In vivo comparison of two mixed venous saturation catheters

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PURPOSE

This study was designed to assess the accuracy and stability of two types of mixed venous saturation pulmonary arterial catheters under adverse physiological conditions. The two types of catheters chosen for assessment both continuously monitor SvO_2 using fiber optic reflectance spectrophotometry. The Swan-Ganz® flow-directed oximetry TD catheter (American Edwards Laboratories) permits the user to update hemoglobin or hematocrit values, but uses two-reference wavelengths. The Shaw Opticath® pulmonary arterial catheter from Oximetrix Inc. (now sold and marketed as TriOx from ICU Medical, Inc.) offers no ability to incorporate changes in hemoglobin or hematocrit, but features three-reference wavelengths. This study comparatively assesses the ability of these two in vivo SvO_2 oximetry systems to track true SvO_2, as measured by a bench top in vitro oximeter, under widely disparate physiological conditions.

MATERIALS AND METHODS

Ten fasted mongrel dogs were anesthetsized, ventilated, and paralyzed with pancuronium. In five each of the ten dogs, either a two-wavelength (Edwards) or a three-wavelength (ICU Medical, Inc.) SvO_2 catheter was positioned in the pulmonary artery following calibration in vitro according to the manufacturer's specifications. A catheter was also placed into a femoral artery and an introducer sheath was placed in a femoral vein. Arterial and mixed venous blood samples were collected anaerobically into heparinized syringes and analyzed immediately with both a benchtop CO-Oximeter and a blood gas analyzer. The CO-Oximeter was adjusted for dog hemoglobin and then calibrated and standardized daily to known reagents.

The following measurements were collected as a baseline and after each experimental manipulation: mean arterial pressure, central venous pressure, thermal dilution cardiac output, arterial and mixed venous blood gases, hemoglobin saturation, hemoglobin, and in vivo SvO_2. Oxygen consumption was calculated as the difference between arterial and mixed venous O_2 content times the cardiac output.

The experimental protocol obtained a broad range of mixed venous saturations by sequentially manipulating those variables that contribute to SvO_2:

- Varied FiO_2 from 1.0-0.12 initially and after each of the other manipulations
- Removed aliquots of blood (25 cc/kg) and replaced with Ringers Lactate (75 cc/kg) in order to achieve isovolemic hemodilution to a hemoglobin level of less than 10 g/dl
- Administered incremental doses of propranolol until either cardiac output was reduced to 50% of baseline or until a total propranolol dose of 1 mg/kg had been given
- Doubled systemic vascular resistance through the use of phenylephrine

All data were collected during periods of relative hemodynamic stability, temperature was maintained between 37-38° C, and each catheter was recalibrated after each protocol according to the manufacturer's instructions.

Paired data points (in vivo and in vitro saturations) were analyzed by the method of least squares, which yielded a regression line and correlation efficient for each catheter. Fisher's z test was used to compare the differences in correlation between catheters overall and in selected ranges. Fisher's z test was also used to test the effect of varying hemoglobin in the two-wavelength catheters. The difference between the initial in vivo SvO_2 and the measured SvO_2 and the same difference at the conclusion of each experiment was analyzed with paired Student's t test to assess each catheter's tendency to drift.

RESULTS

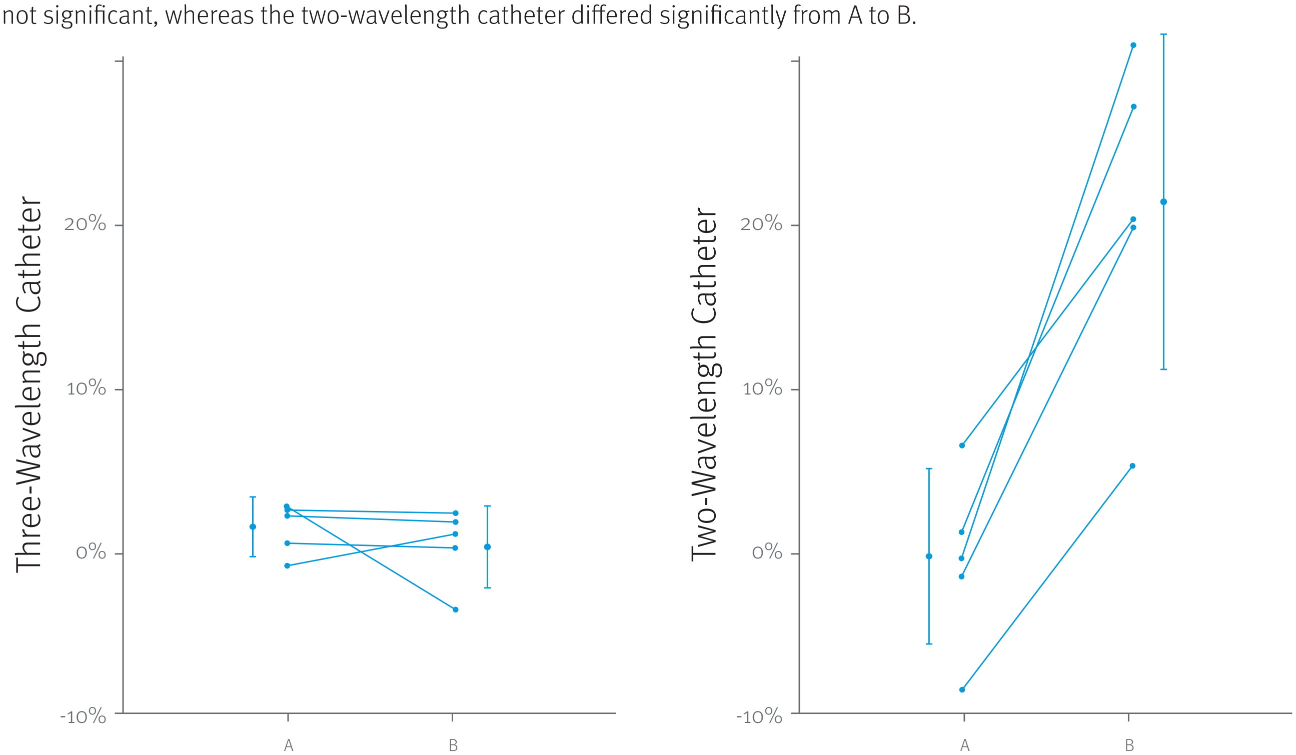
Pre-insertion calibration for both catheter types compared favorably with the CO-Oximeter prior to physiological manipulations, although the three-wavelength catheter more closely approximated the CO-Oximeter.

The three-wavelength catheter tracked SvO_2 accurately under adverse conditions for up to 10 hours. The two-wavelength catheter tended to drift under the same conditions.

Each of the two-wavelength catheters displayed a higher SvO_2 than the measured SvO_2 at the end of the protocol.

TABLE 1

The drift in SvO_2 catheters is displayed as the difference between the catheter-displayed value and the reference CO-Oximeter at the beginning (A) and end (B) of each experiment. The differences with the three-wavelength catheter were not significant, whereas the two-wavelength catheter differed significantly from A to B.



Means and standard deviation were not significantly different from A to B with the three-wavelength catheter. The two-wavelength catheter differed significantly from A to B ($P < 0.003$, paired Student's t test).

CONCLUSION

The magnitude of the error measured in the two-wavelength system is sufficiently large to be clinically important. Pending further analysis of the tendency of the two-wavelength system to drift, it would seem prudent to limit its clinical application. The three-wavelength system accurately reflects measured SvO_2 during a wide variety of simulated clinical conditions.

Summarized from the study originally published in the journal Anesthesiology in March 1987.