Title: SMART ANESTHESIA MONITORING SYSTEM
Authors: P.H. Pan, MD; J.J. van der Aa, PhD; F.J. Gomez, MEE; J.H. van Oostrom, MEE; J.E.W. Beneken, PhD; and J.S. Gravenstein, MD
Affiliation: Dept. of Anesth., Univ. of Fla. Col. of Med., Gainesville, FL 32610

In the U.S. today, most operating rooms and anesthesia machines are equipped with arrays of monitors. Integrating all the data could aid in detecting mechanical malfunctions or changes in physiologic status and in making a differential diagnosis in critical events. We developed a computer-based, smart anesthesia monitoring system (SAMS) for just this purpose and tested it.

SAMS consists of standard, front-end monitors of inspiratory airway pressure and expiratory and fresh gas flows, a capnograph, and a pulse oximeter. The patient's age, height, and weight must be entered into the database. Slope and minimum and maximum values for the monitored variables were extracted from the monitored signal by signal-processing algorithms. These features were input into a rule-based expert system implemented on an IBM-AT computer. The system was designed to provide specific information on breathing circuit integrity (stuck inspiratory or expiratory valve, exhausted CO_2 absorber, small to large obstruction, or leak in or disconnection of endotracheal tube, inspiratory or expiratory hose, ventilator hose and Y piece, or CO_2 absorber) or on adequacy of ventilation and oxygenation (accuracy of delivered tidal volume, hyper- or hypoventilation, hypoxic mixture, O_2 delivery less than O_2 consumption, O_2 desaturation, mainstem intubation, pulmonary air embolism [0.25 ml/kg], or hypercarbia). SAMS was tested during 31 mechanical malfunctions and 11 adverse physiologic conditions simulated on an anesthesia simulator and created in 4 sheep; each test was repeated 8 times.

SAMS appropriately identified 91% of mechanical malfunctions within 30 s and 100% of adverse physiologic conditions within 10 breaths or 1 min. The 9% unidentified malfunctions were "small" mechanical obstructions of no clinical significance and the false-positive rate of the system was zero. In a comparison between front-end monitors and SAMS in detecting malfunctions or physiologic deterioration, detection by SAMS was more specific and occurred earlier than detection by front-end monitors. SAMS also detected adverse physiologic conditions such as air embolism and mainstem intubation that were not detected individually by front-end monitors.

By looking at multiple variables and by detecting early trends, SAMS can alert the clinician before threshold alarms are triggered. Therefore threshold alarms can be set at extreme values and the incidence of annoying false alarms can be reduced. SAMS offers an intelligent and better alternative to common threshold alarms and can be an important aid in differential diagnosis of critical events.

A451

TITLE: ULTRASOUND GUIDED CANNULATION OF THE INTERNAL JUGULAR VEIN
AUTHORS: C.A.Troianos,M.D.,D.R.Jobes,M.D.,N.Ellison,M.D.
AFFILIATION: Dept. of Anesthesia, University of Pennsylvania Philadelphia, PA 19104

Cannulation of the right internal jugular vein (RIJ) carries the potential for serious complications from unintentional puncture of surrounding structures. The standard approach to RIJ cannulation is accomplished using external landmarks to guide needle placement and direction. Ultrasound imaging, by providing visualization of the RIJ and surrounding structures, may facilitate RIJ location and provide safer cannulation. This study compares the ease and safety of the standard approach based on external landmarks alone with an ultrasound guided approach.

With approval by our Investigational Review Board, a series of 89 cardiothoracic surgical patients undergoing RIJ cannulation were prospectively studied. The patients were randomly assigned to cannulation with external landmarks alone (CONTROL group) or with ultrasound guidance (ULTRASOUND group). The ultrasound device employed a 7.5MHz transducer, covered by a sterile sheath, which displayed 2-D images on a portable CRT display (Dymax® TM18 Personal Scanner). The 2-D images allowed identification of the carotid artery and the RIJ by their orientation on the CRT, by the compressability of the vein and by venous distention during Valsalva. In all patients, external landmarks were used to identify the site for injection of local anesthetic. Cannulation proceeded in Trendelenberg position utilizing an 18ga x 6.35cm radiopaque catheter over a 20ga introducer needle. For patients in the ultrasound group, the ultrasound probe was placed on the neck and the location of the RIJ identified. Placement and direction of the cannulating needle were then guided by the ultrasound probe. The number of needle passes required for cannulation, incidence of carotid puncture, and time between application of the local anesthetic and RIJ puncture were compared between the control and ultrasound groups using Chi-square and ANOVA. Confirmation of all central venous cannulations was made by connecting the catheter to a pressure transducer and measuring the pressure.

Cannulation of the RIJ was successful in all patients studied. Patients with ultrasound guidance required an average of 1.29 needle passes, while the control patients required an average of 2.37 needle passes per cannulation ($p<0.05$). Greater than two needle passes were required in 5% of the ultrasound patients as compared to 29% of the control patients ($p<0.05$). Average time was 64 seconds and 98 seconds in the ultrasound and control groups respectively. There were three carotid punctures in the control group and none in the ultrasound group.

It is concluded that ultrasound imaging facilitates location and safe cannulation of the right internal jugular vein.

	CONTROLS (n=51)	ULTRASOUND (n=38)
Passes per cannulation	2.37 ± 0.35*	1.29 ± 0.09*
Time to RIJ puncture	98 ± 16 secs	64 ± 8 secs
One pass cannulations	30 patients	29 patients
> One pass per cannulation	21 patients	9 patients
> Two passes per cannulation	15 patients†	2 patients†
Carotid punctures	3 patients	0 patients

* p= 0.02, ANOVA † p = 0.004, Chi-Square