Overall, it seems that increasing the threshold of EAdi would decrease the false-negative rate, improving the sensitivity of any given automated detection software and keeping a good specificity. We believe that, according to our reassessed results, an EAdi >2 μV could be suitable for this purpose. In addition, as Jonkman and colleagues mentioned, the removal of cardiac electrical activity is technically challenging, particularly when the signal:noise ratio of the crural diaphragm electromyography signal is low. In this scenario, we hypothesized that the automatic detection of true ineffective efforts from EAdi will be improved by using a personalized adaptive threshold for each patient considering the signal:noise ratio of the diaphragm electromyography signal. Interestingly, nonlinear methods less sensitive to ECG interference based on sample entropy algorithms (4) could be used to reduce the delay on the neural onset when an ECG peak matches at the beginning of the breath. ■

Author disclosures are available with the text of this letter at www.atsjournals.org.

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Reply to Aquino-Esperanza *et al.*

From the Authors:

We greatly appreciate the interest of Aquino-Esperanza and colleagues in our research letter (1) regarding the influence of suboptimal filtering of the electrical activity of the diaphragm (EAdi) signal on the detection of patient–ventilator asynchronies. In that letter, we raised the concern that cardiac activity–related artifacts in the EAdi signal may be mistakenly detected as ineffective efforts when the EAdi threshold is too low. Based on this work, Aquino-Esperanza and colleagues have thoughtfully reanalyzed the performance of their Better Care algorithm (2) to find an appropriate EAdi threshold for the automatic detection of ineffective efforts. They conclude that increasing the EAdi threshold from 1 μV to 2.3 μV improved the sensitivity of their algorithm and maintained adequate specificity. We appreciate this careful reanalysis and agree with the authors that a threshold >2 μV is reasonable. It should be noted that in our work (1), EAdi artifacts were mostly <4 μV, but we agree that a threshold of 4 μV would be clinically disproportionate and increase the false-negative rate.

We also agree with the authors that a personalized adaptive EAdi threshold may improve the performance of automatic detection of true ineffective efforts. We considered testing this with our dataset; however, the incidence of true ineffective efforts was too low (1). In contrast, because the processing of these EAdi artifacts is a technical issue, it might be rather impossible to distinguish between artifacts and true ineffective efforts based on a certain EAdi threshold solely. As part of our earlier work, we aimed to quantify waveform characteristics of the cardiac activity–related artifacts (e.g., slope of the inspiratory EAdi increase, timing, and amplitude) and predict the occurrence of these artifacts based on patient characteristics. For instance, we hypothesized that cardiac activity–related peaks had steeper increases (“sharp waves”, possibly consistent with fast cardiac depolarization); however, slopes of the artificial and true peaks were similar on average, and artificial peaks with both lower and higher slopes compared with true EAdi peaks were found within patients. Furthermore, factors such as the presence of ventricular hypertrophy were not related to the occurrence of these artifacts. We did not include these findings in our research letter, as this is clinically not very helpful at this time.

Importantly, the main challenge with developing a (personalized) EAdi threshold using signal characteristics is the

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uncertainty regarding how the ventilator algorithm processes the EAdi signal ("black box"). In addition, artifacts may look different when originating from cardiac or catheter movements (mechanical artifact) or when being secondary to inefficient filtering of the QRS complex (electrical artifact). This requires specific analysis of the raw diaphragm electromyography signal, and indeed, complex mathematical techniques might offer a solution. As the diaphragm electromyography is not available to the clinician to test this approach, we reason that using a threshold >2 μV as proposed by Aquino-Esperanza and colleagues is an appropriate practical solution for automatic detecting of ineffective efforts in large datasets. However, one should keep in mind that artifacts of larger amplitudes can be present and that careful consideration of the EAdi catheter position and signal quality is required when using EAdi for clinical decision-making and research. ■

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Network Analysis Subtleties in ICU Structures and Outcomes

To the Editor:

We were extraordinarily pleased to read "The Structure of Critical Care Nursing Teams and Patient Outcomes: A Network Analysis" conducted by Dr. Costa and colleagues (1). This is a timely study using methodologic approaches to measuring structure in complex healthcare systems, such as critical care teams. In this letter, we feel there are additional approaches Dr. Costa's team can consider, which we believe will improve the quality of the following network analysis in critical care.

The excellent way Dr. Costa and colleagues created connections among nurses has an unfortunate potential risk of building a high-density network, which may lack structural information, such as k-core and betweenness (2, 3). This Michigan team defined a connection (tie) between two nurses as they provided direct care for the same patient during the patient's ICU stay. In this way, nurses caring for one patient within a period (the patient's ICU stay) will form a complete subnetwork, within which all nurses are interconnected. The complete subnetwork has less structure information. Such a phenomenon becomes even worse (i.e., almost all nurses are interconnected in the nurse network) when *1*) the patient's ICU stays are prolonged (e.g., over 30 d) and *2*) each nurse cares for a majority of patients in the ICU. As a consequence, most nurses will have the same values of k-core and betweenness (2), respectively. The downside here is disabling the exciting opportunity of investigating associations between network structure and mortality risk.

Understanding the evidence to validate that nurses are randomly assigned to a patient, regardless of their mortality risk, would augment this fine work. Currently, it is hard to determine if the low mortality risk is because of core and high-betweenness nurses or the strategies used to assign nurses to patients. If the majority of nurses are assigned to care for a higher percentage of low-mortality-risk patients than that of high-mortality-risk patients, then they will have more connections in the nurse network, and they have the potential to be core and high betweenness. Generally speaking, there are a larger number of low-mortality-risk patients than high-mortality-risk patients in the neurosurgical and surgical ICUs, so nurses caring for a higher percentage of low-mortality-risk patients have more connections. Therefore, the finding would be that nurses caring for patients with a higher percentage of low mortality risk have more connections in the network, so they are core and high betweenness.

To let researchers understand such a complicated situation deeply, we provide an example. Assume we have a scenario in which 50 nurses from group A and 50 nurses from group B cared for both high-mortality-risk and low-mortality-risk patients. Nurses in group A cared for 90% of patients with low mortality risk and 70% of patients with high mortality risk. Nurses in group B cared for 70% of patients with low mortality risk and 90% of patients with high mortality risk. In this hypothetical scenario, a low-mortality-risk patient was cared for by more nurses in group A than those in group B. Assuming there were 920 patients, 900 of them were low mortality risk, and 20 were high mortality risk. Nurses in group A would care for 810 patients with low mortality risk and 14 patients with high mortality risk, whereas nurses in group B would care for 630 patients with low risk and 18 patients with high risk. Based on the way Dr. Costa and colleagues built the nurse network, nurses in group A had more dense connections, and thus they are potentially core and high betweenness. An explanation of the finding would be that because group A nurses cared for more patients with low mortality risk, they were core and high betweenness. In short, if Dr. Costa and colleagues can provide the percentages of low- and high-mortality-risk patients cared for by high core and betweenness nurses, then it will improve the quality of this already high-value paper.

Dr. Costa and colleagues used the number of high-betweenness or core nurses involved in individual patient care rather than the

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