P wave indices, Does it make any sense?

BY
Ahmed Salah Salem, MD
Suez Canal University

- P wave morphology represents atrial electrical activation which depends mainly on the distance travelled by the electric current from the first point of depolarization to the latest point of depolarization along with the velocity of the electric current.

- The P wave indices of maximum duration and dispersion have received increasing attention and have been examined in a broad range of clinical settings.
- The ECG, as a vectorcardiogram, quantifies the magnitude and direction of electric propagation and depolarization.

- Insults such as chronically elevated atrial pressure, ischemia, and metabolic stress lead to atrial remodeling marked by inflammation, fibrosis and poor cellular coupling.
- The electrophysiological result is slowed conduction with inhomogeneous recovery, leading to abnormal P wave indices and increased risk of atrial arrhythmias.

Measurment of P wave indices

- Currently, P wave indices are calculated from the absolute difference between the shortest and longest P waves from the surface ECG.
- Use of adjacent leads with shared vectorial orientation may provide greater sensitivity for distinguishing the inhomogeneity of atrial activation.

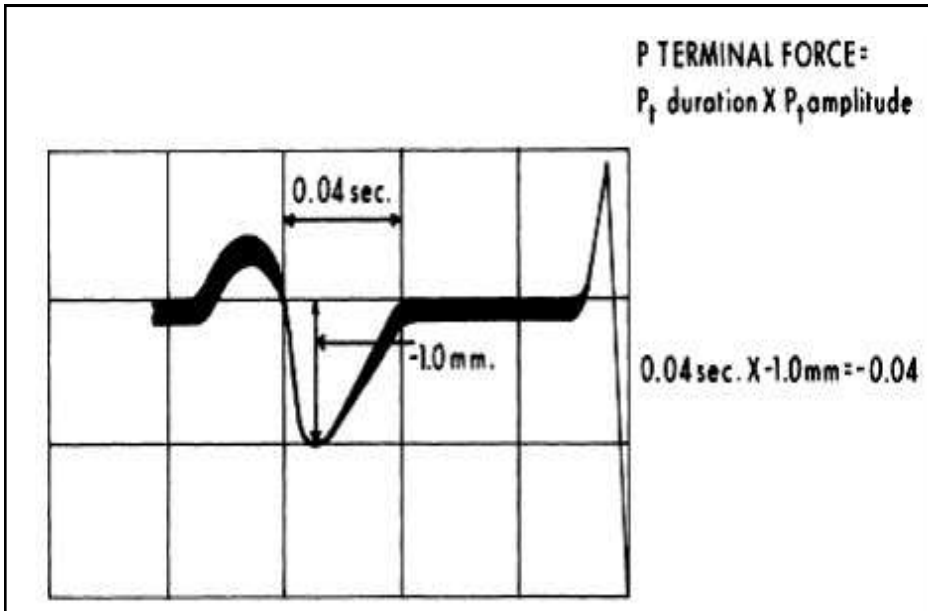
Measurement and Reproducibility of P Wave Indices

- P wave duration was the time measured from the start to the end of P wave.
- P-wave dispersion was measured by subtracting the minimal P wave (Pmin) duration from the maximal P wave (Pmax) duration (Pmax – Pmin).

- P wave indices have been calculated by measurements on paper or digitized images. Manual measurement with calipers has entailed increasing the ECG rate to 50 mm/s and the voltage to 1 to 2 mV/cm accompanied by use of magnification.
- Hand-held caliper measurements have less accuracy compared with digital measurements. Reliability of P wave indices calculation requires accurate determination of the P wave on-set and off-set.

P wave terminal force (PWTF)

- Calculation of the PWTF was done by measuring the P wave duration in seconds multiplied by the P wave amplitude of the negative terminal portion of the P wave in V1 in millimeters.



Reproducibility

- Comparing paper and digital measurements, for maximum P wave duration measurements, the intraobserver relative errors were reduced from 16% to 7% and the interobserver relative errors were diminished from 17% to 8%.
- Similarly, the relative errors for P wave dispersion were reduced from 24% to 13% for intraobserver, and from 30% to 14% for interobserver comparing paper and digital measurement acquisition.*

* Andrikopoulos GK, Dilaveris PE, Richter DJ, Gialafos EJ, Synetos AG,Gialafos JE. Increased variance of P wave duration on the electrocardiogramdistinguishes patients with idiopathic paroxysmal atrial fibrillation.Pacing Clin Electrophysiol. 2000;23:1127–1132.

- Although the criteria for abnormal P wave indices vary by study, several investigators have examined the prevalence of P wave duration exceeding various cutpoints.
- The prevalence of P wave duration 110 ms has been estimated as high as 41%, and 120 ms as high as 47% in hospitalized samples prompting the description of this finding as “pandemic”.*

*Ariyarajah V, Asad N, Tandar A, Spodick DH. Interatrial block: pandemic prevalence, significance, and diagnosis. Chest. 2005;128: 970–975.

Clinical Correlates Associated With P Wave Indices

- Most studies have reported that P wave duration increases with advancing age.
- However, because most prior studies have not adjusted for the increases in risk factors and disease that occur with advancing age, it is uncertain whether aging per se increases P wave indices.

Hypertension and P wave indices

- Cross-sectional studies have examined the relations between risk factors and P wave indices. Subjects with uncontrolled hypertension have been shown to have significantly prolonged P wave duration and dispersion.*

- *Dagli N, Karaca I, Yavuzkir M, Balin M, Arslan N. Are maximum P wave duration and P wave dispersion a marker of target organ damage in the hypertensive population? Clin Res Cardiol. 2008;97:98 –104.

Diabetes and P wave indices

- In an unadjusted cross-sectional case-control study subjects with diabetes (n76) had significantly longer P wave indices than controls (n40).*

- *Yazici M, Ozdemir K, Altunkeser BB, Kayrak M, Duzenli MA,Vatankulu MA, Soylu A, Ulgen MS. The effect of diabetes mellitus onthe P-wave dispersion. Circ J. 2007;71:880-883.

Obesity and P wave indices

- Several studies have examined the relations of P wave indices to obesity and have shown individuals with obesity had significantly longer P wave indices compared with control groups.

- Of interest, a decrease in P wave indices has been observed after weight loss. Similarly, bariatric surgery in a severely obese cohort was associated with a significant reduction in P wave indices over a 12-month period.

- Russo V, Ammendola E, De C, I, Docimo L, Santangelo L, Calabro R. Severe obesity and P-wave dispersion: the effect of surgically induced weight loss. Obes Surg. 2008;18:90 -96.

Subclinical and Clinical Cardiac Disease

- Cross-sectional studies have assessed diastolic function and P wave indices and associated diastolic dysfunction with prolonged P wave indices compared with referent cohorts.*
- P wave indices and diastolic dysfunction may comprise markers of a common pathophysiologic process. P wave indices and diastolic dysfunction may influence each other in a bidirectional fashion, one may predispose to the other, or their association may be due to confounding resulting from a more complex pathophysiologic process.*

- *Gunduz H, Binak E, Arinc H, Akdemir R, Ozhan H, Tamer A, Uyan C.The relationship between P wave dispersion and diastolic dysfunction. Tex Heart Inst J. 2005;32:163–167.

Valvular heart disease

- P wave indices have been examined in structural and valvular disease. They were significantly longer in subjects with aortic stenosis compared with controls.*
- A single center, case control study identified a significant decrease in P wave indices at 1 month after mitral balloon valvuloplasty for mitral stenosis.**

- *Turhan H, Yetkin E, Atak R, Altinok T, Senen K, Ileri M, Sasmaz H, Cehreli S, Kutuk E. Increased P-wave duration and P-wave dispersion in patients with aortic stenosis. Ann Noninvasive Electrocardiol. 2003;8: 18–21.
- **Turhan H, Yetkin E, Senen K, Yilmaz MB, Ileri M, Atak R, Cehreli S, Kutuk E. Effects of percutaneous mitral balloon valvuloplasty on P-wave dispersion in patients with mitral stenosis. Am J Cardiol. 2002;89: 607–609.

Congenital heart disease

- Similarly, subjects with a secundum atrial septal defect have had longer maximum P wave duration and P wave dispersion compared with matched controls; surgical repair of atrial septal defects has resulted in regression of P wave indices.*

- *Guray U, Guray Y, Yylmaz MB, Mecit B, Sasmaz H, Korknaz S, Kutuk E. Evaluation of P wave duration and P wave dispersion in adult patients with secundum atrial septal defect during normal sinus rhythm. Int J Cardiol. 2003;91:75–79.

Noncardiac Conditions

- Studies have examined P wave indices in a variety of noncardiac conditions. The largest identified study (n32) examining the effect of hemodialysis on P wave indices reported that maximum P wave duration and P wave dispersion increased significantly postdialysis.

- Tezcan UK, Amasyali B, Can I, Aytemir K, Kose S, Yavuz I, Kursaklioglu H, Isik E, Demirtas E, Oto A. Increased P wave dispersion and maximum P wave duration after hemodialysis. Ann Noninvasive Electrocardiol. 2004;9:34 –38.

- Another study reported that individuals with hyperthyroidism (compared with euthyroid individuals) had greater baseline maximum P wave duration and P wave dispersion, and that hyperthyroidism suppressive therapy was associated with a decrease in indices.

- Katircibasi MT, Deniz F, Pamukcu B, Binici S, Atar I. Effects of short-term propylthiouracil treatment on P wave duration and P wave dispersion in patients with overt hypertyroidism. Exp Clin Endocrinol Diabetes. 2007;115:376 –379.

Limitations

- The investigations of P wave indices with clinical correlates, cardiovascular and noncardiac conditions have limitations.

- Most studies were small to moderate in sample size, involved referral cohorts, and consequently had limited power and generalizability.

- Furthermore, the cross-sectional studies generally did not assess for either confounding or effect modification between advancing age, and clinical correlates in relation to P wave indices.
- The long-term impact of treating most risk factors or disease states such as hypertension and diabetes has not been assessed systematically and merits elucidation. Multiple clinical correlates in the community have yet to be investigated.

Signal Average ECG

- Signal average ECGs (SAECG) have been used for predicting AF. Applications of SAECG are similar to P wave indices described above.
- Prolonged P wave SAECGs have been associated with increased incidence of AF and recurrence of AF after cardioversion.

- Advantages of SAECG include its incorporation of information from hundreds of data points and lack of reliance on distinguishing P wave on-set and off-set, which improve the reliability and accuracy of the technique.

- Disadvantages of P wave SAECG are that it requires high fidelity, and highly specialized equipment that is not in wide clinical usage.
- The need for patients to lie completely still for 3 to 5 minutes in a room with no electric interference also limits its broad implementation.

P Wave Indices and AF

- Prolonged P wave indices have been associated with increased risk for incident AF.
- Subjects with recurrent AF have been shown to have significantly longer P wave indices and longer documented history of AF duration compared with individuals that maintained sinus rhythm.

- Prolonged P wave indices (=or> 130 ms and dispersion=or> 40 ms) are sensitive predictors of AF incidence and recurrence post cardioversion and post ablation.*

- *Ciaroni S, Cuenoud L, Bloch A. Clinical study to investigate the predictive parameters for the onset of atrial fibrillation in patients with essential. Am Heart J. 2000;139:814–819.

Summary

- P wave indices are good markers and predictors for several cardiac and non cardiac conditions however they lack specificity, and can be affected by many confounders.
- Moreover there usage in clinical practice for prediction of cardiac illness specially atrial fibrillation is underused in comparison to other more reliable parameters such as atrial volumes measured by echocardiography.

Thank You