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REPLY: More Than Meets the AI: Electrocardiograms in Heart Failure Prognosis

We thank Dr Usmani and colleagues for their thoughtful engagement with our publication. Moreover, we wholeheartedly agree that there is merit in leveraging several methods to noninvasively assess central hemodynamics, and Dr Usmani and colleagues point to several recently published works along these lines. It is our view that an optimal solution for estimating important prognostic features in patients with heart failure will involve a suite of machine learning methods that collectively estimate hemodynamic quantities using easily obtained physiologic signals, like the 12-lead, or even a single-lead electrocardiogram (ECG).[1]

We also agree that the continuous wavelet transform is an interesting signal-processing method for representing and analyzing ECG data. The work cited by Dr Usmani and colleagues used a continuous wavelet transform to generate a 643 dimensional representation from an ECG signal. The authors then selected a subset of these features to construct a predictive model.[2] More generally, feature engineering—the process of manipulating raw data to generate features that can be used for machine learning—constitutes a time-tested approach that has been leveraged to construct models with improved predictive performance. Indeed, our group has experimented with different representations of ECG signals in the past, and in some cases, these representations have led to predictive models that outperform risk models used in clinical practice.[3] Nevertheless, deep learning models that use raw data, rather than features that are engineered from the raw data, have the advantage that they do not require one to prespecify a feature set that the model will see.[4] This is often important because it can be very difficult to know a priori what type of engineered features will have the greatest predictive power.

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The authors attest they are in compliance with human studies committees and animal welfare regulations of the authors' institutions and Food and Drug Administration guidelines, including patient consent where appropriate. For more information, visit the Author Center.

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