Title: AN ALGORITHM FOR THE AUTOMATIC REMOVAL OF VENTILATORY DISTORTIONS OF PULMONARY VASCULAR PRESSURES

Authors: William G. Ricks, B.A., Edward A. Meathe, M.S.

Affiliation: University of California Medical Center, San Diego
Department of Anesthesia
225 Dickenson Street
San Diego, California 92103

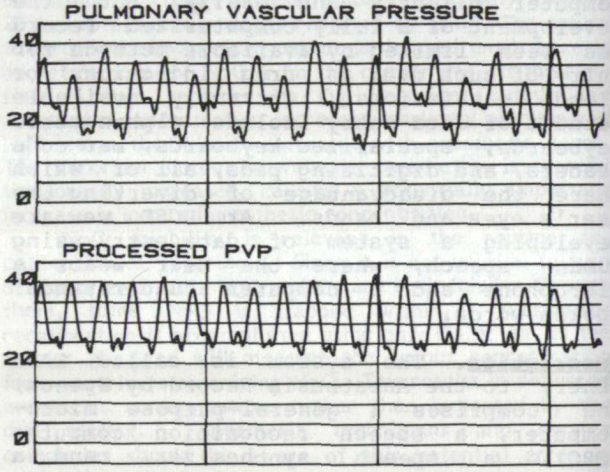
INTRODUCTION: Many critically ill patients have pulmonary vascular pressure (PVP) monitored with Swan-Ganz catheters; using pulmonary artery end diastolic and pulmonary capillary wedge pressures to assess cardiopulmonary status. Changes in intrathoracic pressure resulting from ventilation have a direct affect on PVP. In the presence of wide excursions in PVP caused by ventilation accurate values are often difficult to obtain particularly when digital monitors are used.(1,2) The currently recommended monitoring technique is to use graphic traces of PVP and tracheal airway pressure to obtain data at the end exhalation period (EEP) of the ventilatory cycle.(2) Rapid wide changes in PVP, dampened or nonexisting airway pressure and inexperience in interpreting graphic traces present problems with the above method. This study illustrates a computer program that significantly reduces excursions in monitored PVP caused by ventilation. We then compared its accuracy in selecting data against those of an experienced clinician.

METHODS: Written consent was obtained from 14 patients according to guidelines set by the Human Subjects Research Committee. All patients had indwelling Swan-Ganz pulmonary artery catheters and airway pressure monitored via a t-piece adaptor connected to their endotracheal tubes. Strain gauge transducers and multi-channel recorders were used for pressure processing. Analog pressure signals from the monitors were recorded on magnetic tape for later analysis on a PDP 11/40 minicomputer. Sixteen second samples from each patient's data were digitized at a rate of 64 points per second and stored on magnetic disk.

Each sixteen second epoch of PVP data was decomposed into its component frequencies using a Fast Fourier transform (FFT). The patient's heart rate was determined from examination of the magnitudes of the frequency data. Frequency components were then segregated into two catagories: components below the heart rate (LF) and components at or above the heart rate (HF). The LF components contain information about ventilatory artifact and mean PVP. The HF components contain information about the phasic PVP-cardiac components less mean pressure. To completely represent the cardiac components of the PVP the mean PVP was determined from the LF data and added to the HF data. This composite array was then processed by an inverse FFT. This produced the original 16 seconds of PVP data less ventilatory artifact.

To assess the efficacy of this algorithm we compared PVP determined by an experienced clinician and PVP determined by the program. The clinician's determinations were made at the point of end-exhalation as determined by monitoring airway pressure.

RESULTS: Figure 1 illustrates the results of this processing. The upper strip is the unprocessed PVP recorded from the distal lumen of the Swan-Ganz catheter located in the pulmonary artery. The lower strip is the same PVP with the ventilatory artifact removed by our algorithm.



The result of the comparisons showed a mean difference of 1.2 ± 1.3 torr for systolic pressures and a mean difference of 1.0 ± 1.1 torr for diastolic pressures and a mean difference of 1.1 ± 1.3 torr for mean pulmonary capillary wedge pressure. The maximum difference in any patient was 4 torr. Heart rates in these patients varied from 58 beats per minute to 144 beats per minute while ventilation rates were between 8 breaths/minute to 50 breaths/minute. Ventilation modes were either entirely controlled, intermittant mandatory ventilation, or completely spontaneous.

DISCUSSION: This algorithm provides a convenient and accurate method of determining pulmonary vascular pressure despite severe ventilatory artifact. Because of its adaptive nature it performs well despite the extreme variations in heart rate and ventilation rate encountered in the clinical setting. In addition, the accuracy of the algorithm is independent of the type of ventilation. Since the algorithm requires only the PVP it is not dependent upon the accurate acquisition of another physiologic parameter or upon any operator intervention. Although implementation in this case was on a mimicomputer the algorithm may be readily adapted to a bedside microprocessor based pressure acquisition unit or a computerized multi-patient data management central station. The accuracy of the algorithm appears to be within clinically acceptable limits.

REFERENCES:

1. Maran AG: Critical Care Medicine 8(2):102-105, 1980

2. Berryhill RE, Benumof JL, Rausher A: Anesthesiology 49:365-368, 1978