EQUIPMENT, MONITORING, AND ENGINEERING TECHNOLOGY III

Title: AN APPROACH TO "SMART ALARMS" IN ANESTHESIA MONITORING

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Introduction. Lack of monitoring alarm integration often leads to a cacophony of auditory input which usually represents false positives. As initial steps toward "smart alarms" (expert systems/artificial intelligence) we have 1) surveyed alarms during typical cases in our operating rooms, 2) designed a computerized central console for input, display and integration, and 3) formulated some preliminary diagnostic "rules" compatible with our console display format.

Methods. 1) Alarm Survey. With Human Subjects Committee approval, alerts during 25 surgical procedures were monitored by an independent observer (KM). Patients were ASA I-III, and anesthesics were classified as predominantly volatile (isoflurane or enflurane) narcotic based (sufentanil, demerol, fentanyl with nitrous oxide) or regional (epidural, spinal, axillary blocks with lidocaine, tetracaine, or bupivacaine).

Results. Alarm Survey. During 25 cases covering 323 hours of anesthesia, 103 alarms occurred. This averaged 3.2 alarms per hour and 4.1 alarms per case. There were 4.4 ± 0.8 (S.E.M.) alarms per hour during volatile anesthetic cases, 3.2 ± 0.4 alarms per hour during narcotic/nitrous cases, and 1.3 ± 0.5 alarms per hour during regional cases. These groups were different (p < 0.05) by analysis of variance. Of all alarms, 60.2 percent were considered valid (non-artifactual) and 36.9 percent were considered to indicate potential patient danger.

2. Centralized Console. Our computerized console is compatible with noninvasive or invasive blood pressure, pulse oximetry, EKG, temperature, oxygen concentration, airway pressures, and tidal CO2, ventilatory rate and volume. The grid format display is shown in Figure 1 with alarm limits in hatched areas, and specific patient values in asterisks. The values shown are from a high spinal with bradycardia, hypotension, and an inoperative pulse oximeter.

3. Interactive Rules. Figure 2 shows preliminary examples of interactive rules based on anesthesia monitors interfaced to our centralized console. Values which exceed the alarm limit "envelope" can activate rule-based combination loci leading to presumptive diagnoses.

Discussion. Anesthesia monitoring may be a fertile area for rule-based expert systems which can potentially minimize unnecessary alarm events, consolidate alarm information, and offer presumptive diagnoses. While such systems will be initially superfluous, they are likely to eventually become entrenched in anesthesia practice as a means to optimize vigilance.