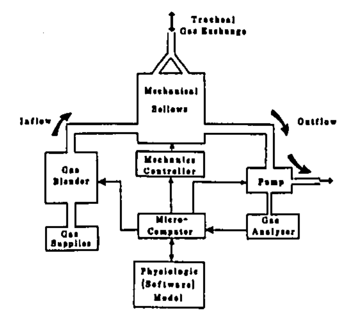
TITLE: HYBRID LUNG MODEL FOR USE IN ANESTHESIA RESEARCH AND EDUCATION
AUTHORS: M.L. Good,M.D., S. Lampotang,M.E., G. Ritchie,Ph.D., J. Heffels, B. Miller, J.E.W. Beneken,Ph.D., R. Tham,Ph.D.
AFFILIATIONS: Depts of Anesth. & Mech. Eng., Univ. of Fla., Gainesville, FL; Div. of Biomed. Eng., Eindhoven Tech. Univ.; Univ. of Ala. at Birmingham; and Ohmeda, Madison, WI

Lung models are used to test anesthesia delivery equipment and to demonstrate to students important pulmonary concepts. The ideal lung model must accurately simulate both the mechanical and the gas exchange characteristics of the pulmonary system. Because such a model is not available, we developed a hybrid lung model.

The lung volumes are represented by a mechanical bellows (Michigan Instruments Vent-Aid). The lung unit was modified so that lung-thorax compliance, airway resistance, functional residual capacity, and dead space volume could be varied by a microcomputer.

Oxygen consumption, CO_2 production, and the uptake or excretion of N_2, nitrous oxide, and isoflurane are determined by a cardiopulmonary software model running on an AT-compatible microcomputer. Gas uptake and excretion are physically created by a gas flux through the mechanical lung (Figure). This gas flux is analogous to cardiac output. A constant flow pump aspirates gas from the mechanical lung, and an infrared multigas analyzer determines the concentration of each gas. These values serve as inputs to the physiologic software model. A multigas blender creates a gas inflow whose composition is determined by the physiologic software model. The net rate of uptake or excretion of each gas is the difference between its inflow and outflow through the mechanical bellows. The physiologic software model accounts for variations in patient weight, height, basal metabolic rate, cardiac output and depth of isoflurane, nitrous oxide and O_2 anesthesia, and appropriately adjusts the O_2 hemoglobin dissociation curve for temperature, CO_2 and pH.

Previous lung models have been either equation-based or mechanical, and have selectively emphasized physiologic characteristics or gas exchange. Our hybrid model uniquely combines the gas exchange, mechanics, and physiologic relationships of the pulmonary system, which allows important aspects of pulmonary physiology and their interactions to be demonstrated and tested with a single model.



A983

Title: Mental models of anesthesia equipment operation: implications for patient safety

Authors: D.D.Woods, Ph.D.**, R.I.Cook, M.D.*, N.Sarter, M.S.**, J.S.McDonald, M.D.*

Affiliation: *Department of Anesthesiology and **Department of Industrial and Systems Engineering, The Ohio State University, Room N-429, 410 W. 10th Avenue, Columbus, Ohio 43210-1228

Little attention is paid to the way physicians actually understand and use their machines. This may have consequences for patient safety, especially in a world of complex devices.[1] Manual devices are giving way to microprocessor based systems with "soft" controls and displays. What are the implications of this changing technology? How do people understand the new devices? How do they diagnose faults when they arise? What are the consequences of "hiding" data and controls? Are "smart" devices easier to use? harder to understand? Recently, a new microprocessor based device replaced a similar older device, providing an opportunity to test the hypothesis that users form mental models which differ from actual device function.

Data from structured interviews with attending and resident physicians were analyzed via cognitive science protocol analysis techniques.[2] Mental models were extracted and knowledge "bugs" catalogued.

All the physicians were confident about their understanding of the device but virtually all of their mental models were unique and fundamentally flawed. Users misunderstood the device function and operation (resetting mechanisms, user callable controls, modes of operation), misinterpreted the meaning of settings and alarms, and attributed to the device features which it did not possess. Many of these defects in mental models could be attributed to device design, particularly hiding features "behind" the display screens.[3] Reasonable default values, warmup modes, automatic alarm disabling, and very simple external appearance created an opaque black box. In lieu of actual understanding, users developed a range of inconsistent ad hoc models of device operation. Apparent simplicity provided no opportunity for learning about actual device function.

In other disciplines faulty mental models have contributed to disasters[4]: inability to understand how equipment operates may make it hard to diagnose difficult and unusual problems. In a domain with multiple devices and complex interactions, human performance is maximized when the mental models correspond closely to the real world. Studying mental models of devices is a recognized and useful method of calibrating the effect of new devices and procedures on human performance.

1. Gaba DM, Maxwell M, DeAnda A: Anesthetic Mishaps. Anesthesiology 66: 670-676, 1987
2. Gentner D, Stevens AL, eds.: Mental Models. Hillsdale, New Jersey: Lawrence Erlbaum Associates, 1983
3. Norman DA: The Psychology of Everyday Things. New York, Basic Books, 1988
4. Rasmussen J: Information Processing and Human-Machine Interaction. New York, North Holland, 1986