

Analysis and detection of patient-ventilator asynchrony via a computerized algorithm

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Around seventy percent of the patients admitted to our medical intensive care unit need mechanical ventilatory support. It is not unusual to detect patient-ventilator asynchrony as discrepancy between neurally and mechanically assisted breath is prone to occur. Ineffective triggering in expiratory phase (ITE) is documented to be the principal type of patient-ventilator asynchrony and manual calculation is the usual way to quantitate it. As ITE is characterized by its high temporal variability and quantification of patient-ventilator asynchrony is known to be important in assessing the appropriateness of ventilator settings. We proposed and validated a computerized algorithm in quantitating ITEs in mechanically ventilated patients.



Methods:

Fourteen mechanically ventilated patients, spanning a nine-month period, with high level of patient-ventilator asynchrony were enrolled in this study. An average of 20 minutes recordings of airway pressure, flow, volume and esophageal pressure were made in each case. The expiratory phase was selected according to the flow signal and ITEs were manually identified first. Thereafter, we aimed at two parameters in the ITE-containing segment. The first was maximum flow deflection (F_{def}), which is equal to the largest magnitude of flow change when the ventilated patient could not trigger the ventilator. The second was the maximum airway pressure deflection (P_{def}), which is the correspondent magnitude of airway pressure change in the same segment of expiration. Graphic illustrations of F_{def} and P_{def} are shown in Fig. 1. For computerized determination of F_{def} , the expiratory phase was selected and F_{def} was obtained by applying the local maximum and minimum search algorithm and their consequent difference. Computerized determination of P_{def} was obtained by utilizing a similar algorithm but in reversed direction.

Results:

A total of 5899 breaths were analyzed and 1831 breaths belonged to ITEs. The distribution of F_{def} and P_{def} in these patients are shown in Fig. 2. Mean value for F_{def} and P_{def} was 13.94 ± 8.0 L/min, 1.91 ± 0.97 cmH₂O respectively. From a starting value of 0.1 L/min for F_{def} and 0.01 cmH₂O for P_{def} , the calculated area under the receiver operator characteristics (ROC) curve of F_{def} and P_{def} for the identification of ITEs was 0.98 and 0.97 correspondingly. By analysis via a logistic regression model with repeated measurements and computations, the best detection criteria of F_{def} was 5.45 L/min with a sensitivity of 91.5% and a specificity of 96.2%; 0.45 cmH₂O for P_{def} with a sensitivity of

93.3% and specificity of 92.9%.

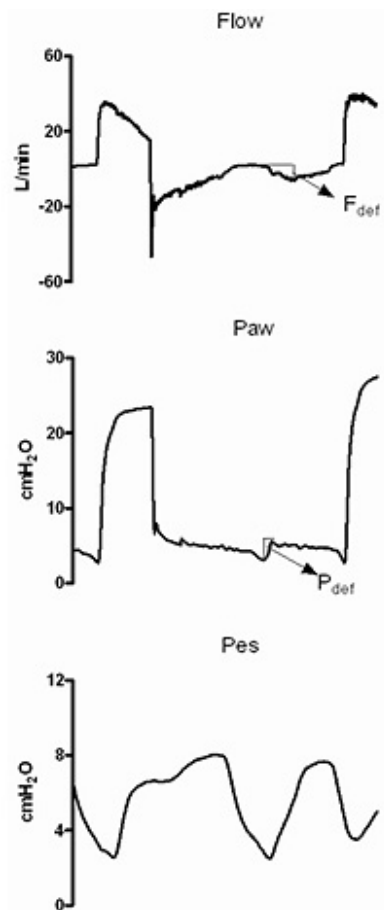


Fig.1: A depiction of ineffective triggering in the expiratory phase (ITE). Paw: airway pressure, Pes: esophageal pressure. F_{def} : maximum flow deflection.

P_{def} : maximum airway pressure deflection.

Conclusion:

This article is an original approach to automatically quantitate one major type of patient-ventilator asynchrony and we have showed that computerized detection of ITE is feasible in mechanically ventilated patients. Actually following acceptance of our manuscript, we noticed publication of a similar algorithm for detecting patient-ventilator asynchrony from a ventilator manufacturer (ResMed). The study reflected our team's capability in doing respiratory physiology in mechanically ventilated patients. This capability is a result of continuing devotion to ventilator physiology in our university hospital. An intimate cooperation between physician and engineer is the key factor for this successful study.

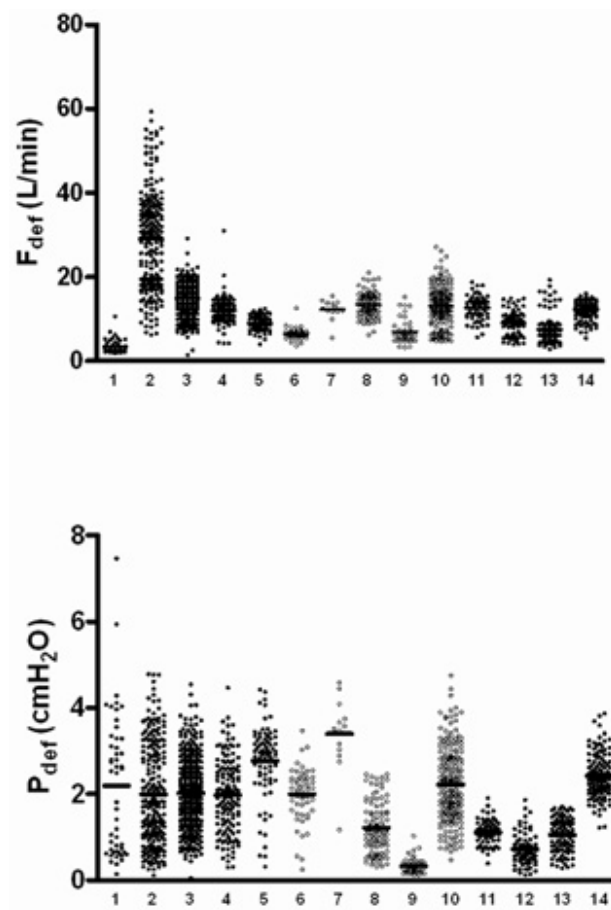


Fig. 2: Scatter plot of the distribution of F_{def} and P_{def} of breaths containing single ITE in all patients.