TITLE: RECEIVER OPERATING CHARACTERISTIC (ROC) CURVE HELPS OPTIMIZE BLOOD PRESSURE DETECTION ALGORITHMS

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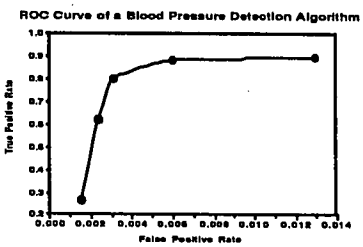
Introduction. Developing physiologic signal processing algorithms is difficult. Determining the optimal settings for the accurate detection of fiducial points from a wave form requires careful analysis of the tradeoffs between sensitivity and specificity. Receiver operating characteristic (ROC) curves have been used extensively in the fields of radiology and laboratory medicine as a tool in designing diagnostic tests. We report on the use of an ROC curve to facilitate optimization of both sensitivity and specificity in arterial blood pressure detection algorithms.
Methods. Digital ECG and arterial blood pressure wave forms were collected from 10 patients (approximately 100 cardiac cycles per patient; total = 1046) routinely monitored during surgery by a PC-based multi-channel data acquisition system. The arterial and ECG wave forms were displayed simultaneously on a large screen, high resolution monitor to allow easy manual identification of the appropriate systolic and diastolic blood pressure values, and their time of occurrance, from each heart beat; these points became our "gold" standard. We implemented a computer-based blood pressure detection algorithm capable of identifying both the systolic and diastolic blood pressures from each cardiac cycle[1]. Internal parameters of the blood pressure detection algorithm were manipulated in an attempt to increase sensitivity without compromising specificity. Manually identified points were compared to those identified by the computer. An ROC curve was constructed for each of these trials (see figure). Optimal algorithm settings were chosen to maximize both sensitivity (True Positive Rate (TPR)) and specificity (1 - False Positive Rate (FPR)). At optimal settings, the computer generated values were compared to the manually detected points by calculating the mean absolute deviation (MAD) of corresponding values.
Results. For the optimal values, TPR = 0.80 and FPR = 0.003. The MAD of the systolic and diastolic arterial blood pressure values was 2.0 and 2.5 mmHg respectively. Calculation of the heart rate from the time interval betweeen systolic peaks resulted in a MAD of 9.5 msec or 0.8 beats/min at a HR of 72 beats/min.
Conclusion. The ROC technique has proven to be valuable for the optimization of specific parameters within a particular blood pressure detection algorithm. ROC analysis is a potentially powerful statistical technique which should be in the repertoire of all investigators developing new event detection algorithms.



(area of interest enlarged)

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Reference. [1] Kinias P, Fozzard HA, Norusis MJ. A real-time pressure algorithm. Comput. Bio. Med. 11(4):211-220; 1981.

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Title: **CONTINUOUS NONINVASIVE ASSESSMENT OF BRAIN OXYGENATION AND BLOOD VOLUME DURING CARDIOPULMONARY BYPASS IN CHILDREN UNDERGOING ASD CLOSURE**

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Introduction: We have previously reported a characteristic increase in brain oxyhemoglobin (HbO_2) concentration in neonates during cardiopulmonary bypass (CPB) to profound hypothermia (15°C) and subsequent HbO_2 consumption during cardiac surgery using deep hypothermic circulatory arrest.[1] We sought to compare this pattern to the changes in brain HbO_2 concentration and blood volume in children undergoing ASD repair using moderate hypothermia (30-32°C) and continuous non-pulsatile CPB.
Methods: After approval from the IRB, we studied six patients aged 2 to 4 years and weighing 15 ± 1kg undergoing ASD repair using continuous non-pulsatile CPB (α-stat) and moderate hypothermia. Anesthesia was induced with halothane , fentanyl 10 μg/kg, pancuronium, followed by tracheal intubation and the placement of a radial arterial line and other routine monitors. A dual wavelength (760 and 800 nm) near-infrared reflectance spectrometry (NIRS) probe[2] was positioned on the right frontoparietal surface of the head, 2 cm above the eyebrow. The differential absorption ($\Delta OD_{760-800}$), ΔOD_{800} and direct arterial pressure were continuously recorded from this point until the values had stabilized after termination of CPB. The children were placed on CPB and cooled to a minimum nasopharyngeal temperature of 31 ± 1°C. Reduction in $\Delta OD_{760-800}$ indicates an increase in brain [HbO_2] while changes in ΔOD_{800} reflect total brain hemoglobin [(Hb)] as influenced by both brain blood volume and blood [Hb].
Results: The figure illustrates representative changes in brain HbO_2 and total brain Hb during the study period. ΔOD_{800} fell rapidly in the first minute of CPB, reaching its nadir by 8 minutes, indicating a precipitous fall in total brain Hb on CPB. OD_{800} increased steadily throughout the remaining study period to achieve a baseline value by termination of CPB and continue to level well above baseline early post CPB. The CPB priming solution achieved hemodilution from a hematocrit of 30 ± 2 prior to CPB to 23 ± .7 on CPB. A small increase in $\Delta OD_{760-800}$ was observed during CPB and returned to baseline upon termination of CPB indicating a transient, inconsequential reduction in brain HbO_2. Arterial oxygen saturation (S_aO_2) was ≥97% throughout the study period. No neurologic sequelae were noted in these children.

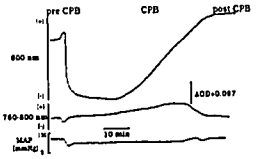

figure. Record of ΔOD_{800}, $\Delta OD_{760-800}$ and mean arterial pressure (MAP) in one patient.

Discussion: A significant reduction in total brain Hb was noted in these children upon initiation of CPB. This likely represents the effects of hemodilution and systemic venous decompression. As blood [Hb] remained constant during CPB, the return of total brain Hb toward baseline must represent a change in brain blood volume. The continued rise in total brain Hb after CPB could represent increased CVP, brain hyperemia, or increased blood [Hb] as a result of transfusion and diuretic-induced hemoconcentration.
1. *Anesthesiology* 71:A1035, 1989 2.*Rev Sci Instru* 22:634, 1951.