Sedation Monitor for the Office-Based Plastic Surgery Setting

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ABSTRACT

Safety is always the primary concern of surgeons and patients in any office-based procedure. With the growing use of safe intravenous sedation in this setting, a need for a standardized protocol for dissociative anesthesia exists. We have accomplished this task by using a sedation monitoring system, which could easily be implemented in any existing office-based operating setting. Our sedation monitor, abbreviated SeMo, provides a standardized means of monitoring deep intravenous sedation administration to patients in the operating room setting. The idea of SeMo is to develop a stand-alone system capable of integrating all facets of the operating room staff through a common communication media to improve efficiency and safety.

KEYWORDS: Dissociative anesthesia, intravenous sedation, sedation monitor, office-based protocol

The use of conscious sedation is rapidly gaining acceptance and popularity in outpatient surgery. Many procedures are being performed using intravenous sedation and local anesthesia with a variety of drug options.¹⁻⁴ This allows surgeons to enjoy reduced cost, decreased complication rates, and improved patient satisfaction.¹⁻⁸ A common criticism by skeptics of dissociative anesthesia is the lack of consistency and efficiency of monitoring and documentation of patient dose response.^{3,6,9} Perhaps because dissociative anesthesia may be used with the aid of an anesthesiologist or certified registered nurse anesthetist (CRNA), it is usually given by the operating surgeon and the nursing staff.

Sensitive administration and monitoring of the intravenous (IV) medication during surgery was originally alleviated by introducing a magnetic board displaying trapezoid dose-response curve color magnets signifying dose, medication, and sedative effect.⁹ By having a display readily available where, at a glance, everyone can see exactly what medications are administered, duration of action, and the time sequence, it is

possible to make those clinical judgments instantaneously without any further distraction. If the staff changes, one need not look through the chart or take his or her eyes off the patient to know how much medication was given and when and what the duration of action is of each component. It can all be seen at a glance.

The sedation monitor (SeMo) system has been designed to replace the magnetic board (Fig. 1). Although the board system served our needs for years, it was clear that a more efficient and versatile medium could be developed. A fully functional computer system coupled with custom-designed software was found to be the ideal solution.

MATERIALS AND METHODS

The System

A fully functional computer system is the backbone of implementing a successful sedation monitoring system in the operating room setting. Adding a conventional

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Figure 1 The original sedation monitoring system involved a magnetized dry-erase board and a series of cut magnets. The magnets were placed at the time a dose of the indicated medication was administered and remained on the board for reference during a procedure.

desktop, however, is unreasonable for most operating rooms because of space constraints and access during procedures. We addressed this problem by customizing a small-form-factor computer desktop case that is less than 9-in. deep $\times$ 5-in. wide $\times$ 5-in. wide, with the components that are necessary for our purpose. This includes a minimum of 800 MHz processor, 512 Mbyte RAM, CD burner, network card, 2 USB ports, a serial port, and the Windows XP operating system. Other features may be included in the PC to allow for future versatility and upgrades to the system.

Integrating the small-form-factor computer seamlessly into the operating room setting is accomplished by mounting on a standard IV pole with base tray (Fig. 2). Another option is to mount directly to an IV pole with brackets that wrap around the computer and can be securely screwed to the pole's surface. It is important that the computer is mounted low enough on the pole to maintain a proper center of gravity when the pole is moved to prevent it from being knocked over.

Efficiently interacting with the computer system is the next important challenge in an operating room setting. A mouse and keyboard are important components of interacting with any computer system but unrealistic during a complicated procedure requiring the staff's full attention. A touchscreen monitor provides a reliable interface that may be used quickly and easily by users. Mounting to the IV pole is accomplished by pipe clamp brackets and a swiveling LCD monitor mount. It is again

Figure 2 A computer has been adapted to fit an IV pole so that it may be easily added to the operating room. When combined with a sedation monitoring program, it is known as SeMo. The time-synchronized chart displays available medications to administer, patient information, and important sedation information in an easily referable format. The chart can then be printed at the end of the procedure and added to the patient's records for quick and easy reference.

Figure 3 Individual surgeon's settings are loaded for convenience and efficiency. The doctor's name and surgical procedures commonly performed must be entered.

important to ensure that the screen is mounted close to the pole to avoid affecting the mounting of the pole and compromising its balance. The monitor cable and serial cable are fed through a small drilled hole in the IV pole and fed through a rubber grommet until they reach the already mounted computer. If desired, the cables may also be simply zip tied to the exterior of the pole.

Although a touchscreen monitor will accomplish most necessary data entry, especially when using the appropriate programs, a mouse and keyboard should be present for lengthy computer interaction that may arise. This is easily accomplished by adding a wireless mouse and keyboard, radio frequency or infrared, to a USB port. The keyboard and mouse may be placed away from the high-traffic areas and accessed out of the way.

Power is the final essential component of the system necessary for SeMo to function properly. A power block is mounted to the IV pole as described for the computer and serves computer, monitor, and accessory power needs. This power cable is then run down or through the remaining length of the IV pole and attached to the top of the track wheel to prevent it getting tangled under the pole base before being plugged in. A battery back-up power system is highly recommended and can also be added to the system to prevent information loss with loss of power. In the event of becoming unplugged or losing power to the outlet, an audible cue will indicate to the staff that the cord should be plugged back in and progress should be saved to ensure no information is lost.

The Software

A computer system is only the first step in establishing a sedation monitoring system for the operating room.

Software is required capable of tracking sedation dosage administration in a time-synchronized manner. We customized a program that emulates the magnetic board that has been used in our operating rooms for years.

The sedation monitoring program uses a one-time setup for each surgeon to set up common procedures, medications, and dosage preferences used in the operating room (Fig. 3). Set-up processes are most efficiently done with the mouse and keyboard. For each medication that a surgeon may use, the medication's name, time to take effect, duration of effect, and time to wear off must be indicated (Fig. 4). These values are used to create the trapezoid graphics that were originally used for the magnetic board mentioned previously. These values can be determined based on documented values for given medications or based on surgical experience. "Time to take effect" is the approximate amount of time required from when a dose of medication is administered until it becomes effective. The period is signified as the positive, upward slope of the trapezoid. "Duration of effect" is the amount of time that a single dose of medication will maintain the desired effect before it begins to wear off. This value is shown as the plateau of the trapezoid. "Time to wear off" is the amount of time required for the drug to stop providing desired effects. This period is shown as the negative, downward slope of the trapezoid. A color must also be assigned to each medication making up the final component of the trapezoid used in the chart. Six commonly used dosages must also be identified at this time. Most surgeons only use a handful of medication doses during any given procedure. The need to specify these values in advance enables the use of a touchscreen instead of a keyboard during an operation. To increase the

The screenshot shows a software window titled "Medication Dosage Setup" with a sub-header "John A. Doe's medications and doses". On the left is a list of medicines: Valium, Ketamine, and Versed. To the right of this list are six input boxes for dosages: 5, 10, 15, 30, 45, and 60. Below these boxes are three buttons labeled "X1", "X2", and "X3". Further down are three sections: "Time to Take Effect" with a dropdown set to 4 Minutes, "Duration of Effect" with a dropdown set to 28 Minutes, and "Time to Wear Off" with a dropdown set to 28 Minutes. At the bottom left is a "Display Colour" button with a small icon. At the bottom right are four buttons: "New", "Save", "Remove", and "Close".

Figure 4 The medication used by a particular surgeon is entered with its appropriate information. The six boxes in the top right corner refer to the common dosage intervals used during procedures. Time intervals chosen may be based either on documented values or on surgical experience.

variability of dosages to appear on-screen, three multipliers are shown. This feature allows for a value of 2.5 mg to be multiplied with "× 2" or "× 3" to equal 5 mg and 7.5 mg, respectively. This concept will make more sense later. Each medication used during any given

surgeon's procedures should be entered and will be saved to that user's setting. These values may be modified at any point in the future.

New patients are entered after choosing the name of the surgeon performing the operation from the opening page. SeMo uses a patient number system already in place to organize its database (Fig. 5). Many practices already have a number system in place, but either birth date, phone number, or other system can easily be implemented. Within a patient's number, patient name, date of birth, sex, admission date, and procedures are entered.

Once the surgeon and patient information is complete, a chart is ready to be started and only requires use of the touchscreen. The patient profile is located based on patient number, name, or birth date (Fig. 6) and loaded into the chart. When a dose of medication is administered and charted, the dose is logged into SeMo. Tapping "administer dose" provides a screen with available medications and associated doses (Fig. 7). If a dose of 20 mg Valium® (Hoffmann-La Roche, Nutley, NJ) is administered, a staff member will select "Valium," "10," and "× 2." The result will be an appropriate-sized trapezoid with the dose indicated (Fig. 8). As time passes during the procedure, the trapezoids will march across the screen from right to left with the current time indicated by a line in the middle of the screen. The location of the line on the trapezoid will indicate to the staff and the surgeon if the current sedative exists at its onset, plateau, or is wearing off at a moment's notice. SeMo may be adjusted to scale and time to eliminate problems regarding length of surgery. The dose entries are continuously saved throughout the surgery and may be printed when complete to add to the patient's chart.

The screenshot shows a software window titled "Patient Setup" with a sub-header "John A. Doe's patients". On the left is a list of patient codes, with "000001" selected. To the right of this list are several fields: "Name" (Jane Doe), "Date of Birth" (6/23/2004), "Sex" (F), and "Admission Date" (3/24/2005). Below these fields is a section titled "Procedures" with a list of checkboxes: BAM, SAL, Bleph Lowers, Bleph Uppers, Rhinoplasty, Breast Reduc..., and Face Lift. At the bottom are four buttons: "New", "Save", "Remove", and "Close".

Figure 5 Patient information is entered in a new patient profile before a procedure is started. The patients are organized based on patient number to eliminate complications from multiple people with the same name.

Patient Search

☐ Patient Code

☒ Patient Name

☐ Patient DOB

Results

Code	Name	DOB	Sex	AdmDate
000001	Jane Doe	6/23/1972	F	3/24/2005 3:02:55 PM

Figure 6 To initiate a new chart, the patient record must be loaded. Locating the patient's chart may be based on the patient number, name, or date of birth.

The Versatility

Once a computer has been adapted to the operating room setting, it may be upgraded and customized to achieve maximum benefit from its addition. An early addition we made is connecting it to the office network.

Administer a Dose

Medication

Medicine	
Valium	
Ketamine	
Versed	

Dose

5	10	15
30	45	60

Multiplier

X1	X2	X3
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Total Dosage 10.0 * 2.0 = 20.0

Figure 7 Administering medication only requires using the touchscreen monitor. To enter 20 mg Valium®, the operating room staff has selected "10," "× 2," and "Administer." The dosage will be indicated on the chart after selecting "Administer."

This addition allows us to print the completed SeMo chart immediately after surgery, look up digital pictures of patients from their files for reference, and check the schedule for upcoming procedures. Many vital sign monitors may also be connected to the computer with a serial cable. The vital signs are then displayed on the LCD screen along with the sedation information providing a single point of reference during procedures. Endless other ways may be discovered to take advantage of having a fully functional computer in the operating room.

DISCUSSION

Implementing a sedation monitoring system such as SeMo can provide a reliable protocol to the operation room of anyone using IV sedation. We have updated a previously proven system to use the ease, reliability, and versatility that a computerized sedation monitoring system offers. SeMo offers a quick reference for the operating room staff to check dosage information with regard to patient sedation at a glance without having to read through nurses' notes or distract them from monitoring vital signs and the patient. It also provides an indicator for the surgeon or during a nurse change to know whether another dose of medication is appropriate for a patient whose sedative appears to be wearing off. A glance at the monitor can reveal whether drug action is declining or has not yet taken effect. It also provides a standard directive for recording dose administration along with the nurses' charts to ensure that a standard protocol is followed.

It is important to integrate a system into one's practice that addresses the needs of one's facility and a protocol that makes sense. Issues that must be addressed include space concerns, screen size, system location, dose options, and so forth. Staff must also train and practice

Figure 8 A surgical procedure produces a chart such as the one shown here. The dark line in the center indicates the current time when being used in live mode, and the graphics move from right to left as time passes. This action indicates the expected effects of each dose administered. This chart has been re-centered at the end of a procedure to show all doses given and ready to be printed and added to the patient's hand documented chart. Note the medication totals calculated on the right-hand side.

using a sedation monitor together to ensure that its purpose and utility are fully understood. At first, the system may seem unnecessary and complicating to some operating room personnel. However, with time, everyone we have encountered appreciates the long-term benefits that SeMo has to offer.

CONCLUSION

SeMo provides a reliable mechanism for consistent sedation monitoring, which can be referenced by all operating room personnel, synchronizes nursing changes, and provides a printable chart record. Because there is no writing involved, the changes can be made instantaneously without the need for the nurses to take their eyes off the patients or to divert their attention. We have been using prototypes and this final device for 2 years and find it to be very useful for dissociative anesthesia in elective patients. Soon after adding SeMo to our operating room, our nurses reported it was difficult to remember how we worked without it.

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