Informatics is a new science within healthcare and anesthesia that leverages computer technology to improve patient safety, the quality of care provided, and workload efficiency. In clinical anesthesia practice, appropriate application of informatics promotes data standardization and integrity, and supports clinical decision-making. This article describes current issues in anesthesia information management to support the critical need for Certified Registered Nurse Anesthetists (CRNAs) to influence functionality, adoption, and use of an anesthesia information management system. The use of informatics tools and concepts should enable CRNAs to enhance their bedside vigilance, align their practice with evidence-based clinical guidelines, and provide cost-effective care for patients and healthcare systems.

**Keywords**: Clinical decision support, data integrity, informatics, nurse anesthetist, standardization.

Nurse anesthetists need to continuously monitor complex and rapidly changing information as the basis for making critical decisions during surgical procedures. Certified Registered Nurse Anesthetists (CRNAs) need to be vigilant to constantly changing patient information, surgical conditions, and intraoperative communication to take prompt action to ensure positive patient outcomes. Informatics is a science within healthcare and anesthesia that uses computer technology as an aid in interpreting patient data to improve patient safety, the quality of care provided, and workload efficiency. Informatics is employed every time a CRNA electronically monitors physiologic data and delivers care using the anesthesia workstation. Unique informatics applications are embedded in anesthesia information management systems (AIMS) to pull patient information directly from anesthesia workstations and transmit the information into documentation systems and databases used for bedside notifications, coding, billing, or administrative functions.

In 2011, a survey revealed that only 24% of anesthesiologists had an AIMS installed in their workplace. Meaningful use legislation and financial strains in healthcare systems are creating new incentives for adopting an AIMS despite historically low implementation rates in anesthesia departments. The Centers for Medicare and Medicaid Services (CMS) provides meaningful use financial incentives for qualified providers who demonstrate using information technology to engage patients and families, promote patient safety, coordinate care, demonstrate efficient use of healthcare resources, and identify the effectiveness of clinical processes. It is critical for CRNAs to influence AIMS functionality, adoption, and use. As AIMS end users, CRNAs must provide insights regarding accuracy, efficiency, and relevance that will improve AIMS functionality and anesthesia outcomes. Participation by CRNAs in this evolution is urgent, as AIMS revisions are currently in progress. They provide insight into the accuracy, efficiency, and relevance of AIMS to anesthetized patients. These systems are being reevaluated in their role to deliver and capture anesthesia events. This creates an opportunity for CRNAs to honestly evaluate how their current system is operating and where investments should be made in system improvement. The purpose of this article is to describe current issues in anesthesia informatics within a historical context to foster a practical understanding of concepts and functions of anesthesia informatics so that CRNAs can advocate for AIMS that improve patient care.

**History and Review of the Literature**

A literature search was conducted using the electronic databases of PubMed and the Cumulative Index to Nursing & Allied Health Literature (CINAHL) using the following terms: anesthesia information management systems, anesthesia AND informatics, and anesthesia AND information technology. Fifty articles were found, and 29 were retained. All articles were read in their entirety. Clinical judgment was used to include those most relevant to the following criteria: historical relevance to anesthesia informatics and AIMS, data integrity, standardization, and clinical decision support (CDS). Articles selected for this review were published in English before July 1, 2013. The literature highlighted the evolving
nature of AIMS and contemporary issues with AIMS. The literature review is intended to equip CRNAs with knowledge of the development and refinement of AIMS to better understand concepts and functions of informatics, and to provide a basis for CRNA involvement in advocacy, development, and use of AIMS. Understanding the development of AIMS will situate CRNAs to advocate for AIMS that align with best practices in anesthesia.

Historical Trends in Anesthesia Informatics Literature

Literature regarding AIMS first appeared in the mid-1980s, describing AIMS’ ability to automatically record data, remove the bias of manual record keeping, and generate searchable databases on clinical activity/productivity for reporting. During the 1990s the anesthesia informatics literature described the experiences of AIMS users, the reduction in time spent documenting when AIMS were implemented, and increased quality of information recorded. Manual documentation reportedly consumed 36.6% of total anesthesia time, whereas AIMS reduced the time spent documenting by half, to 14.9% (P < .001). Further evidence revealed that AIMS increased the amount of information recorded and improved legibility of the anesthesia record. Another study demonstrated how AIMS created less bias (smoothing) of intraoperative data.

As evidence emerged about AIMS, clinicians questioned whether having automatic documentation reduced anesthesia providers’ awareness of intraoperative events. Researchers, however, found no difference between automated record keeping and manual data entry regarding anesthesia provider attention to patient care during surgery. This provided evidence that patient safety was not being compromised. These advantages of AIMS were foundational for understanding how to deal with the challenges of data artifact, standardized language, and optimal design of AIMS to promote user functionality.

Anesthesia informatics researchers in the first decade of the 21st century sought to understand the impact of data entry. Incorporating menu options into AIMS, instead of fields where clinicians could type narrative notes (free text fields), improved efficiency, record completeness, and the timeliness of the anesthesia record. Minimizing free text fields also enhanced compliance with coding standards, which facilitated timely reimbursement of anesthesia services. Timely bedside documentation, complete anesthesia records, and frequent scanning bedside monitoring and documentation software improved relevant anesthesia displays for clinical decision making. Real-time visual reminders automatically sent by AIMS to remind clinicians to address antibiotics during surgical procedures and emails sent to individual providers identified their performance in antibiotic administration compared with that of the entire department.

In the future, the possibilities exist for anesthesia providers to digitally capture laryngoscopy or ultrasound images and wirelessly enter these images as documentation in the patient electronic health record (EHR). A patient’s unique medical and surgical history may be applied to evidence-based practice algorithms to create recommendations on preoperative type and screening for blood products or prophylactic nausea and vomiting interventions.

Contemporary Informatics Issues

Literature reviewed from 2010 until July 2013 described contemporary issues in anesthesia information technology that expose critical insights into the low adoption rates of AIMS. The lack of acceptance of AIMS is strongly influenced by data integrity, standardization, and CDS. Clearly delineated definitions of and relationships among data and terms underlie each of these issues. By reviewing the literature in these contemporary areas, CRNAs should be keenly aware of how data integrity, standardization, and CDS are being refined within the AIMS to support complex anesthesia care.

- Data Integrity. Anesthetists rely on several aspects of data integrity to support practice, including timely, accurate, and visual displays of physiologic information. The AIMS must accurately record and display information. Data integrity issues described in the literature included missing data, artifact, the large quantity of data being applied to computer intelligence logic, and electronic time stamping. A case report exemplifies the importance of data integrity for clinicians. The patient in the case report emerged from surgery with a postoperative neurologic injury. When the anesthesia record was reviewed, the plaintiff’s attorney discovered that hemodynamic data was lost because of a technical malfunction. This case was settled out of court but highlights 2 important data integrity concepts for anesthesia providers. Foremost, providers must verify that current patient data are recorded in the EHR. Additionally, providers need to document in real-time and not pre-attest to events, thereby ensuring the validity of the information documented.

Technical malfunction or artifact (erroneous) data can obscure anesthesia information. Artifact data stem primarily from 2 sources. Foremost, electrical interference from surgical equipment disrupt transmission of patient information and create artifact: most notably in heart rate and rhythm displays (Figure 1). Artifact also affects practice when a monitor or transducer is not correctly positioned: specifically, when a pulse oximeter does not have good skin contact or when an arterial line transducer is not level with the patient. Whether manually or automatically recording data, artifact impacts interpretation of patient data. Artifact obscures real-time interpretation of patient trends and retrospective review
of anesthesia records for morbidity and mortality review or chart audits.

A review of 86 patient records demonstrated the presence of artifact for certain anesthesia data. Invasive blood pressure artifact was present in 14% of the records, and ST-segment artifact was present in 4.7% of the records.23 Heart rate artifact was reported as 0%; however, the definition for determining artifact was a heart rate greater than 100/min or less than 40/min.23 This criterion likely resulted in underreporting the proportion of heart rate artifact, and this biased the findings.

The time, date, and location of AIMS activities are electronically recorded and can be retrieved from computer logs. This documentation is known as time stamping. Although the primary purpose of AIMS is to improve patient care and information exchange, the use of AIMS generates user-specific data that may be used to monitor employee performance. Electronic time stamping enables identification of the timing and location from which a clinician accessed an EHR, medication dispensing system, or Internet site. Time stamping may be a valuable asset in anesthesia research but also has legal implications for practitioners and employers. Investigators using time stamping data found that anesthesia providers’ concentration was not impaired when anesthesia providers accessed information that did not pertain to the current case.24 The researchers installed software in anesthesia workstations to monitor active AIMS use, compared with other activities such as web browsing, monitoring other anesthesia locations, and performing student evaluations.24 Although this activity may not impair patients’ hemodynamic variability, time stamping information could create retrievable objective information that can be used to investigate a possible breach of duty.22,24

• **Implications.** Given the critical need for accurate real-time data, data integrity issues in AIMS must be addressed. Certified Registered Nurse Anesthetists continuously monitor data to anticipate and prevent potential problems. Artifact can lead to inappropriate decisions and unnecessary treatment of patients. Newer methods to filter out erroneous data are in development.25 When the bispectral index system (BIS) is represented free from artifact and in real-time, it provides data for CRNAs to modify anesthesia depth. A randomized blinded study found that postoperative delirium in patients greater than 60 years old was reduced 4.7% (P = .04) when BIS was used, and deep anesthesia (BIS < 20) had 1.027 greater odds of postoperative delirium (P < .001).26 Nurse anesthetists need to evaluate the accuracy and appropriateness of newer technologies to ensure they are consistent with clinical judgment. Furthermore, nurse anesthetists should have knowledge about time stamping so they can maintain professional integrity and transparency in their practice.

• **Standardization.** Standardization underlies how knowledge is displayed, represented, and exchanged between different electronic software systems, both within and between organizations. Ideally, a standardized terminology provides defined terms and relationships that support practice and generate meaningful data.27 The CMS stage 2 meaningful use criteria include adoption of standardized terminologies in the EHR, including Systematized Nomenclature of Medicine—Clinical Terms (SNOMED CT), Logical Observation Identifiers Names and Codes (LOINC) for laboratory test results, International Classification of Diseases (ICD) for diagnosis, and Current Procedural Terminology (CPT) for procedures.6 The adoption of standards in anesthesia has been problematic, as there are numerous examples in anesthesia for which multiple words represent the same concept (Figure 2). Terminology specific to anesthesia is being standardized with SNOMED CT to enhance coding, billing, review of medical records, and research capacity.27

Approximately 5,000 anesthesia terms have been described and standardized; however, a gap exists for linking SNOMED CT terms to preoperative anesthesia guidelines29 and having a standardized format and data in the anesthesia record.30 During a review of 4,989 records, emergence from anesthesia was omitted on 28.6% of documentation records, and surgical positioning was omitted during 18.9% of cases.31 Lack of consistent terminology and lack of consistent charting are 2 possible explanations for these omissions.

• **Implications.** Standardized format and concepts make interoperability possible. Information can be efficiently transmitted and received when anesthesia providers use the same language to describe information.27 Therefore,
consistent use of standardized anesthesia documentation within AIMS is needed to promote efficiency, improve anesthetic record completeness, streamline billing, facilitate case review, and generate reliable data. Nurse anesthetists need to be involved to ensure completeness of the data standards to adequately describe nurse anesthesia practice.

- **Clinical Decision Support.** Technology enables synthesis of large amounts of patient data, current literature, and clinical guidelines to supplement CRNA knowledge and support patient care. Clinical decision support is information provided to clinicians by computer technology to lessen the chance of an omission of care.\(^3^2\) Decision support is provided in AIMS by converting patient data into information displays, and associated reminders and prompts for timely attention to intraoperative events.\(^3^2,^3^3\) For example, electronic data input (eg, heart rate, laboratory value) can be analyzed in the anesthesia workstation using algorithms based on logic (eg, if the Train of Four is greater than a set value, then a notification is sent to the provider), as shown in Figure 3. After implementing CDS within AIMS, an organization reported that antibiotic administration improved from 88.5% to 99.3% (\(P < .05\)), redosing antibiotics improved from 62.5% to 83.9% (\(P < .05\)), documentation reminders enhanced anesthesia
appropriately within AIMS. Informatics applications are developed and deployed in care systems that support bedside practice by accurately recording intraoperative information to provide relevant and timely CDS. This article described current issues in anesthesia care, including timely, accurate standardized data, and CDS. This article described current issues in anesthesia information technology to inform the critical and urgent need for CRNAs to influence AIMS functionality, adoption, and use.

An informed consumer of AIMS. Advocate for systems that support bedside practice by accurately recording intraoperative information to provide relevant and timely CDS. Use terminology standards to promote interoperability and increase the speed of transmitting information. The use of informatics should enable CRNAs to enhance their bedside vigilance, align their practice with evidence-based clinical guidelines, and provide care that is cost effective for patients and healthcare systems.

**Summary**

Informatics has compelling applications in anesthesia care, including timely, accurate standardized data, and CDS. This article described current issues in anesthesia information technology to inform the critical and urgent need for CRNAs to influence AIMS functionality, adoption, and use.

An informed consumer of AIMS. Advocate for systems that support bedside practice by accurately recording intraoperative information to provide relevant and timely CDS. Use terminology standards to promote interoperability and increase the speed of transmitting information. The use of informatics should enable CRNAs to enhance their bedside vigilance, align their practice with evidence-based clinical guidelines, and provide care that is cost effective for patients and healthcare systems.

**REFERENCES**

10. Edsall DW. Computerization of anesthesia information management systems: past, present, and future of anesthesia information management systems. CDS is implemented well, it can facilitate powerful practice changes that improve patient care and financial sustainability. However, information technology alone should never replace the knowledge and wisdom of the clinician.33,34 It is imperative to understand how informatics applications are developed and deployed in anesthesia practice to ensure that CDS is implemented appropriately within AIMS.


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