Anesthesia Information Management Systems

A Guide to Their Successful Installation and Use

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Anesthesia information management systems (AIMS) are rapidly increasing in both their adoption and overall functionality. These systems have become much more than automated record keepers. They have been shown to improve patient care and, in some cases, the financial health of a department. Although the underlying technology has improved greatly over the past 5 years, the process of selecting and implementing an AIMS remains complex, and must be approached carefully in order to obtain all of the benefits these systems can provide.

Introduction

AIMS are a specialized form of electronic health record (EHR) systems that allow the automatic and reliable collection, storage, and presentation of patient data during the perioperative period. In addition to providing basic record-keeping functions, most AIMS also allow end users to access information for management, quality assurance, and research purposes. AIMS typically consist of a combination of hardware and software that interface with intraoperative monitors, and in many cases hospital clinical data repositories or EHRs. Although the primary role of an AIMS is to capture data during the intraoperative phase, most systems also can incorporate pre- and postoperative patient information (Figure 1). Typically, all of this information is stored in a robust relational database that can be accessed simultaneously by multiple users either via a vendor's commercial application or standard database tools, such as structured query language.

Widespread adoption of AIMS, which have been in existence since the 1970s, has been hindered primarily by the financial barriers associated with implementation of these systems.[1] As a result of these hurdles, only an estimated 5%

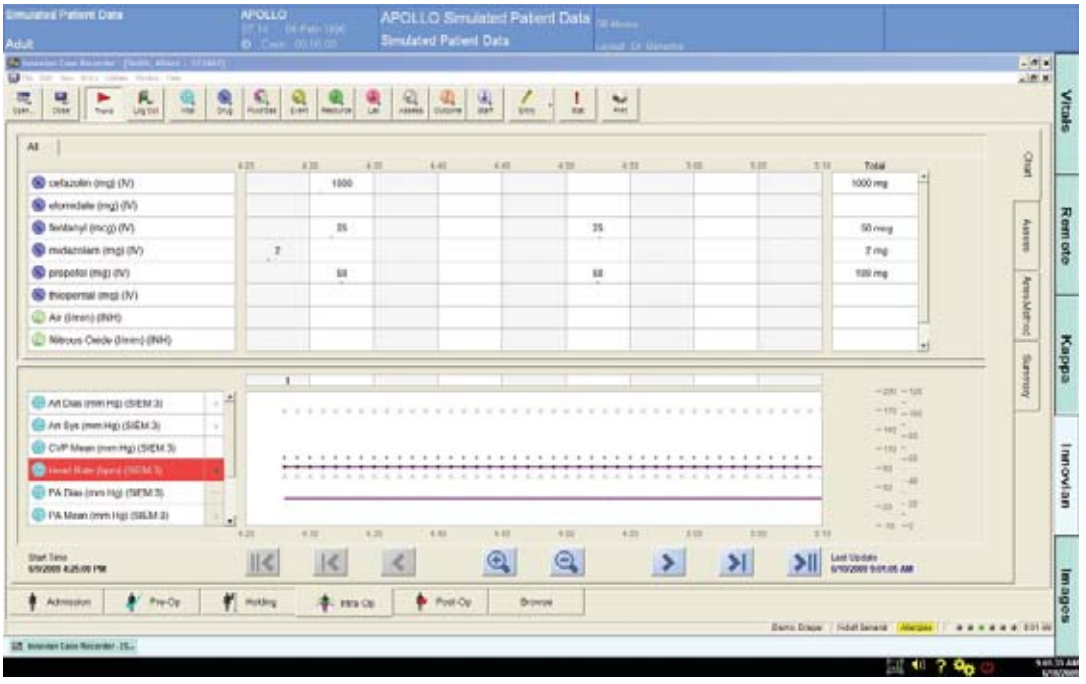

Figure 1. AIMS intraoperative display.

Image courtesy of Dräger.

of US operating rooms in 2006 had an AIMS.[2] Adoption has accelerated recently (44% of academic centers have implemented or are now planning to implement an AIMS), driven primarily by a need to address increased regulatory reporting requirements and a desire to improve routine clinical documentation.[3] The areas where AIMS have proved beneficial to both patients and anesthesia departments are summarized in Table 1.

The specific benefits of a particular AIMS installation (Table 2) depend on a number of factors including the system purchased, the overall implementation scheme, and the departmental work flow. One mistake institutions often make when installing an AIMS is to simply replace paper with the electronic system—without changing processes in order to obtain the full benefit of these systems. For example, after installing an AIMS, one institution continued to send copies of incomplete anesthesia records to physicians via interoffice mail with a handwritten note asking for correction of the documentation error. The rate of unbillable charts was unchanged until the institution began using electronic tools that interfaced with the new AIMS installation to facilitate error correction.[5]

Why Purchase an AIMS?

Many departments choose to install AIMS because fundamentally, anesthesia relies on the provision and timely documentation of accurate information. These data are the basis for how anesthesiologists make decisions; given the ever-growing amount and complexity of the information, electronic systems can facilitate the capture and interpretation of data.

In addition to assisting providers with the specific task of record keeping, AIMS have been shown to improve patient safety in a variety of settings by facilitating appropriate clinical care[13,21] and providing accurate documentation for retrospective review. Most systems can generate point-of-care alerts for patient allergies or drug–drug interactions. In fact, the Anesthesia Patient Safety Foundation has both endorsed and advocated the use of AIMS because of the ability of the technology to provide high-quality data.[22]

Although the potential safety and clinical benefits of an AIMS installation are compelling to some facilities, others choose an AIMS because of its potential to positively impact a department's economic performance despite large upfront capital costs ($4,000-$9,000 per operating room plus an additional $15,000-$40,000 for AIMS servers). The actual return on investment will depend on the specific institution's existing management, financial, and billing practices.[22] A recent review of the literature revealed 4 ways that installing an AIMS can contribute to a positive return on investment. These include reduced anesthesia drug costs, improved staff scheduling and reduced staff costs, improved billing/charge capture, and improved hospital reimbursement resulting from better hospital coding.[5,23,24] For example, one institution customized its AIMS so that the system would generate reminders about more accurately billing for placement of arterial lines, central lines, and

epidural catheters, which had previously gone unbilled[5]; other hospitals have used their AIMS to reduce the time patient bills spend in accounts receivable, thus speeding up revenue cycles.[7]

Finally, many departments are using AIMS to facilitate reporting of the increasing number of quality measures (such as on-time administration of prophylactic antibiotics and maintenance of normothermia) as a condition of participation in various pay-for-performance contracts. In the absence of an AIMS, reporting on these types of quality metrics typically requires a laborious—and often expensive—manual chart review. Electronic systems also offer the additional advantage of providing a means for changing provider behavior, through clinical decision support, to meet quality metrics, as opposed to merely reporting on them.

Functionality

The core strength of most AIMS is still recording intraoperative data. However, many systems now offer preoperative evaluation modules, clinical decision support, and advanced management tools for process improvement.

Preoperative modules vary widely in terms of their breadth and features. Some simply provide a way to input patient demographics (name, age, American Society of Anesthesiologists physical status) and type free-text notes. Others provide robust electronic history-taking questionnaires and suggest preoperative laboratory tests based on customizable algorithms that take into account the specific procedure and any comorbidities for a particular patient.[25] Systems that capture preoperative data as structured data elements via check boxes or pull-down menus (rather than free-text comments) also can provide on-the-fly patient risk stratification by using algorithms such as the modified Lee-Goldman index.[26] Most systems provide an easy way to access a completed evaluation, either by providing an information summary or sending data to a hospital EHR system. All preoperative modules should allow providers to reduce redundant entry of information by carrying data (such as a patient's weight) forward into the intraoperative record. When selecting a system, it is necessary to decide which features are important to the particular department, as well as how the system will impact existing work flow. For example, use of a preoperative module may require installing an AIMS in preoperative anesthesia clinics or holding rooms in order to obtain the maximum benefit of the technology.

Intraoperative charting remains the core piece of any AIMS installation and involves 2 primary activities: the automatic transcription of data from physiologic monitors (eg, vital signs and ventilator settings) and the manual entry of case events (eg, intubation events, case times, and drug administrations) into the EHR. Because the vast majority of data is used in real time during a case, the user interface must allow easy and continuous access to the accumulating anesthesia record.[22] The user interface also should facilitate the work flow of end

Table 1. Areas Impacted by Anesthesia Information Management Systems[4]

Impact on patients
More accurate recording of patient responses to anesthesia
Improved availability of historical records
Allow anesthesiologist to focus on patient, rather than charting
Impact on the practice of anesthesia
Improved quality assurance functionality due to more accurate and complete records
Ability to quickly search for specific occurrences or rare events across multiple cases
Provide a means to track individual provider performance over time
Assessment of patient outcomes through integration with other hospital databases
Availability of accurate, high-resolution charts for educational purposes
Legal protection through provision of more accurate, unbiased information
Impact on departmental management
Facilitate accurate and timely billing
Allow analysis of supply costs by patient/provider/type of surgery
Can assist with concurrency and other regulatory compliance issues
Satisfy Joint Commission requirements for comprehensive, legible records
Provide ready verification of ACGME case requirements for residents in training programs

ACGME, Accreditation Council for Graduate Medical Education

Table 2. Specific Benefits of AIMS In Peer-Reviewed Literature

Cost and billing improvements
Controlling and reducing anesthesia drug costs[6]
Improving capture of anesthesia-related charges[5,7]
Impact on hospital reimbursement[8,9]
Decision support and provider education
Clinical decision support[10,11]
Training and provider education[12]
Patient safety and quality assurance
Increased patient care and safety[13]
Enhancement of clinical quality improvement programs[14]
Support of clinical risk management[15]
Monitoring for diversion of controlled substances[16]
Data quality and clinical research
Enhancement of clinical studies[17,18]
Improved intraoperative record quality[19,20]

Table 3. AIMS-Based Decision Support Features

Medication administration
Drug-dose calculations
Drug–drug interaction checking
Drug allergy checking
Drug-redosing reminders
Quality of care delivery
Guidance around maintenance of normothermia
Reminders to document presurgical antibiotic management
Compliance and billing issues
Ensuring electronic charts contain elements required for billing
Attending physician compliance statements
Case type (general/MAC/regional)
Patient details (ASA physical status, case times)
Concurrency checking
Algorithm support for critical events
Critical event detection (chaotic ECG + no pulse-ox wave form → consider ventricular fibrillation)
Algorithm display and guidance (ACLS, malignant hyperthermia)

ACLS, advanced cardiac life support; **ASA,** American Society of Anesthesiologists; **ECG,** electrocardiogram; **MAC,** monitored anesthesia care

users so that manually recorded events may be entered easily and rapidly. The AIMS should allow performance of basic tasks—initiating a case, recording an event—with little training. Ideally, the user interface should be flexible enough that users can enter data at their own pace and in ways that complement their existing work flow, rather than requiring them to change their processes to meet the needs of a particular system. Finally, the intraoperative charting module should facilitate situational awareness by organizing and highlighting critical data elements as they become available. This might involve placing a key piece of information in a larger font or in a different color so that it is quickly identified by the user.[27] For example, some systems will flash on-screen notifications when heparin is due to be readministered while a patient is on cardiopulmonary bypass.

Decision support, or the provision of tools that allow end users to more effectively accomplish a particular task, is a fast-growing area within AIMS product development. Although this advanced feature is not universally available, decision support can facilitate both improvements in the quality and reductions in the cost of providing care. The most basic decision support tools—such as systems that provide drug-dosing guidance based on a patient's weight—offer passive guidance. More complex tools are designed to actively manage provider behavior; they may use on-screen pop-up displays or link to a hospital's paging or e-mail system to alert clinicians about changes in a patient's clinical condition. Because not every product supports all of these functionalities, it is important to decide which features are indispensable for any particular department prior to generating a request for proposal (RFP).

Quality improvement is supported by AIMS in several ways. First, these systems enable the rapid and objective collection of complete data sets that can provide insight into existing deficiencies in care processes. By gaining insight into practices through uniform collection of data, AIMS can facilitate the careful planning of process improvement exercises. In addition, the availability of a large electronic data set, which can be quickly scanned, can help to rapidly identify practice trends—a process that often is time-consuming and cost-prohibitive when performed with paper charts. Second, once areas for improvement have been identified, many AIMS can be customized to provide clinicians with electronic tools to reach better levels of performance. (Table 3 lists AIMS-based decision support features.) These may include improvements in patient flow or reductions in missed billing opportunities. Finally, many systems allow direct capture of or provide links to quality-assurance tracking systems.[28]

Purchasing an AIMS

The decision to purchase an AIMS is a complex one that touches on every aspect of an anesthesia department (clinical operations, billing, contracting, physician credentialing, quality assurance), as well as many places outside of a department (medical records, clinical

engineering, admitting, compliance office, information technology, security).

The first step when considering an AIMS purchase is to determine the overall scope of the project and to identify the specific needs of the department. This process usually involves discussions among key members of the departmental leadership team in conjunction with representatives from the hospital information systems department. The selection of a system is best done after addressing some of the key questions listed in Table 4.[29]

Selecting a Vendor

Once the overall scope and system functionality have been decided, an RFP is generated. The RFP should describe the functional requirements of the planned installation, the level of clinical activity to be supported, and the type of locations involved.[22] The RFP should be sent to a wide range of vendors (Table 5) to ensure complete and competitive bids are received.

Responses from vendors to the RFP should include itemized implementation costs for hardware and software licenses, training and support options, warranty details, and service pricing. Vendors should outline their built-in redundancy systems and ability to manage catastrophic events such as power outages, and hardware or network failures. The vendor should detail all interfaces and network requirements required for the system to function fully. Live demonstrations or site visits to existing clients can be extremely helpful when trying to make a sound product assessment. When evaluating a system during a demonstration, key points to assess should include overall ease of use, coherent display of and access to intraoperative data, system stability, and security.[22]

During the contracting process, vendors should itemize all costs associated with system implementation, as well as the dates and the terms of delivery. Ongoing maintenance fees and support costs—typically 20% of the initial purchase price—should be outlined clearly. The total cost of a new system will depend on the number of clinical and administrative workstations to be installed. Workstations may cost between $4,000 and $9,000 per anesthesia location, and from $2,000 to $3,000 per administrative site. The hardware required for the AIMS server itself may cost 3 to 5 times that of a clinical workstation. All of these costs will be highly vendor-specific, with wide ranges in price reflecting the different features made available by competing manufacturers.[22]

System Implementation

Once a system has been selected, an implementation plan should be developed that outlines the overall approach (incremental or one time) and timing for system implementation. This plan must account for changes in the clinical and administrative work flow of the department. The need for additional technology support staff and training also must be considered carefully. A committed clinical champion, who is familiar

Table 4. Questions To Consider When Purchasing an AIMS

What will be the scope of the system?
Which activities will the system handle (preoperative evaluations, intraoperative recordings, postoperative checks)?
How will the AIMS integrate with existing departmental work flow?
Which sites will the system support (main operating room only, off-site locations, labor and delivery, free-standing ambulatory sites)?
Will the system stand alone? Will it interface with existing hospital systems?
What additional infrastructure will be required to support an AIMS?
Who will provide AIMS support personnel (department or hospital)?
What physical infrastructure will be required (network connections, secure location for the AIMS server, hardware/displays for use within operating room suites)?
How will the system be deployed and maintained?
When and how will installation and testing occur?
Who will provide initial and ongoing training?
What kind of backup systems will be available?
Who will provide ongoing system maintenance and upgrades?

Figure 2. Physical setup of a clinical workstation.

Image courtesy of GE Healthcare.

Table 5. Commercially Available AIMS

AIMS Vendor	System Name	Web Site
Acuitec	GasChart	www.acuitec.com
Cerner	SurgiNet	www.cerner.com
DocuSys	DocuSys AIMS	www.docusys.net
Dräger	Innovian Anesthesia	www.draeger.com
GE Healthcare	Centricity Anesthesia	www.gehealthcare.com
iMDsoft	MetaVision	www.imd-soft.com
Merge Healthcare	Frontiers	www.merge.com
Philips Healthcare	CompuRecord	www.healthcare.philips.com/us/
Picis	Anesthesia Manager	www.picis.com
Surgical Information Systems	SIS Anesthesia	www.SISfirst.com

Figure 3. AIMS workstation mounted on an anesthesia machine.

with the departmental work flow and who can set up and maintain the AIMS interface, should be identified. This individual often is an anesthesiologist who is familiar with information systems and other medical device interfaces.[30]

During the implementation phase, a careful plan for testing and deployment should be outlined and made widely available within the department to ensure that all individuals who will be affected are aware in advance of the upcoming installation. This list may include several people outside the anesthesia department, such as staff members in perioperative services, nursing, compliance, medical records, and billing. Finally, a contingency plan should be developed in case unexpected problems or a system failure occur during the installation phase.

Ergonomics

The physical setup and characteristics of a clinical workstation have a tremendous impact on overall usability of a particular system.[31] Many vendors recommend mounting touch screens on adjustable arms either on the anesthesia machine or nearby (Figures 2 and 3). These displays typically accommodate both a full keyboard for data entry as well as flexible positioning during a case. The physical setup matters tremendously, as it will facilitate the end user's work flow and is likely to impact the quality of data captured.

End-User Training

In order to receive the maximum benefit from a new AIMS, all users will need to be trained on the technology. Although all modern AIMS have graphical user interfaces that will be familiar to most anesthesiologists, the specific details about how to accomplish any particular task will vary from system to system. Initial training should occur as close as possible to the installation date, so that end users will be able to apply

and practice what they learned.[22] Clinical, administrative, and technical support staff should receive separate training that emphasizes the functions unique to each specific group. Initial training may take the form of one-on-one tutorials, classroom sessions, or Web-based tutorials; it is helpful to have dedicated support staff available on demand during the first few weeks of system implementation.

Data Definitions and Timely Documentation

The data stored within an AIMS are only as robust as what end users enter into the system. Consistent documentation depends on clear definitions of data. These definitions will vary by institution—for example, what is the induction of anesthesia?—and the data will be used for reporting, billing, and in many cases, to support clinical decisions. Consistent documentation, therefore, is essential to obtain the full benefit of an AIMS. Furthermore, many decision support systems rely on the availability of timely information, which may be adversely impacted by delayed data entry.[32]

Advantages and Limitations

The major advantages and potential limitations of AIMS are summarized in Table 6. Overall, adoption of these systems has been slow because their potential to improve patient care has not been as obvious as with other technologies, particularly the new physiologic monitors and late-generation anesthesia machines.[29] However, as AIMS continue to demonstrate an ability to markedly improve processes of care, billing efficiency, and quality assurance, they will no longer remain a prized luxury owned by a small number of early adopters.[30] Instead, these systems will become an essential modality for providing the lowest-cost, highest-quality care across institutions.

Summary

The adoption of AIMS appears to be accelerating for several reasons, most notably their increased functionality, decreased cost, and increasing pressure to report data for external review, such as with pay-for-performance contracting. AIMS have been reported in the literature to be able to increase quality of care and improve operating room efficiency, but only with careful planning, installation, and customization. Successful implementation of an AIMS requires significant resources, above and beyond those that will be directly specified in a vendor's contract because of the time required for training, installation, and software customization.[30] Although growing federal pressure to increase overall use of EHR systems likely will impact the practice of anesthesiology, the direct effect on AIMS remains unclear. Despite significant advances in technology that have led to the development of modern AIMS, widespread adoption of these technologies will not occur without better interoperability, standardization, and integration between vendors.

Table 6. Advantages and Limitations Of Currently Available AIMS

Advantages
Automated and accurate intraoperative data collection may enhance quality of anesthesia records[10]
Provide real-time decision support[33]
Increase time providers can focus on providing patient care[34]
Support efforts to improve quality and processes
May increase billing revenue through enhanced charge capture[35]
Enhance accessibility and quality of data for research
Support automated process monitoring and control[10]
Limitations
Inadequate vertical integration (information does not transfer easily from one phase of care to the next)[36]
Limited mobility (AIMS typically accessed on desktop computers; pre- and postoperative assessments usually performed at bedside)[36]
No AIMS standards across vendors
Unrecognized system failures can lead to gaps in data collection[37]
Initial expense may not be recovered quickly in small practices
Requires significant time and effort for initial training and implementation
Potential introduction of monitoring and recording artifacts into electronic record
Limited interoperability and compatibility with other electronic or hospital systems

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