60 µV = severe risk of SCD.
Microvolt TWA Consensus Guideline,
JACC 2011; 44:1309–1324

Each 20-uV increase in TWA indicates +58% SCD risk.
Leino et al *Heart Rhythm* 2011; **8**(3): p. 385-90

Further reading

Duca ST, Roca M, Costache AD, et al. **T-Wave analysis on the 24 h Holter ECG monitoring as a predictive assessment of major adverse cardiovascular events in patients with myocardial infarction: A literature review and future perspectives.** Life (Basel) 2023; 13(5):1155. https://www.mdpi.com/2075-1729/13/5/1155

Aro AL, Kenttä TV, Huikuri HV. **Microvolt T-wave alternans: Where are we now?** Arrhythmia & Electrophysiology Review 2016; 5(1):37-40. https://www.aerjournal.com/articles/microvolt-t-wave-alternans-where-are-we-now

Lewek J, Ptaszynski P, Klingenheben T, Cygankiewicz I. **The clinical value of T-wave alternans derived from Holter monitoring.** Europace 2017; 19(4):529-534. https://academic.oup.com/europace/article/19/4/529/2952436

You T, Luo C, Zhang K, Zhang H. **Electrophysiological mechanisms underlying T-wave alternans and their role in arrhythmogenesis.** Frontiers in Physiology 2021; 12:614946. https://www.frontiersin.org/articles/10.3389/fphys.2021.614946/full.

Verrier RL, Klingenheben T, Malik M, El-Sherif N, Exner D, Hohnloser S, Ikeda T, Martinez JP, Narayan S, Nieminen T, Rosenbaum DS. **Microvolt T-wave alternans: Physiologic basis, methods of measurement, and clinical utility. Consensus guideline by the international Society for Holter and Noninvasive Electrocardiology.** *J Am Coll Cardiol* 2011; 44:1309-1324.

Abbreviations: CV = Cardiovascular; **SCD** = Sudden Cardiac Death; **NPV** = Negative Predictive Value

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