## Anesthesia Information Management Systems: Almost There

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Arely in medicine does one observe the adoption of a new technology as it moves from infancy (and a domain of early adopters) into the realm of widespread, general use. Anesthesiologists may be an exception; they have long been in the vanguard of new technology adoption as a part of an ongoing quest for improved patient safety. More recently, however, technological developments in anesthesiology have involved information systems. These systems' potential to improve patient care is not so traditionally obvious as something such as a new physiologic monitor or a better anesthesia machine. Hence, the adoption of anesthesia information management systems (AIMS) has been slow, in part, because they are regarded as expensive, "optional" technology with little direct patient benefit. However, a new study by Halbeis et al. indicates a sharp uptick in the number of academic anesthesia departments that are either in the process of installing an AIMS, or have allocated resources to do so in the near future.<sup>1</sup> The authors suggest that adoption of AIMS in academic departments is passing through a "tipping point," as defined by Gladwell, wherein a new idea catches on and penetrates the culture widely.<sup>2</sup> In other words, AIMS appear on the verge of completing the adoption lifecycle.

Suddenly, anesthesia departments are finding themselves heavily involved in information systems (IS) either as clients or, in many cases, as the "business owners" of their own IS groups. Once installed, AIMS applications quickly become critical to the department's financial health and daily clinical activities. This focuses a sharp lens on the resources required to operate an AIMS. Limited IS funds and competition for priority are frequently cited reasons for delayed or deferred AIMS adoption in the Halbeis et al. study.<sup>1</sup> This state of affairs commands attention from potential AIMS adopters, as every center with any substantial AIMS experience has learned that the acquisition and implementation costs are only part of the total cost of AIMS ownership. There is also a continuing requirement for application and system support that must be reliably met, so that the AIMS continues to meet changing clinical and administrative demands.

What are the resources required to ensure initial and ongoing AIMS success? An AIMS requires dedicated personnel, not just for implementation, but also for ongoing support of the software, the associated hardware, maintenance and modifications of the user interface, and development and implementation of new functionalities. The specifics of how these resources are provided, which budget(s) they are supported by, and under whose jurisdiction they fall in the organizational chart differ widely, ranging from all support provided by hospital-wide IS departments to all AIMS activities being supported by the anesthesia department. Despite the disparate organizational features of the AIMS-dedicated IS resources, there are key roles that are common and easily identified in organizations with a successful AIMS. These roles must be anticipated and filled by departments considering an AIMS installation.

First, there must be a competent, committed clinical champion—an individual familiar with the anesthesia workflow of the department who can both set up the AIMS interface and keep the interface up to date as the needs of the

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department change. This person must understand the capabilities and limitations of the AIMS well enough to know what can and cannot be accomplished when setting up the AIMS in order to match the operating room workflow. Almost always, this person is an anesthesiologist with facility in software, computer hardware, medical device interfaces, or database management. Given that none of these topics is addressed during anesthesia residency, such individuals are rare.

The AIMS clinical champion should participate in product selection, so that their expertise regarding local anesthesia workflow, practices, and expectations may influence the selection of an AIMS whose capabilities most closely match the clinical setting. Here we encounter a Catch-22. How would the AIMS expertise required to make an informed selection develop in a department preparing to select its first AIMS? Frequently, a clinician with some prior interest and acknowledged ability in personal computing is nominated, and an informal consultation network with existing AIMS users is established. The process repeats for each new department selecting an AIMS; very few centers have been through the process more than once. Fundamental questions such as "How much of the clinician's time will selection and implementation require?" are negotiated anew each time. Given the financial and practice-impact issues at stake, AIMS selection is an area ripe for the development of capability and professionalism.

The clinical champion must either be capable of maintaining the AIMS software and databases themselves, or be assisted by a software engineer, database administrator or programmer analyst with sufficient cross-training to work in all of the aforementioned specialties. For a multi-specialty anesthesia practice, this "AIMS engineer" role typically requires a fulltime professional. Increasingly, hospital IS include electronic health records, provider order entry systems, and computerized lab result systems, all of which must interface with the AIMS. This increases the complexity of the programming/engineering services required, and potentially calls for more than one full-time equivalent person in the AIMS engineer role.

The AIMS is literally and figuratively at the interface between medical devices and medical information systems. Thus, a successful AIMS requires constant attention from biomedical personnel (usually a biomedical engineer) who has sufficient IS background to set up, maintain and troubleshoot the physical connections and interfaces between the anesthesia equipment, intraoperative monitors, and the AIMS. Problems with these connections have resulted in medico-legal liability and losses that offset the value of the AIMS.<sup>3</sup> Because this maintenance and troubleshooting capability must be available, or at least on call during all times the AIMS is in use, multiple individuals are typically required. Behind the scenes, perhaps the largest end-user of any AIMS is actually the anesthesia billing office. Because the AIMS functions required to support a successful billing operation are quite distinct from the clinical implementation, maintenance and development efforts, one or more separate, dedicated programmer analysts are often required to support the business functions.

As mentioned above, no two organizations are alike in the exact configuration, governance, and funding of the resources supporting the AIMS. However, each of the half-dozen departments with established, successful AIMS implementations have either provided or secured personnel to fill these roles. For many early adopters, the resources were secured "on the fly," as it became clear that the AIMS would founder without them. In successful programs the resources applied are not aberrations but, practically speaking, are quite homogeneous with respect to full-time equivalent clinicians, engineers, programmers and analysts across the various institutions. Every organization contemplating an AIMS installation should plan for these requirements or risk appearing ill-prepared when they must be urgently met.

Installing an AIMS brings the anesthesia department into the world of operating room medical information systems demanding new personnel and capabilities, and ongoing resources to support this new operation. Can there be additional benefits, beyond the obvious (better charting) from the new expertise and expense? The Halbeis et al. study provides a hint: upcoming AIMS adopters strongly value improved data collection for clinical, quality assurance, and safety purposes, and to support clinical research as reasons for installing an AIMS.<sup>1</sup> The early adopters have demonstrated the added benefits of having an AIMS, with examples such as easy retrospective searches for Quality Assurance/Quality Improvement purposes, easy reporting for "pay-forperformance" purposes, a platform for active quality management (including documentation quality related to billing, which justifies the cost), and a platform for managerial decision support.<sup>4-10</sup> However, in virtually every case reported, the "out of the box" AIMS product was insufficient to provide the extra value. Instead, the considerable resources applied by the early adopters were used to modify or extend the capabilities of the AIMS. In some cases, AIMS vendors have incorporated new functionalities into their products in response to user examples or demands.<sup>3</sup> However, the current offerings still do not perform all of the functions that a department will desire.

The take-home message is that when planning for AIMS acquisition, anesthesia departments and hospitals must specify in their requests for proposals the additional personnel and list the additional functionalities to be developed, in addition to the capital and software acquisition and installations costs. Departments should develop their own requirements for additional AIMS functionalities, but should start by searching the medical literature. Almost without exception, what is known about AIMS modifications and additional functionalities has been published in peerreviewed journals. In other words, the fundamental proof-of-concept reports about various additional functionalities and their operational and/or financial impacts are readily available. This is not to say that there is nothing more to be learned; the available reports merely scratch the surface, but the current body of knowledge is available and searchable. Thus, when developing additional requirements, the key reliance should be on the applicable scientific literature.

In addition to the selected examples cited above, review of the AIMS-related literature indicates that AIMS-mediated improvements in anesthesia are related to the process of care (e.g., on-time antibiotics), billing, managerial decision-support, etc. In contrast to electronic health record systems in primary care settings, the time course of the data flow from (input)  $\rightarrow$ AIMS  $\rightarrow$  (output) is seconds to minutes as compared to hours to weeks. This compressed time frame may be a key differentiator between AIMS and other electronic medical record systems. A traditional medical informatics approach may not be ideally suited to advancing knowledge and capabilities. Instead, the early AIMS adopters are moving towards automated process monitoring and process control. The general form is as follows:

- 1. Process modeling to create a reference process against which actual process progress can be compared, seeking noteworthy exceptions.
- 2. Data integration of multiple electronic sources and different data types.
- Continuous process monitoring by recursive queries of the AIMS and other databases to identify process exceptions.
- 4. Pushing data to key stakeholders, seeking to provide the right information to the person who needs it, at the time when it is most useful.

The skills required to build these capabilities are closer to industrial engineering and scientific programming than to medical informatics. Anesthesia departments contemplating AIMS adoption must also think about how to get that expertise into their organizations.

There is a significant risk to AIMS success that is still at hand, but little discussed. All of the successful AIMS implementations that have produced added value beyond simpler charting have been systems that were either developed by the implementers themselves, were products that the vendors modified in response to customer requests, were products that allowed additional software to be run on top of the AIMS, or some combination of these. Each of these AIMS products could be considered an anesthesiologyoriented product, and is frequently a standalone application. However, many hospital IS departments are seeking to cover all of the hospital's needs with one monolithic solution from a single vendor. Thus, there is a potential conflict among AIMS-users and AIMS-purchasers (i.e., the hospital) over a fundamental choice between vendors producing systems that serve anesthesia well (but are mute with respect to the rest of the hospital's needs), and vendors producing systems that cover more areas but may not perform the AIMS function very well. Depending on the hospital IS department's orientation, the larger software vendors' products may have a significant sales advantage. However, the AIMS adopters who have reported value-adding successes in the peer-reviewed literature have, to date, voted with their feet in favor of products over which they have the most control.

Although AIMS adoption may have tipped in favor of implementation at academic centers, the technology as a whole is still vulnerable, perhaps more so because of the increased exposure to demanding users and high expectations for benefits that the out-of-the-box products do not provide. The potential for frustration and missed opportunities is high, as not all centers will succeed in selecting an optimal product, or in securing the resources to adapt the AIMS to best meet their needs. Hence, AIMS vendors would be well advised to attend to the users' needs themselves.

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