DESIGN OF THE FOUR-COMPONENT ANESTHESIA WORKSTATION

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DESIGN APPROACH

Our team chose the following approach in which to develop the design solution:

1. Definition of scope and design constraints
2. Anesthesia workstation problem identification
3. Brainstorming for solutions to problems
4. Integration of solutions into a coherent design

DEFINITION OF SCOPE

The following scope was defined: Design a new and improved general-purpose anesthetic workstation that can improve the delivery of anesthesia.

DESIGN CONSTRAINTS

This team imposed the following limitations in the development of their design.

1. The workstation should be designed within the limits of existing technology.
2. The workstation should not increase the practitioner's workload; the practitioner should be allowed to focus more on patient care.

CURRENT ANESTHESIA WORKSTATION PROBLEMS IDENTIFIED

The following problems were identified.

1. Poor organization and ergonomics of the workstation environment:
   a. Monitors are located behind the practitioner such that the clinician spends considerable time looking away from the patient
   b. Monitors are scattered on top of the machine, spreading information over a wide field of view
   c. Cables and tubing from the workstation to the patient are numerous and frequently get tangled or obstruct the clinician
   d. Workstation is large, frequently top heavy, and not easy to move
2. Lack of standardization:
   a. Monitors come in all sizes and shapes
   b. Monitors adhere to no generally accepted communications standard
c. Monitors conform to no consistent alarm format
d. Monitor displays meet no minimal standards for visibility or readability

3. Lack of integration:
   a. No centralized display for alarms, physiologic data, machine data, etc.
   b. No prioritization of alarms
   c. No coordination of information between monitors to prevent or reduce false alarms
   d. No centralized control location

4. Other problems:
   a. Limited flexibility to configure the monitoring to the patient’s needs
   b. Limited intelligence
   c. Limited mobility
   d. No measure of the reliability of information displayed

**ANESTHESIA WORKSTATION**

The anesthesia workstation, as envisioned by this design team, consists of four basic components that perform the necessary functions of display, control, monitoring, and anesthetic gas delivery. This system, along with an optional fifth component, additional work surface, is displayed in Figure 1. The components of the system are:

1. A large flat-panel central display/controller
2. A modular, monitoring/drug-infusion rack
3. An anesthetic gas machine/ventilator unit
4. An equipment/drug-storage cart
5. A work-top linking (3) to (4) (optional)

This design incorporates little “new” technology (except, perhaps, for the display, because of its size) and represents a reorganization of the workstation into an integrated, compact, organized unit. Such a setup offers the user tremendous flexibility, ease of service, ease of upgrading, and overall greater cost-effectiveness.

The key to this solution to the organizational and ergonomic problems that plague current workstations is the use of a large (at least 11 x 17-inch) flat-panel, touch-sensitive, display/controller. It displays all patient, workstation, and alarm variables, and provides for centralized electronic control of all system functions. The use of a flat-panel display minimizes space and weight considerations, allowing the panel to be mounted on an adjustable, articulated arm. Practitioners can then position the display where they can use it best, and fold the display face-down on top of the gas machine/ventilator unit for easy storage and transportation. Linked by a single cable (or telemetrically) to the modular, monitoring-infuser rack, it monitors all information on the bus/local area network (LAN), linking all components in the system and displaying information through a windowed, graphical user interface (GUI), according to the practitioner’s wishes.

The display format is a two-page layout, where the first page displays physiologic variables continuously, and the second page serves as a multiuse workspace area.

The monitoring (first) page would incorporate animated icons of each major organ and mechanical system, oriented vertically. Animation and color or gray-scale intensity are used to convey qualitative information about organ function: monitored and derived variables (as developed) such as oxygen, anesthetic, and carbon dioxide flows, dead space, shunt fractions, pulmonary compliance, and airway resistance for the respiratory system; or wall motion, valvular function, cardiac output, and systemic and pulmonary vascular resistances for the cardiovascular system. Organized horizontally from each icon are selectable, corresponding numerical data and waveforms, in expanded real-time and compressed “trend” formats (Fig 2).

The second page serves as the display workspace area. It can lay out the anesthetic plan (analogous to a flight plan in aviation), display the ongoing record, pull up control and monitoring routines, review the patient’s electronic chart, call up laboratory data, control data flow to and from other sites (intensive care unit, postanesthesia care unit, etc.), access on-line references, and

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![Figure 1: The anesthesia workstation consisting of five major components: (1) flat-panel control display/controller; (2) modular monitoring/drug infusion rack; (3) anesthesia machine/ventilator; (4) equipment/drug storage cart; and (5) work-top.](image-url)