TITLE: CAN THE K-FACTOR BE A SOURCE OF INACCURACY IN THE DETERMINATION OF ESOPHAGEAL DOPPLER CARDIAC OUTPUT?

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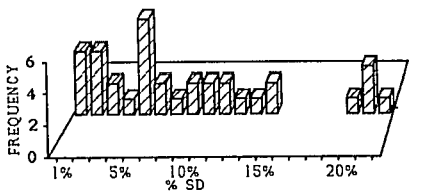
Introduction: Esophageal Doppler instruments have recently been introduced for continuous monitoring of cardiac output during anesthesia.[1] Cardiac output is determined by measuring descending aortic blood flow velocity using the Doppler frequency shift. For each cardiac stroke, the instantaneous maximum velocity is derived by spectral analysis of the velocity signals and integrated over the duration of ejection. Stroke volume is derived from the product of the velocity integral and the cross-sectional area of the aorta, while cardiac output is computed from the product of heart rate and stroke volume. To correct for blood flow distribution to the aortic arch vessels and for the angle between the Doppler beam and the direction of blood flow, the velocity signals are automatically multiplied with a proportionality constant, the K-factor (K). The aim of the current study was to test the reproducibility of K.

Methods. After institutional approval and written informed consent had been obtained, 11 patients scheduled for elective myocardial revascularization were studied. None of the patients had documented valvular heart disease or required pharmacologic circulatory support. After induction of anesthesia with fentanyl 50μ/kg and pancuronium 0.15 mg/kg, a 24 Fr esophageal Doppler probe (Lawrence Medical Systems, Redmond , Washington) was inserted and positioned to obtain an adequate Doppler signal[1]. Subsequently, guided by the audible Doppler signal, 3-5 K-factor determinations were performed with a suprasternal Doppler probe according to the manufacturer's recommendations. Additional sets of K were recorded at stable end-tidal levels of 0.5% and 1% enflurane. To assess reproducibility, mean values of K and their standard deviations (S.D.) were calculated for each patient and for each set of measurements. Differences were tested for statistical significance using Student's t-test with Bonferroni's modifications and were considered significant at $p<0.05$. Values are expressed as mean ± standard deviation.

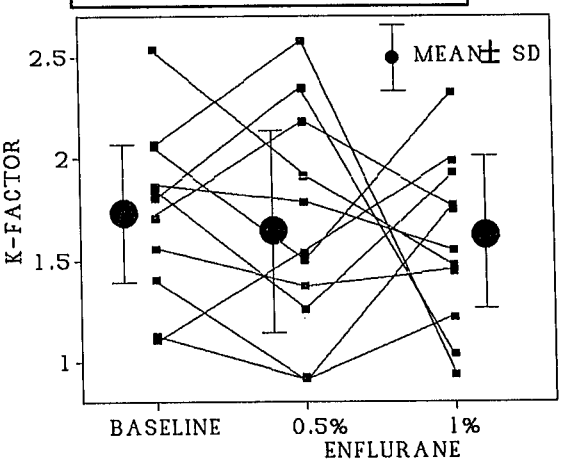
Results. In all patients satisfactory Doppler signals were obtained and a total of 115 K-factors were measured. For individual patients, the K ranged from 1.05 ± 0.23 to 2.19 ± 0.34, while the S.D., expressed as % of K, were between 6 and 26% with a mean of 17%. When each set of measurements was analyzed, the K ranged from 0.92 ± 0.02 to 2.58 ± 0.14, while the S.D. ranged from 1 to 20% with a mean of 8% The distribution of S.D. is shown for all measurements in figure 1. In more than half the measurements the S.D. was greater than 5%. When enflurane was added to the anesthetic, the mean value of K did not change significantly, but for individual patients, the changes were inconsistent (figure 2).

FIGURE 1: Distribution of standard deviations



Discussion. The K-factor is essential when cardiac output is measured with esophageal Doppler. It corrects the velocity signals for the loss of flow to the aortic arch vessels and for the unknown angle between the Doppler beam and the direction of flow in the aorta. In the monitoring mode, K is assumed to remain unchanged with varying hemodynamic conditions. Our results demonstrate that the measurement of K is poorly reproducible and may be a source of inaccuracy in the determination of Doppler cardiac output. Because the only guide to its determination is a subjective analysis of the audible Doppler signal, it is by nature operator dependent.Improvements in esophageal Doppler technology should be aimed at eliminating this particular source of errors.

FIGURE 2: K-Factors



References. 1. Mark JB et al. Continuous noninvasive monitoring of cardiac output with esophageal Doppler ultrasound during cardiac surgery. Anesth Analg 65:1013-1020, 1986.