Anesthesia Information Management System Implementation: A Practical Guide

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Anesthesia Information Management Systems (AIMS) display and archive perioperative physiological data and patient information. Although currently in limited use, the potential benefits of an AIMS with regard to enhancement of patient safety, clinical effectiveness and quality improvement, charge capture and professional fee billing, regulatory compliance, and anesthesia outcomes research are great. The processes and precautions appropriate for AIMS selection, installation, and implementation are complex, however, and have been learned at each site by trial and error. This collaborative effort summarizes essential considerations for successful AIMS implementation, including product evaluation, assessment of information technology needs, resource availability, leadership roles, and training.


A ccurate recorded data are the foundation of clinical science and evidence-based practice, and anesthesiologists base many clinical decisions upon repeated measurements. Given the complexity of even routine physiological monitoring, digital data systems are a compelling option for automatically acquiring and recording the information generated while caring for surgical patients. Despite concerns regarding cost and compromised vigilance due to reduced involvement by the anesthesia provider, the advantages of an anesthesia information management system (AIMS) appear to outweigh the drawbacks. In fact, the directors of the Anesthesia Patient Safety Foundation (APSF) have explicitly stated “the APSF endorses and advocates the use of automated record keeping in the perioperative period and the subsequent retrieval and analysis of the data to improve patient safety.”

The AIMS concept has evolved from a simple record keeper, first proposed more than 2 decades ago, into a more complex digital electronic network (Fig. 1). Interfaces between medical databases, physiologic monitoring devices, and input devices are used to collect, organize, display, archive, and retrieve perioperative information for subsequent analysis. The two basic components of a modern AIMS are an automated anesthesia record (AAR) and a perioperative database (PD) for patient-specific clinical information. The most comprehensive AIMS also include a preanesthesia evaluation component and an electronic data warehouse (EDW) in which patient identifiers are removed from PD-derived information to generate and organize anonymous physiological data for outcomes research.
Successful AIMS implementation requires many decisions regarding hardware and system configuration and the training and support of personnel. General information is available from the AIMS Consensus Working Group of the Society for Technology in Anesthesia and the American Society of Anesthesiologists. This review shares lessons learned during AIMS implementation at different institutions using a variety of AIMS products.

JUSTIFYING THE PURCHASE OF AN AIMS

Compelling justification for a large capital investment such as an AIMS generally requires anticipation of positive return on investment (ROI), a regulatory mandate, or obvious patient safety benefits. Any or all of these may be applicable to AIMS implementation, although computation of ROI for the purchase and installation of an AIMS requires many assumptions about improved efficiency that are often unrealistic and difficult to quantify. AIMS may also improve institutional resource utilization by assisting with operating room (OR) management decisions and tracking the use of anesthesia-related drug and disposable supplies. At each institution, the true ROI for an AIMS installation will vary inversely with the effectiveness of the management, clinical quality assurance (QA), financial, and billing practices already in place.

Correctly configured to minimize artifacts, the AAR reduces the need for manual charting, in theory enhancing patient safety by allowing the anesthesia provider to focus on intraoperative events. Most AIMS should also improve perioperative workflow by providing point-of-care alerts for allergies or medical contraindications and automatically retrieving diagnostic assessments and laboratory results before or during surgery. Generation of a professional services report (PSR) by the AIMS also eliminates handwritten billing vouchers. Once the required billing elements have been extracted from the AIMS (Table 1), the PSR can be transmitted electronically at time of case closure rather than days after the procedure has been completed. This should shorten the revenue cycle, improve charge capture, and reduce the direct costs of billing. There are concerns regarding the reliability of automated charge capture and professional billing with AIMS, but at least at one academic institution, reductions in charge lag and days in accounts receivable yielded a one-time revenue gain of about 3.0% of total annual receipts.

An AIMS facilitates compliance with the Joint Commission mandate that legible and retrievable records be maintained for every patient encounter. The AAR is more complete, readable, and objective than a handwritten anesthesia record. Because critical physiological variables are often not accurately represented with pen and paper anesthesia charting, only an AIMS can provide automatically acquired objective data to assess the impact of changes in practice patterns on intraoperative incidents such as tachycardia, arterial hypotension, or electrocardiographic changes.

Figure 1. Basic information flow for a typical anesthesia information management system (AIMS) installation. ADT = admission, discharge, transfer database for patient identifiers and insurance information.
The AIMS PD can also generate QA reports that track compliance with institutional procedures, and protocols.

While not entirely eliminating dependence upon voluntary reporting of adverse events, an AIMS can facilitate better documentation by prompting the anesthesiology provider for essential clinical details. AIMS-based documentation of comorbid disease increases the accuracy of severity of illness (SOI) index and risk of mortality scores, and higher SOI may increase reimbursement through weighting of diagnosis related group values.\textsuperscript{15} Both SOI and risk of mortality also have value with regard to institutional reputation because they are used by the Joint Commission and the National Committee for Quality Assurance to compare patient outcomes relative to disease severity. Finally, an AIMS eliminates the need for collection, handling, and storage of paper-based anesthesia documents and may minimize the risk of financial penalties imposed for accidental exposure of federally protected health information.

**PRODUCT SELECTION AND CONFIGURATION

Identifying Needs**

Successful AIMS implementation depends, in large part, upon accurately identifying the requirements of both the department and the institution and allocating adequate resources for system installation, maintenance, and, in particular, training of dedicated AIMS support personnel and users. Planning for AIMS implementation typically begins 1 to 2 yr before the “go-live” target date. An AIMS steering committee consisting of senior departmental and institutional

| Table 1. AIMS-derived Data Elements Needed for Automatic Generation of an Anesthesia PSR |
|---------------------------------|--|
| Patient name | Surgeon name |
| Date of admission | Surgical service/division |
| Admitting physician | Actual procedure CPT codes |
| Admitting service | CPT modifiers |
| Account, visit, or case number | Anesthesia attending name |
| Patient date of birth | Anesthesia provider name |
| Patient gender | Medical direction concurrency |
| Outpatient/inpatient status | Anesthesia type |
| Medical record number | MAC justifiers, if any |
| Location of service (hospital) | Anesthesia start time |
| Insurer | Anesthesia end time |
| Insurance plan | Other billable procedures |
| Insurance ID number | Total anesthesia time |
| Insurance authorization number | Procedure attestations |
| Diagnosis—ICD9 | Medical direction attestations |
| Patient ASA physical status | Date of surgery |

AIMS = anesthesia information management system; PSR = professional services report; OR = operating room; MAC = monitored anesthesia care; CPT = Current Procedural Terminology; ICD9 = International Classification of Diseases, 9th Rev.

information system personnel with long-term administrative or clinical interests in the AIMS should generate a document specifying planned AIMS functionality to guide the implementation team in evaluating AIMS products. The implementation team needs to receive a clear directive as to whether their final choice is to be the product considered “best of breed” or, instead, an AIMS that is a “best fit” with their information system environment. The team establishes specific minimum performance standards and confirms compatibility of the AIMS software and hardware with existing clinical workflow and patient care protocols and required security, documentation and billing procedures.

The implementation team is typically large, with members representing information technology (IT), anesthesiology, surgery or perioperative services, nursing, medical records, clinical engineering and biomedical support, QA, patient admissions, billing and regulatory compliance, laboratory medicine, pharmacy, materials management, house staff education, and institutional network and personnel security. The size of the group necessary for full inclusiveness may seem unwieldy, but only a few key team members will be actively involved throughout the entire selection and implementation process. Nevertheless, participation of every team member must be budgeted to appropriate cost centers. The team and the steering committee should collaborate to generate a request for proposals (RFP). The RFP, sent to all potential AIMS vendors, not only clarifies functional requirements but also initiates administrative and legal oversight of purchase and implementation. The RFP should describe the volume and acuity of clinical activity, the institutional IT environment, including physical and human resources, and whether the institution is community-based or primarily academic. It should be clearly stated who will purchase and install the server, workstations, and peripheral devices as well as any additional required software.

A vendor’s response to the RFP itemizes costs for licensing and purchase, training and user support, upgrades, and other maintenance charges. It specifies workstation, servers, and network requirements and lists the applications and interfaces needed for full AIMS functionality. The vendor should describe warranties as well as service and support options, including those for setup and maintenance of the AIMS PD. Responses should estimate requirements for essential additional components such as uninterruptible power supplies, network switches, mounting arms and brackets, cables, keyboards, magnetic card readers, optical scanners, or radio frequency identification devices for identification, materials charge capture, or even transfusion tracking.\textsuperscript{16} Vendors should confirm that their AIMS is compatible with industry-standard network protocols and that server configurations are redundant and fault-tolerant.

On-site AIMS demonstrations arranged by the implementation team are most valuable if the vendor
is presented with several troublesome but realistic scenarios (Table 2). Site visits to institutions where the vendor’s product is already in use can provide additional insight if the visitors have specific objectives regarding product assessment. For administrators, system stability, support and maintenance costs, and data security are priorities. For clinicians, access to perioperative data and workstation ease-of-use are critical decision-making factors. The RFP response usually includes a list of active AIMS installations at similar institution and names of previous customers who can provide referrals.

**Leadership Roles**

AIMS implementation requires an executive sponsor and an implementation project manager (IPM). The executive sponsor leads the steering committee and may be the institution’s Chief Information Officer, Chief Financial Officer, or Chair of Anesthesiology. The sponsor communicates the strategic goals and the perceived value of the AIMS project to the department, the institution, and to collaborating departments. If necessary, the sponsor escalates any issues that are beyond the authority of the implementation team up to institutional administrative levels and to the vendor’s senior management.

The IPM, usually an IT professional well-versed in clinical workflow or a physician familiar with IT, leads the AIMS implementation team. Because implementation requires cooperation across many departmental boundaries, senior individuals are generally the best choice. The role of IPM encompasses oversight of interface design and data sharing, server and network issues, hardware purchase and installation, as well as the daily progress of AIMS implementation and training in cooperation with the vendor’s project manager. The IPM should be empowered to assign adequate on-site storage and assembly areas to the vendor as well as the meeting and classroom facilities needed for training. The IPM facilitates adherence to the implementation schedule and gives final approval for the go-live event.

The AIMS implementation team must also have a designated Anesthesia Clinical Leader (ACL), an anesthesiologist or certified registered nurse anesthetist (CRNA) who may also serve as a co-IPM. The ACL is responsible for integration of AIMS-required workflow into existing clinical practice patterns. The ACL provides liaison between the implementation team and the clinical users with regard to configuring the user interface, verifying the clinical documentation process, locating preoperative and postoperative workstations, and organizing and scheduling training. The ACL often introduces surgeons and nurses to the AIMS and obtains approval from the institution’s medical board and director of medical records for the format of AIMS-generated documents. The ACL confirms the accuracy and completeness of drug and procedure lists before go-live and afterwards advises clinicians on the resolution of problems or addition of new system features.

The system administrator (SA) has primary responsibility for day-to-day AIMS management after go-live. Either a clinician with expert knowledge of the AIMS or an IT specialist, the SA is the primary contact with the AIMS vendor’s support personnel. The SA also oversees in-house application support, coordinates software updates and server patches, and is the contact person for interface issues and data exchange within the institution. The SA should develop standard procedures to triage workstation malfunctions, replace or add additional workstations, and initiate disaster recovery measures. The SA may assist the IT department with server and PD maintenance. In addition to generating scheduled reports for QA and other institutional processes, the SA is often the gatekeeper for access to the AIMS PD or EDW.

**Contracts and Costs**

Many institutions have master contracts in place with prospective AIMS vendors that define terms and legal remedies. For AIMS purchases, a supplemental contract is prepared by the vendor that itemizes the cost of software, hardware, and installation as well as dates and terms of delivery and completion. The contract should specify annual fees for maintenance of the AIMS application, typically about 15% to 20% of the initial software purchase price, and for server maintenance, technical support for database and report-generating software, and licensing fees for required third-party applications. The contractual price for AIMS implementation may not include travel or on-site out of pocket expenses incurred by the vendor’s installers and it is unrealistic to expect

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**Table 2. Examples of Scenarios that Establish the Robustness of an AIMS**

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Answer</th>
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<tbody>
<tr>
<td>How does the workstation respond to a transient hospital power failure?</td>
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<tr>
<td>Does the workstation automatically reboot to the log-in screen if the workstation is accidentally powered-down?</td>
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<tr>
<td>Does the AIMS require network access for case startup and closure?</td>
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<tr>
<td>How does the workstation respond to a mid-case network failure?</td>
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<tr>
<td>Is there an emergency case start button that initiates capture of physiologic data before patient identification?</td>
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<tr>
<td>How could errors of patient identification be corrected?</td>
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<tr>
<td>Is there a workflow and documentation process for intraoperative death?</td>
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</tr>
<tr>
<td>Is there a workflow and documentation process if a patient is recovered at locations other than postanesthesia care unit or surgical intensive care unit?</td>
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</tr>
<tr>
<td>How are daylight savings time transitions handled?</td>
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<tr>
<td>How will server software patches be installed without disrupting AIMS availability?</td>
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<tr>
<td>Will a server hard drive failure corrupt the AIMS database?</td>
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<tr>
<td>Can the AIMS compute provider concurrency in real time?</td>
<td></td>
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<tr>
<td>Can the AIMS accommodate discontinuous provider times at off-site anesthetizing locations?</td>
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</table>

AIMS = anesthesia information management system.
that any hardware, software applications, or required interfaces not listed in the contract will be provided by the vendor without additional charge. Defining intellectual property rights to AIMS modifications or software developed at academic centers during implementation may also be advisable as part of contract negotiations, as is a provision to keep the AIMS source code “in escrow” should the vendor go out of business.

The supplemental contract should also include a list of acceptance criteria (Table 3) that define the AIMS functions essential to go-live. The payment schedule is often linked to specific implementation milestones and final payment can be made contingent upon meeting all these criteria. Given the complexity of an AIMS and the extent to which it must fulfill many needs, it may also be helpful to add a “scope of project” appendix to the supplemental contract. This document lists what features, actions, and functionality beyond those already established as acceptance criteria are, or are not, part of the contractual agreement. Items typically included, or excluded, in a scope of project document include additional interfaces with other databases, physician concurrency tracking, integrated patient diagnosis (ICD-9) and surgical procedure (CPT) coding functions, customization of compliance-related documentation, or PD search and reporting tools.

Table 3. Examples of Performance or Functionality Requirements for Minimum Acceptance Criteria for Successful AIMS Implementation

<table>
<thead>
<tr>
<th>Requirement</th>
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<tbody>
<tr>
<td>Consistent capture of data from all patient monitoring and anesthesia delivery equipment</td>
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<tr>
<td>Real-time data exchange with the institutional surgical scheduling, laboratory medicine, and admission databases</td>
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<tr>
<td>Automatic generation of a graphic anesthesia record at each workstation</td>
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<tr>
<td>Hardcopy printout of the anesthesia record in institution-approved format</td>
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<tr>
<td>Creation of an electronic “e-signature” for anesthesia attending and provider</td>
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<tr>
<td>Differential access privileges to attestation statements</td>
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<tr>
<td>Visual or electronic paging prompts to end-users at log-off for missing billing information</td>
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<tr>
<td>Automatic generation of a professional services billing report upon record closure</td>
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<tr>
<td>Electronic transmission of a graphic image of each closed anesthesia record as a *.pdf or similar file to the permanent institutional electronic medical record</td>
</tr>
<tr>
<td>Automatic daily data backup to local or server-based magnetic or optical storage</td>
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<tr>
<td>Automatic generation of a daily reconciliation report between AIMS and surgical scheduling</td>
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</table>

AIMS = anesthesia information management system.

The total cost of AIMS workstation hardware primarily reflects the number of clinical and administrative locations and, to a lesser degree, the physical installation requirements as assessed during the vendor’s on-site hardware survey. A clinical workstation costs from $4000 to $9000 for each anesthetizing location, an administrative workstation about $2000 to $3000. The cost of the AIMS workstation and server software is highly vendor-specific, but typically averages about $10,000 per clinical workstation. Mobile clinical workstations or computers-on-wheels (COWs) with attached portable physiological monitors are an obvious choice for off-site locations where procedures are done with sedation and monitoring and the delivery of anesthesia care moves from one procedure room to the next. However, COW hardware is expensive ($6000–$8000) and requires consistent wireless network coverage and secure overnight storage locations for recharging of battery packs.

The institution may reduce implementation costs by purchasing workstation hardware directly from preferred vendors, but if the AIMS vendor does not supply both hardware and software, implementation issues may produce finger-pointing regarding the source of the problem. If new dedicated AIMS workstations are not required in the postanesthesia care unit or intensive care units, sharing existing clinical workstations for preoperative assessment or for anesthesia record “closeout” functions can also reduce costs if they meet AIMS processor and memory requirements. The AIMS implementation budget must provide for purchase and installation of additional institutional network infrastructure such as routers, switches, wall plates, and patch cables.

Legal statutes mandate disclosure of financial relationships between institutional employees and vendors. Most academic centers also have conflict of interest policies that preclude an employee or faculty member from influencing purchasing decisions if that person has a financial relationship with the vendor. Therefore, an anesthesiologist or an information systems administrator participating in implementation who owns stock in, or has received gifts or compensation from, an AIMS vendor must provide prior full disclosure to all parties and should not be involved in AIMS vendor selection or contract negotiations. After contract signing, the vendor and institution implementation teams meet to clarify roles, and share contact information, shipping addresses, and meeting schedules. Vendors should supply a detailed timeline establishing milestones and proposed target dates. The IPM reviews the institution’s security processes for personnel and equipment, the layout of the OR suite and recovery areas, and times during which anesthetizing locations can be accessed. When the vendor installs the hardware, the vendor’s expert surveys workstation location to identify all monitoring and anesthesia equipment, data port configurations and availability, and proximity of electrical and network connectivity.

Working with the ACL to insure compatibility with clinical workflow, the IPM should confirm that there is a specific hardware mounting solution for each location, including brackets, adjustable arm mounts, cables and connectors. Anesthesiologists rarely have control of the work environment in radiology, cardiology, or gastroenterology suites, and the monitoring
devices often differ from those of the surgical OR. Therefore, the complexity of AIMS workstation installation and configuration increases significantly for these off-site anesthetizing locations. Simply finding a place for the AIMS workstation, even a mobile COW, may be a challenge requiring IPM and executive sponsor involvement.

**Software Customization and Configuration**

There are no “off the shelf” AIMS solutions. Every institution has a unique IT environment that requires some degree of AIMS customization. The most difficult but critical decision to be made by the IPM and ACL is the extent to which the vendor’s software must be modified to suit the users, and the degree to which the users must adapt their workflow to use the AIMS software. Ease of use and compatibility with clinical workflow ultimately determine the willingness of anesthesia providers to work through the learning phase of AIMS implementation and eventually accept AIMS as a fact of clinical life.

The IPM and ACL should review the AIMS workstation user interface and, if necessary, ask the vendor to modify it prior to implementation. However, extensive changes of the AIMS application or user interface is time-consuming, expensive, and may jeopardize overall reliability. Ideal user interfaces exhibit consistent functionality for all action buttons, dropdown menus, and “pick lists” in every screen and should generate “help balloons” that appear automatically to succinctly define action keys. Even with good design, however, the inevitable need for some text entry into the AAR may generate some initial user dissatisfaction.

Privacy considerations and the varied needs of departmental clinicians, researchers, administrators, and financial personnel require secure log-on and electronic signatures with multiple levels of access to the AIMS PD, EDW and report-generating software. A list of authorized users and their privileges should be easy to create and maintain. Alternatively, log-on credentials can be managed by an institutional active user directory or other security privilege database. For clinicians, the AIMS must also generate an electronic signature suitable for billing and compliance documentation. In academic centers, patient care responsibilities of resident and attending anesthesiologists must be delineated and there should be specific documentation for anesthesiologists working with CRNAs or anesthesiologist assistants within the “anesthesia care team” model. Attestation of resident teaching or anesthesiologist assistants within the “anesthesia care team” model. Documentation of the Joint Commission-emphasized anesthesia-related milestones such as immediate preinduction patient reassessment, or intraoperative “patient safety time-out,” can be uniformly formatted and “flagged” in the AIMS PD to facilitate routine compliance audits. Configuring an AIMS to generate context-specific visual alerts (pop-ups) can also encourage adherence to preferred clinical protocols. These alerts and PD-generated physician-specific performance report cards can complement continuing physician education in improving compliance with Centers for Medicare and Medicaid Services (CMS) Pay for Performance protocols that provide financial incentives designed to reduce health care costs by improving outcomes.

Analysis of PD data can be used to assess a patient’s risk of postoperative nausea and vomiting and the need for prophylactic antiemetic treatment.

AIMS must be configured to share preoperative data and the AAR with postanesthesia and intensive care nurses for continuity of care at hand off. Unless there is a compatible electronic information system for AAR display at the postanesthesia care unit or surgical intensive care unit bedside, a paper record or intraoperative summary sheet should be generated in each anesthesia recovery area. AIMS COWs can be wheeled to the bedside at those sites for completion and closure of the AAR, printing hardcopy to a local printer via a wireless network. A process must also be established for incorporating the AIMS-derived perioperative information into the institution’s electronic medical record (EMR) as an electronic data or image file. A paper record generated at time of care transfer can be optically scanned into the EMR but it may not be a final version of the AAR with all necessary documentation. Alternatively, the AIMS can be configured to transmit an electronic image of the AAR at time of final file completion and closure, using digital scanning to grab patient identifiers and place the image of the AAR directly into the patient’s EMR.

Although not primarily designed for OR management, an AIMS should track perioperative milestones in a manner that facilitates management decisions. To permit comparisons for benchmarking, an AIMS should comply with the current standard for defining time intervals and events, the Procedural Times Glossary generated by the Association of Anesthesia Clinical Directors and adopted by the Association of Operating Room Nurses and the American College of Surgeons.
Automatic tracking of costs and charges for anesthesia-related disposables is an appealing concept, but accurate charge capture is a complex process. Some AIMS generate an on-screen version of the traditional materials charge form that requires manual data entry, but most institutions bundle charges for anesthesia supplies.

**Data Exchange and Interfaces**

AIMS must communicate with the databases for patient admitting, discharge, and transfer (ADT) information and OR schedules, and most will interface with laboratory information systems. Digital data streams between medical databases generally follow the industry standard Health Level 7 Clinical Data Architecture format, but the implementation team must confirm the robustness of transfer for each data element. Interfaces may be included within the AIMS application or available at extra cost, or they may require custom coding in collaboration with another vendor and the institution’s interface specialists. The team must also specify how each interface is to be configured to receive only those elements relevant to anesthetic management. For example, which laboratory results are needed for preoperative assessment, and for what time period before surgery? Automated billing with an AIMS requires the ADT interface to transmit identifiers and financial data for every patient who may receive departmental services, including, but not limited to, inpatients, outpatients, and those admitted on the day of surgery, as well as those scheduled for obstetrical, endoscopic, radiographic or diagnostic cardiology procedures.

Interfaces for time-sensitive preoperative data such as blood gas results should be configured to send new data to the AIMS when the transaction occurs. However, the volume of preoperative data flowing into an AIMS is easily under-estimated and processor and memory requirements for large-scale real-time data exchange are substantial. Therefore, it may be desirable for some data to be batch processed during off-hours when there is ample server capacity. Another approach to real-time data exchange is software system integration that allows sharing of data fields between different applications. Some vendors, for example, offer periooperative nursing documentation software that can be partially or fully integrated with an AIMS, minimizing redundant keyboard entry and facilitating synchronized tracking of intraoperative milestones. However, the implementation team must establish who has access to, and who owns, each shared data element.

There are obvious benefits in sharing data with many additional sites within the institution, but developing custom data interfaces is expensive and time-consuming. New interface projects must designate responsibility for proper function and have budgets for development costs and human resources. A pharmacy interface permits analysis of drug costs and provides a mechanism to track use of controlled substances. An interface with the materials management database can be used for inventory control and charge capture. Sharing data with the emergency department, blood bank, or computerized physician order entry system can facilitate patient care through timely sharing of vital signs, allergies, medications, and difficult airway status. Once established, interfaces are usually monitored by an institutional interface engine.

Where feasible, an interface with the institution’s EMR may permit easy access to a surgical patient’s comprehensive medical record. A few AIMS offer patient-interactive electronic preanesthesia evaluation modules that query for general health history, allergies, and medications and guide nonanesthesia personnel in obtaining anesthesia-focused medical and surgical details. They may use “rules engines” to automatically generate requests for appropriate screening studies and consultations. If preoperative information resides on hardcopy only and is not electronically accessible, it must be entered by keyboard or scanner into the AIMS PD. Scanned data are quickly available and readable by clinicians but cannot be searched for individual data elements.

**Billing and Coding**

To automatically generate a complete PSR for all cases, an AIMS must occasionally have input from the anesthesia provider (Table 4) as well as ADT and surgical scheduling data. AIMS with integrated coding modules permit anesthesiologists to document ICD-9 and CPT codes in the OR in collaboration with the surgeon. If these data are shared with the institution’s EMR, the hospital, surgeon, and anesthesiologist can all bill using identical codes as required by the CMS through its National Correct Coding Initiative of 1996. Institutions should benefit financially from improved coding accuracy and also from Diagnosis Related Groups designations that reflect an anesthesiologist’s typically comprehensive assessment of comorbid medical conditions. CMS has also proposed increased reimbursement for CPT codes associated with any of 14 defined comorbidities (e.g., congestive heart failure, malnutrition) that make surgical patient management more difficult.

**Databases**

An AIMS should build a PD searchable with a user-configurable structured query language database.

<table>
<thead>
<tr>
<th>Table 4. Additional Information Requiring Physician Input into an AIMS that may Modify Electronic Anesthesia Billing</th>
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<tbody>
<tr>
<td>Emergency case designation</td>
</tr>
<tr>
<td>Scheduled case requiring emergent return to operating room</td>
</tr>
<tr>
<td>Case cancelled before induction</td>
</tr>
<tr>
<td>Case cancelled after induction</td>
</tr>
<tr>
<td>Outpatient converted to inpatient</td>
</tr>
<tr>
<td>Patient repositioning during surgery</td>
</tr>
</tbody>
</table>

AIMS = anesthesia information management system.
manager, proprietary reporting tools, or third-party report generation software. Case auditing is necessary for departmental QA and for institutional compliance reports. Report generation to realize the full benefit of a PD requires substantial time and human resources, however, and institutional expectations regarding access and use of this information must be balanced against considerations of privacy, data integrity, and the limitations of AIMS server capacity. Appropriate database structure also facilitates creation of an EDW from which data can be exported to a third-party program for statistical analysis and clinical outcomes research. The volume and accuracy of data extracted from a large EDW easily exceeds what can be derived from visual scanning of handwritten records.

Pooling clinical data with other institutions to increase sample size and enhance statistical power becomes problematic, however, without consistent terminology. The APSF-sponsored Data Dictionary Task Force which began the standardization of anesthesia-related data elements merged with a similar European initiative in 2003 to form the International Organization for Terminology in Anesthesia, now an extension group of Systematized NOmencla
ture of MEDicine, developed by the College of American Pathologists. The Canadian Anesthetists Society, the Society for Technology in Anesthesia, and the American Society of Anesthesiologists are represented within International Organization for Terminology in Anesthesia which is now creating the “Anesthesia Subset” of terms in Systematized NOmenclature of MEDicine for use in the United States and the United Kingdom. This international effort to generate consensus regarding AIMS terminology and data format has also generated the Special Interest Group for the Generation of Anesthesia Standards.

Workstation and Servers

A web-enabled AIMS workstation facilitates access to perioperative data on the institutional intranet. There are also many valuable medically related sites on the Internet, but in installations that permit access from AIMS clinical workstations, most user visits to the Internet have been found to be neither patient nor case-related. Isolating AIMS workstations behind the intranet firewall also secures protected patient health information. Vulnerability to electronic viruses, worms, and other “malware” may be reduced by blocking Internet access, but ultimately workstation security is determined by the AIMS operating system and the configuration of the installed applications. Even if Internet access is blocked, utility software is required on AIMS workstations for remote administrative access and protection against malware originating from within the intranet. Most IT departments install a standard workstation image of the supported operating system and utility applications under site license.

A Windows-based AIMS requires a process for installation of critical operating system security patches, usually distributed remotely to servers and workstations by IT personnel on a monthly schedule. The implementation team should also define specific responsibility for scheduled backups of the AIMS PD and prepare a detailed written procedure and contact list in case of server or network failure. To facilitate remote access to servers and workstations for software upgrades and diagnostics, the vendor may request a virtual private network or similar secure high bandwidth connection. However, some institutions prefer to have their own IT personnel validate and install all server and workstations software.

Support

Support of AIMS implementation requires institutional IT resources for hardware installation, network, server, and workstation management, and replacement of defective components. Commitments to purchase and inventory spare parts for AIMS maintenance and to repair or replace malfunctioning components quickly should be explicitly negotiated. The processes for installation of new or replacement workstations and software updates must also be defined by the SA with clear accountability for these functions. Operational IT priorities during implementation are confirmation of workstation software compatibility, integrity of data transfer and storage, and network and server reliability. Network or server malfunctions require immediate notification of the AIMS IPM and SA and a vendor-trained IT AIMS expert who can contact the vendor’s on-call support system. Vendors provide estimates of support requirements, typically one full-time equivalent (FTE, usually a CRNA or registered nurse) for routine clinical oversight and training, 0.5 to 1 institutional dedicated IT FTE for network and server issues, and one departmental FTE for workstation and general system support.

Training

The proximity of AIMS training to the go-live event is important because concepts and techniques that are not immediately reinforced by repetition and clinical experience are quickly forgotten. Many institutions already have nursing- or IT-based software training facilities set-up for classroom-style sessions. These are most effective if each trainee works at an individual workstation running a training version of the AIMS application. Vendors generally specify the recommended hours of individual and group training and should provide both digital and hardcopy versions of user manuals. Training of IT staff for network, server, and workstation support is a vendor responsibility and training the SA and other administrators to manage the PD and generate customized reports should also be included in the AIMS contract.

The focus of AIMS training sessions should vary depending upon the primary role of the trainees. All anesthesia providers must be taught how to correctly
identify the patient, enter text-based clinical information, and complete and close an AAR file. However, procedures such as attestations of medical direction apply to attending anesthesiologists but not to residents or CRNAs. Training new residents or student anesthesiologists to use an AIMS is especially challenging because they have not yet acquired a frame of reference for how the AIMS process relates to clinical workflow. Other clinicians such as perioperative nurses or surgery residents may need minimal training to access perioperative AIMS data. Administrators or billing personnel must be shown how to review completed records and extract information through report generation, and IT support staff must understand the AIMS server and database details.

Scheduled daytime training sessions are appropriate for administrative and support personnel but problematic for anesthesia providers with concurrent patient care responsibilities. Therefore, it is unrealistic to rely solely upon this modality for training of clinical users unless off-hours classroom instruction can be arranged. Alternatives include open “drop-in” sessions where demonstration AIMS are set up close to the OR suite throughout the workday for several days or weeks, manned by trainers or AIMS super-users. All training modalities can be supplemented by Web-based tutorials. They are particularly valuable for clinicians based at satellite hospitals or multiple locations but creating web-based content requires substantial institutional IT resources or vendor commitment.

Whatever training modality is used, each clinician should be required to demonstrate the ability to generate an AAR that meets departmental standards for accuracy, completeness, and billing and regulatory compliance before go-live. Concise written instructions such as laminated cheat sheets or pocket-sized cards that summarize how to identify a patient and start, complete, and close an AAR file are helpful. To facilitate technical support, all users should also be familiar with basic trouble-shooting steps, such as workstation reboot and confirming connection to the network. Additional in-depth diagnostic training will prepare the AIMS “super-users” to assist with training, facilitate the go-live process, and act as a continuing resource for their colleagues and the AIMS SA.

GOING-LIVE

There are two basic types of go-live, the “big bang” and the “incremental” approach. Big bang implies that all AIMS workstations go live within several days or a week, which may be particularly important if time for implementation and training is limited. All resources can be concentrated around the go-live target date. The big bang concept also generates a sense of urgency that encourages participation by all parties. However, if the AIMS fails during go-live, this approach risks becoming a big bust, and it may be difficult to reschedule training and support for a second attempt. The big bang has the best chance of success if the institution has a relatively uniform clinical environment and the AIMS itself is known to be robust. Nevertheless, the vendor and institution must provide ample on-site support personnel, perhaps even around the clock at busy tertiary medical centers, and establish a rapid response help mechanism by telephone or pager that is always available.

An incremental approach may be preferable if there are insufficient personnel to train all users at once and provide go-live assistance at every anesthetizing location. In effect, a series of partial go-lives are scheduled over a period of weeks to months, usually starting in a subspecialty area with long cases and then moving to areas with more rapid or more varied clinical procedures. Small user groups can be trained sequentially in synchrony with the planned go-live schedule. This also allows additional time to train super-users, train the trainers strategy that can provide additional on-site support as the AIMS is more widely implemented. An incremental approach is also preferred in large institutions with a complex clinical environment or if the AIMS is not fully proven or has been heavily customized. The incremental approach mitigates much of the risk of the big bang but requires processing and archiving both paper-based and electronic anesthesia records and PSRs during the transition. The prolonged commitment of resources for training and support also needed for incremental go-live may also produce implementation fatigue.

Expectations that go-live will be smooth or easy are never realistic. No prototype systems exactly duplicate the complex, multiuser environment of a real-world AIMS and its dependence upon network and server responsiveness. Even when the AIMS functions well, new users inevitably produce EMRs with errors, omissions, and inconsistencies. For example, obvious measurement artifacts that were simply ignored by anesthesia providers keeping pen and paper records may now appear on the AAR.37 Some users will feel compelled to identify and annotate or delete all inaccuracies from the AAR, whereas other users will accept easily explained artifacts as an unavoidable consequence of automated data collection. Therefore, during go-live and for the first few weeks thereafter, it may be prudent to review all AIMS documents before they are placed in the patient’s EMR. Although duplicate record-keeping is tedious and time-consuming, it may also be advisable to generate paper and electronic anesthesia records concurrently for each case for several days after go-live.

Constraints and Obstacles

The training and change of workflow required for AIMS implementation usually generates some user resistance. Complaints about workstation hardware placement and the user interface are common, and the AIMS can become a lightning rod for criticism by those who view it as an unnecessary burden and a
source of medico-legal risk. A new PSR format and a revised process for reviewing and reconciling the data needed for anesthesia billing may, at first, also increase administrative anxiety and workload. However, adequate support can minimize implementation difficulties, and leadership, planning, and patience largely mitigate these obstacles. An AIMS can also be configured to facilitate implementation by prompting anesthesia providers for essential information and automatically alerting billing personnel when documentation is inadequate. Scanning algorithms can identify missing documentation elements in near real-time, before case closure, and generate a paging alert for the responsible anesthesiologist.

Clinicians eventually acknowledge that an AIMS improves the quality of their practice and rarely ask to switch back to paper anesthesia records. The novelty and enthusiasm generated by AIMS training and the go-live event energizes most clinical users for several months. Therefore, the need for long-term oversight and continuing user education may be overlooked until departmental audits reveal discrepancies in AIMS documentation. Unlike handwritten records, every AIMS-generated comment and preformatted attestation is time- and date-stamped. This may increase compliance liability risk if the timing of the note does not reconcile logically with that of the procedure itself. For example, the veracity of an attestation of participation in emergence from anesthesia can be questioned when the attestation was entered into the AIMS hours before the end of the anesthetic.

Inconsistencies in the AAR compromise the credibility of both the AIMS and the anesthesia providers, especially if associated with an adverse outcome. Maintaining the accuracy of AIMS-generated documents, therefore, requires frequent review of the AAR documents and sustained behavioral change, best accomplished by a three-step process of education, regular individual performance feedback, and personal contact by the departmental chair. An intuitive or friendly user interface also encourages more accurate and detailed documentation and has been shown to increase voluntary reporting of QA-related events, a factor essential for assessment of individual physician performance and a robust clinical effectiveness and quality improvement process.

SUMMARY AND FUTURE DIRECTIONS

Financial, regulatory, and QA considerations may justify the expense and resource commitments required for AIMS purchase and implementation. Requirements for physician accountability and comprehensive and searchable documentation of perioperative events make a compelling argument for incorporating AIMS into the practice of anesthesiologists in both academic and community environments. Currently, AIMS offer quality-related functions such as alerts for patient-specific risk factors, reminders for protocol-based interventions, and time-stamped documentation of surgical milestones such as the preincision time-out. AIMS documentation supports electronic billing for professional services and facilitates compliance with recently initiated CMS Pay for Performance incentive bonuses (Fig. 2).

Widespread adoption of AIMS, standardized nomenclature, and sharing of EDW information among different institutions may eventually provide universal reference limits for physiological variability during anesthesia. AIMS-based data analysis is ideal for perioperative clinical research and may establish the etiology of adverse clinical events. AIMS also offer ample opportunity for customization and integration with ancillary software to perform tasks beyond those initially envisioned. AIMS could facilitate inter-service communication, for example, by alerting the anesthesia pain service when a patient with an epidural is ready for postoperative care. An AIMS could query the PD in near real-time, recognize significant variation from normal physiological limits, and then alert clinicians using automated paging. Integration of physiological data flow with “expert system” clinical decision support software could also be used to prescribe specific anesthetic techniques, monitor adherence to best practice guidelines, and provide preemptive risk management by identifying patients at increased risk for specific adverse events.
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