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Title : Estimation of Left Atrial Mean From Right Heart Measurements

Authors : M. L. Yelderman, M.D., and W. New, M.D., Ph.D.

Affiliation: Department of Anesthesia, Stanford University Medical School, Stanford, California 94305

Introduction. The mean value of left atrial mean pressure (LAM) is a valuable indicator of cardiac preload in the systemic circulation and a prerequisite for calculation of vascular resistance (PVR) in the pulmonary circulation. Jenkins (1) showed that pulmonary artery diastolic pressure (PAD) approximates LAM with a large error dependent on PVR and thus, by inference, on pulmonary artery mean pressure (PAM) and cardiac output (CO). Our objective was to determine experimentally the exact correlation between LAM, CO, PAM and PAD, and thereby to develop a mathematical formula suitable for bedside calculation that could accurately estimate LAM from these three right heart measurements.

Methods. Five dehydrated medium mongrel dogs were intubated and mechanically ventilated after induction of general anesthesia with thiopental. Four hemodynamic states were sequentially obtained by combined administrations of cardiovascular pressors, inotropes and fluids: State I - low CO/low PVR (dehydration, deep halothane anesthesia); II- low CO/high PVR (dehydration, halothane, phenylepherine); III - high CO/low PVR (fluids, isoproterenol, nitroprusside); IV - high CO/high PVR (fluids, isoproterenol, norepinephrine). Multiple excursions were made through each state: $80 < PVR < 700$ dynes x sec/cm^5; $0.5 < CO < 7.2$ liters/min. Approximately 50 sets of data points were obtained from each dog, evenly distributed through all four states. Immediately following thermodilution measurement of CO, the PAM, PAD and LAM pressures were respectively measured to 1% accuracy through a balloon-flotation catheter in the pulmonary artery and a surgically placed cannula in the left atrium, using commercial transducers and pressure monitor. The analog monitor's output was digitized and recorded by a small laboratory digital computer (DEC PDP 11/03). Data was pooled and a multilinear regression fit obtained between LAM and PAD, PAM, PAM^2, PAM^3, CO, CO^2, CO^3. The higher order terms were included to reflect non-linear relationships observed by Jenkins and ourselves. Using regression coefficients and the values of pulmonary pressure and cardiac output in each data set we calculated a "best estimate" LAM_{est}, then matched LAM_{est} with the true LAM_{true} measured in that set. Paired values LAM_e, LAM_t so obtained were plotted over the entire range of LAM pressure experimentally observed: $0 < LAM_t < 31$ torr.

Results. The plot of LAM_e vs. LAM_t results in a tight linear cluster of points graphically indistinguishable from the identity line: $LAM_{true} = 1.0000004\ LAM_{est} - 0.000003$. The best fit line of PAD (only) vs. LAM_{true} pairs is plotted for comparison.

Discussion. This study confirms Jenkin's conclusion that PAD alone is a crude estimator of LAM and that improvement results when PAM and CO corrections are added. An optimum power series combination of PAM and CO yields simple correction terms whose summation with PAD provides an improved estimate of LAM with less than 2.1 torr standard error over the entire physiologic range. Mean left atrial pressure can be accurately determined from (only) pulmonary artery pressure and cardiac output obtained from a single flow-directed balloon-tip catheter; no left heart measurements are required.

Reference. Jenkins B.S.: Evaluation of pulmonary arterial end-diastolic pressure as an indirect estimate of left atrial mean pressure. Circulation 42:75-78, 1970.
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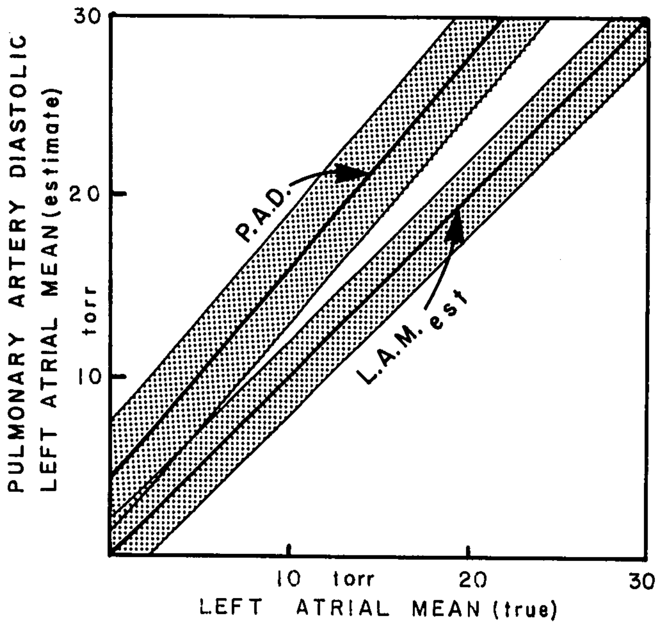

Estimation of LAM_{true} from PAD (only) and from optimal multivariant estimator LAM_{est} using PAD,PAM and CO (shading represents standard error of estimate).