Title: CONTINUOUS REMOVAL OF VENTILATORY VARIATIONS FROM THE PULMONARY ARTERY PRESSURE SIGNAL USING ADAPTIVE DIGITAL FILTERING

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Introduction. In order to assess the cardiopulmonary status of many critically ill patients pulmonary artery (PA) pressures are often monitored via a Swan-Ganz catheter. The pulmonary artery pressure signal is influenced by fluctuations in pleural pressure caused by ventilation. These ventilatory induced variations can make it difficult to obtain an accurate reading of the pulmonary artery transmural pressures. The variations of the pulmonary artery signal due to ventilatory influences are always of lower frequencies than the heart rate. This factor has been utilized in a previous study which, using a method of signal analysis called the Fast Fourier transform (FFT), was able to remove the respiratory components from the pulmonary artery signal and reconstruct the signal in a readable form.(1)

There are drawbacks to the FFT method of removal of the ventilatory variations. In using the FFT, a discrete block of data must be analyzed and reconstructed. It is not possible to process the signal in a continuous manner. The inability to process the signal in real time makes this method impractical for application in the clinical monitoring setting.

A method is presented here which continuously removes ventilatory components from the pulmonary artery pressure signal. This was accomplished through the use of adaptive filtering. The results of the filtering process were checked for accuracy against readings of the unprocessed data by a clinician.

Methods. After obtaining informed consent, fifteen patients with Swan-Ganz catheters in place were monitored via strain gauge transducers on multichannel recorders. Airway, arterial and pulmonary artery pressure signals were transferred to magnetic tape and converted to digital form on a PDP 11/40 computer.

The heart rate was determined from the arterial pressure pulse. Based upon the heart rate, an appropriate low-pass and high-pass filter was selected from a bank of filters.

The raw PA pressure data was passed through the low-pass filter to remove high frequency components. This resulted in a signal composed of only the airway components and the mean PA pressure. From this signal the mean PA pressure was determined. The unfiltered PA signal was also passed through a high-pass filter resulting in a signal containing the phasic cardiac components. The mean PA pressure was then added to the high-pass filtered data. The resulting signal was plotted on an Hewlett Packard grahics plotter along with the raw PA pressure signal and the airway pressure.

To test the accuracy of this method an experienced clinician determined the pulmonary artery systolic and diastolic pressures from the raw PA pressure at end exhalation. These values were compared with the average systolic and diastolic values of the filtered PA signal.

Results. An example of the digitally filtered PA pressure signal is shown in Fig. 1.

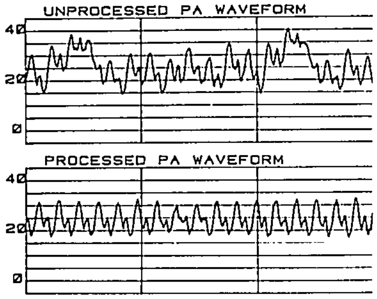

Figure 1

The results of the comparisons of unfiltered and filtered PA systolic and diastolic pressures is shown in Fig. 2. The heart rate varied from 80 beats/min to 145 beats/min. Ventilation rates varied from 8 breaths/min. to 38 breaths/min.

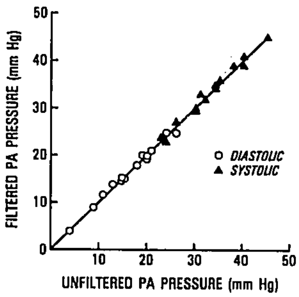

Figure 2

The mean difference between the pulmonary artery systolic and diastolic pressures determined by adaptive filtering and those observed by the clinician was 0.28 ± 1.5 mmHg. and 0.10 ± 1.10 mmHg respectively.

Discussion. Adaptive digital real time filtering has been utilized to remove the ventilatory components from the pulmonary artery pressure signal. This method of signal processing provides the advantage of a continuously processed pulmonary artery pressure signal. It is applicable to other central vascular pressures (e.g., CVP, PA wedge, LAP) and lends itself to direct implementation in a clinical setting.

References:

1. Ricks WG, Meathe EA: Anesthesiology 57:A166, 1982.