Quality Improvement Using Automated Data Sources: The Anesthesia Quality Institute

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- Quality management
- Anesthesiology information management system
- AIMS • Registry • Outcomes

QUALITY IMPROVEMENT IN ANESTHESIOLOGY

Improving the quality of health care, including anesthesia, is a fundamentally simple cycle of observing outcomes, analyzing causation, making changes in care, and reobserving. The first step, observation, assumes the collection of data. The second step, analysis, defines the data that will be needed, which falls broadly into 3 categories, as shown in **Fig. 1**, and can be described as what we start with, what we do, and what happens. Risk factors are those elements of a case that are in place at the start, and are largely beyond the anesthesiologist's control. Risk factors include data such as patient age and sex, preexisting diseases and physiology, the kind of operation to be performed, and even systemic variables such as the presence or absence of surgical residents. Process data includes all that the anesthesiologist brings to the equation: the type of anesthesia performed, the specific medications used, the quantity of fluid or blood products administered, the monitors applied, and the maintenance targets for blood pressure, heart rate, glucose, hematocrit, and other measures of physiology. Outcomes are the real data of interest to patients and regulators, and these reflect the interaction between risk and process. Outcomes can be patient centered (eg, mortality, postoperative nausea and vomiting) or system centered (eg, cost of care, length of stay). Outcomes can be durable changes in function (eg,

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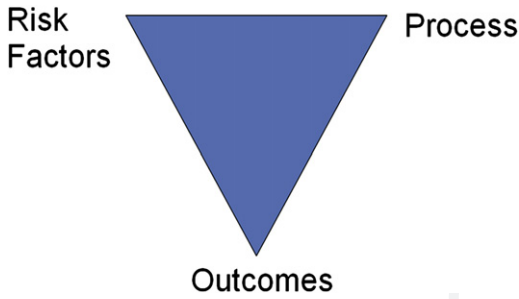

Fig. 1. The quality triangle, illustrating the data required to improve anesthesia care.

a myocardial infarct) or surrogates associated with such a change (eg, postoperative increase of troponin level). Comparing risk-adjusted outcomes associated with different process decisions is at the heart of both scientific research and anesthesia quality management (QM).

In the information age, the passive acquisition and processing of electronic data offers new opportunities for quality improvement that were not present even a decade ago. As discussed elsewhere in this issue, it is now possible to envision a future state of anesthesia practice that is completely paperless, from preoperative assessment through intraoperative record to postoperative collection of outcomes. Transition from paper to digital records creates the possibility for automated accumulation of anesthesia case data at an unprecedented scope and scale. The Multicenter Perioperative Outcomes Group (MPOG; discussed elsewhere in this issue) is one effort to leverage this capacity for academic purposes. The National Anesthesia Clinical Outcomes Registry (NACOR) of the Anesthesia Quality Institute (AQI) is another.

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THE NEED FOR ANESTHESIA OUTCOMES DATA

Coincident with the increased capacities of digital record keeping, there has been a steady increase in regulatory pressure to document the quality and value of health care. The Federal Government, which directly or indirectly funds more than half of the health care provided in the United States, has implemented a series of laws and regulations designed to encourage the quality and financial efficiency of health care. One example is the Physician Quality Reporting System (PQRS), which offers participating physicians a small incentive bonus to payments from Medicare if they can document compliance with specialty-specific, evidence-based processes of care that are known to be associated with improved patient outcomes. Three of these standards currently apply to anesthesiologists, all related to prevention of surgical site infections: administration of preoperative prophylactic antibiotics in a timely fashion, use of a best-practice bundle of techniques for central line placement, and maintenance of patient normothermia during and after major surgeries.[1] Another example is the recently announced physician incentive for meaningful use of health care information technology. Although in its infancy, this program will provide financial incentives to doctors, possibly including anesthesiologists, who have committed to the use of electronic record-keeping systems (discussed elsewhere in this issue). The Center for Medicare and Medicaid Services (CMS) has initiated a program whereby physicians can meet their requirements for PQRS standards by contributing their data to qualifying electronic case registries, and has made contribution through this mechanism easier than independent (claims-based) documentation.[2]

Noteworthy in the government roll-out of both PQRS and meaningful use is the concept that the incentives of today will transform, in the next 5 to 10 years, into penalties for those physicians who are not participating. Other regulatory pressures are coming to bear on anesthesiologists as well. The Joint Commission, the deemed certifying body of most US hospitals, has made the Focused Professional Practice Evaluation (FPPE) and the Ongoing Professional Practice Evaluation (OPPE) requirements for all physicians working in a surveyed hospital. FPPE is required for each new physician coming on staff, as well as for credentialing existing providers to perform new procedures. It asks the hospital the simple question, "How do you know this physician is qualified?" Previously, this might have been answered through reference to documented completion of a residency and perhaps certification by a specialty board, but now the expectation is that it will include direct observation of patient care and analysis of outcomes. OPPE asks the equivalent question for existing staff members: "How do you know this doctor is still capable?" OPPE similarly expects ongoing documentation of outcomes from current practice. Both of these programs merely reflect the emerging standards for maintenance of certification that all professional boards have now adopted. Maintenance of Certification in Anesthesiology (MOCA) is required for any anesthesiologist to be board certified in 2000 or later, and is voluntary (but strongly encouraged by state and local hospital requirements) for others. What began as a simple written recertification test has now become a multiyear process that involves documentation of ongoing continuing medical education and completion of a personal practice assessment that closely mirrors the FPPE and OPPE process.

These emerging regulatory requirements will have a profound effect on the practice of anesthesiology in the United States. Recognizing both the need to assist its members and the enormous potential of digital case information to improve patient care, the American Society of Anesthesiologists (ASA) chartered the AQI in 2009 to provide a new resource for anesthesia practice benchmarking nationwide.

DATA AVAILABLE

In creating NACOR, the AQI focused on the potential for collection of existing digital data. Operations began with a review of what was already available. Although there are literally billions of pages on the Internet, most information is not organized in a way that makes it tailored for data analysis. The usefulness of online databases is generally based on the format of their stored data, which includes unstructured, structured, and semistructured information. Clinically oriented databases such as those that contain drug information are often unstructured.[3] These databases are human readable but require a human to translate the information if analysis is required. Structured data, which limits the data stored in a field to a specific list (eg, a predefined values) or format (eg, whole numbers), simplifies automated analysis, filtering, and sorting. For instance, the Entrez Gene database (http://www.ncbi.nlm.nih.gov/gene) provides specific information related to the name, lineage, and location for genes. Another example, although not tailored to medicine, is online travel databases, which would not be useful if the user could not search for a flight based on date, city pair, or airline. In addition, a semistructured database like PubMed (http://www.ncbi.nlm.nih.gov/pubmed/) includes discrete values for items like the publication name, date, and page numbers, but unstructured information in the form of the abstract. A list of common medical databases can be found at http://www.nlm.nih.gov/databases/.

Unstructured data may be easier for clinicians to use, but is harder to manipulate in the digital world. Structured data are easy to transmit, report, and analyze, but may lose precision when translated from original, unstructured data entries. Clinical

information of interest to anesthesiologists comes in both structured form (eg, vital signs) and unstructured form (eg, procedure notes or comments on the anesthetic record). There are 4 major sources for digital data of relevance to anesthesiology:

- Anesthesia professional billing systems. These systems are in use in virtually every anesthesia practice (or the professional management company that supports them) and are highly structured, but limited in content. In the simplest form, the billing system includes only a provider, a procedure (usually by Current Procedural Terminology [CPT] code), and a duration.
- Anesthesia information management systems (AIMS). These electronic medical records for the OR include structured capture of most intraoperative process data: vital signs, medications, times, and fluids. AIMS also include unstructured or semistructured reporting of events (eg, induction, intubation, emergence). The relative degrees of structured, semistructured, and unstructured data in AIMS is based on the vendor, configuration of the software, and the practice patterns of the providers using the system. AIMS are in use in 10% to 20% of (mostly larger and academic) US hospitals; many more facilities are in the process of buying or installing an AIMS.
- Hospital electronic records. There are useful data on patient demographics and on short-term outcomes available in digital hospital records, including laboratory values before and after surgery, diagnostic codes before and after surgery, medications used, and length-of-stay information. Availability and constructive interconnection of these systems is highly variable across facilities. In some hospitals, the AIMS is purchased from the same vendor as the hospital's electronic health care records (EHR) system. In these environments, the AIMS is completely integrated into hospital EHR and both draws from and contributes to the overall patient record. Other hospitals use custom-developed interfaces to share data between AIMS and the EHR. In this scenario, the AIMS and EHR software are sold by different vendors, thus preventing seamless integration between the systems. In other settings, AIMS may be isolated from other systems and contributes little more than a printout at the end of the case.
- Anesthesia QM systems. These systems are home-grown programs, databases (often using Microsoft Access), or simple spreadsheets created to capture outcome information collected by the hospital, anesthesia group, or a specific anesthetic service (eg, pediatrics). They are typically populated by providers at the end of a case, or by Postanesthetic Care Unit (PACU) or clinic nurses trained to call back patients 24 to 48 hours after surgery and screen them for outcomes of interest. Variability in timing, topics, and definitions is high. A few practices are beginning to offer their software for sale to others, but there is no single system in common use. Q8

REGISTRY MODELS

Up to the present day, most successful registries of clinical data have been based on a similar development model: identifying a population to focus on, listing the variables of interest, recruiting groups to contribute data, and manual abstraction of information from patient medical records into the registry. Examples of this model of registry that may be familiar to anesthesiologists include the National Surgical Quality Improvement Project (NSQIP), the National Trauma Data Bank, the Society of Thoracic Surgeons Database, and the Malignant Hypothermia Association of the United States registry (MHAUS). Modern technology can make it easier to identify patients, and can facilitate the work of the data abstractors in entering data. The data entered can be

precisely defined, and the abstractors (usually nurses employed by the hospital's QM office) can be trained in a uniform fashion. These advantages are balanced by the time and cost of data acquisition, which can be substantial. Because every data element must move through the human filter of the abstractor, there are limits on the number of patients that can be included and the number of data points that can be captured. Participation in these registries is expensive ($150,000 per year on average for NSQIP hospitals) and the sample is therefore biased toward larger and more academic hospitals.

In building NACOR, the AQI sought to develop a different model, based on periodic transfer of case-specific data directly from one electronic system to another. This model takes advantage of the ongoing implementation (and interconnection) of health care information technology in anesthesia practice, and, in theory, should be far more cost-effective than a registry dependent on individual human case abstraction. Other potential advantages of this model include:

- All cases are reported, instead of a potentially biased subset
- Many more data points per case can be reported and archived
- Data flow is automatic and passive
- Uniform definitions can be applied in the electronic transfer process
- Data from different systems can be linked
- Automated cleaning and audit functions can be built in
- Technology solutions developed for one institution can be easily ported to other clients of the same vendor. Automated reports and trending over time can be built into the system
- New data elements and revised definitions can be easily added, and data collection can be made deeper over time as facility and practice capabilities expand

The use of AIMS to store and transmit data to NACOR is particularly advantageous in anesthesia. First, the 80/20 rule applies to anesthesia data collection: 80% of the data captured by anesthetic providers are already standardized (even if the formatting or meaning is slightly different), making it simple to share common data elements. Second, market consolidation among AIMS vendors has led to only a handful of major vendors. The use of standard AIMS software eases the incorporation of AIMS data into NACOR, because the mapping of data elements from the vendor software to NACOR needs to occur only once. Third, the analysis of large data sets can be used to influence and justify future data collection needs.

Compared with the traditional model, a new model registry will offer several challenges as well. These challenges must be identified as early in the process as possible, so that steps can be taken to mitigate their impact. First, the capacity to roll up electronic data at the national level requires the existence of that data in the first place. Some data (eg, administrative billing information) are already universally available. Some data (eg, anesthesia process information from AIMS) are available in some practices but not others, although all groups are moving toward increasing use of electronic records. In addition, there are some data (typically postoperative patient outcomes) that are rarely collected in the first place and, when collected, may not be recorded in an accessible electronic system. Overcoming this problem will require collective effort across the profession. Motivation will arise not only from an increasing desire to understand the best way to care for patients but also from increasing regulatory requirements to measure and report on patient-centered outcomes.

Second, the practice patterns of individual anesthesiology providers (whether anesthesiologists, residents, or Certified Registered Nurse Anesthesiologists) may possibly

affect the quality and quantity of data collected. Although AIMS automatically captures physiologic and ventilation data and uses electronic forms to collect other perioperative data, the anesthesiologists' professional experience and their exposure to AIMS may have an impact on the collected data. For instance, a provider who rotates among hospitals may only use AIMS once a month and never gain complete comfort using the system. This approach contrasts with the precision and uniformity of a nurse data abstractor.

Third, the choice of a specific AIMS vendor and the corresponding configuration of the AIMS may affect the mapping of data to NACOR. For instance, certain anesthesiology groups may be interested in capturing anatomic details related to the intubation process, whereas others may require far fewer data. Even within anesthesiology groups, the level of data captured may vary based on the practice patterns of the provider. The variability in the types of data collected could potentially affect the ability to perform data analysis systematically.

Fourth, most anesthesia-relevant electronic data exist at the present in various proprietary formats. In order for NACOR to accept these data, they must first be normalized into a standard schema or format. As shown in **Fig. 2**, translation of data (sometimes called mapping) can occur at either end of the communications pipeline, but requires a significant commitment of knowledgeable technical resources to accomplish. Translation further requires that the meaning of each data element be clearly and unambiguously defined. For instance, data accumulation would be compromised if 2 different organizations did not have the same understanding of the ASA Physical Status system or used different terms to specify this variable (such as Arabic vs Roman numerals). Another simple example that highlights the ambiguity of collecting even simple data elements is the specification of the units for height (inches or centimeters) or weight (pounds or kilograms) that are required to calculate body mass index (BMI). Even in a single hospital system, different services may not communicate this information consistently. If the EHR does not include the units while transmitting the relevant data, there is no way to calculate the BMI. Thus, a common vocabulary is required to successfully fill the registry.

The National Center for Clinical Outcomes Research (NCCOR) recognized these challenges in the course of developing their registry in the 1990s. As a result of this

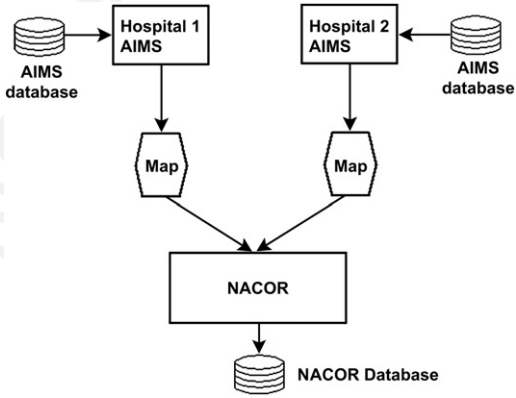

Fig. 2. Mapping data from various providers to the National Center for Clinical Outcomes Research (NCCOR). Each hospital has installed an AIMS from a different vendor. In order for NACOR to store the data, there is a mapping utility that converts the data to a common format.

project, the Anesthesia Patient Safety Foundation committed to establishing a common data format for anesthetic providers. The original Data Dictionary Task Force (DDTF) (established in 2000) merged several times with international organizations and now exists as a subproject within SNOMED (Standard NOmenclature for MEDicine), a comprehensive standard for medical terminology developed and used by the Federal Government. In turn, SNOMED partnered with the International Health Terminology Standards Development Organization (IHTSDO) to create a worldwide common language for medicine, and the DDTF has transitioned into the International Organization for Terminology in Anesthesia (IOTA). The development of this anesthetic ontology (in simplistic terms, an electronic representation of the perioperative and anesthetic record) has required a cooperative effort between practitioners and established AIMS vendors.[4–6] Future versions of AIMS software will hopefully incorporate these standards.

Where possible, the AQI has embraced existing standard definitions, such as those developed by IOTA, as the basis for its schema. Where a standard definition for a desired variable does not exist in IOTA, the AQI has either found a common definition developed by a national consensus organization (eg, the procedural times glossary of the American Association of Clinical Directors)[7] or developed its own, based on the best information available. The AQI has deliberately chosen to make its definitions, and the entire schema, publicly and prominently available on its Web site.[8,9] This has been of use to EHR vendors, and will hopefully encourage the universal adoption of common definitions.

Even when commercial EHR vendors use different definitions, mapping of most data is still possible. The MPOG has successfully created a research database with inputs from multiple different AIMS (see the article elsewhere in this issue). Walsh and colleagues[10] at the Massachusetts General Hospital have used Extensible Markup Language (XML) to link anesthetic data from their AIMS into the National Surgical Quality Improvement Program, successfully combining anesthesia process information with perioperative patient risk data and postoperative surgical outcomes.

BENEFITS OF ELECTRONIC ANESTHESIA DATA

Understanding the potential of the AQI to improve the practice of anesthesiology depends on first understanding the benefits of electronic data collection at the local hospital level. Although commercially available anesthesiology information management systems (AIMS) have existed for more than 20 years, the rate of adoption in anesthesiology practices has been low because it has taken time and technical evolution for them to realize their potential. However, the process of adoption does seem to be accelerating, and will likely do so even faster in the next decade in response to government pressure on providers and facilities to adopt EHR. A survey within the last 3 years estimated that 5% to 10% of US hospitals have adopted AIMS,[11] whereas 44% of US academic medical centers have implemented AIMS or committed to do so.[12]

Early AIMS were developed for their ability to reduce the workload of the anesthesia provider by capturing physiologic data automatically and printing it on paper.[13] However, as technology has evolved, the benefits of an AIMS now include revenue generation (automated support of billing functions), quality assurance, satisfaction of regulatory mandates, decision and research support, and enhancing the ability of the provider to focus on the patient.[14–19] Despite these perceived benefits of an AIMS, possible reasons for the low rate of adoption have been an inability to justify the return on investment (ROI), the inherent complexity of the system, challenges related to system integration, inability to acquire funding, and substantial ongoing

operating and maintenance costs.[20,21] For instance, the computation of ROI for the purchase and installation of an AIMS is often dependent on unrealistic and difficult-to-quantify assumptions.[20] Furthermore, the standard AIMS configuration may not meet an organization's needs, resulting in costly development of custom capabilities.[19]

One challenge for AIMS adopters, similar to adopters of any other information technology product, is learning to view AIMS as a tool and not as a complete solution.[18] Although tailored to the anesthesia environment, the benefits of AIMS have taken time to accrue, as early adopters have increasingly used core AIMS features such as perioperative data collection and workflow management (eg, templates and event alarms).

Because of the quality and quantity of data captured within AIMS, retrospective data analysis has been used for adverse event planning,[22] identifying patient risk factors,[23] economic benefits,[24] and risk management.[25] A deficiency in voluntary adverse event reporting has been shown by scanning AIMS records to automatically detect adverse events,[22] and an association has been found between the existence of these adverse events and the occurrence of inpatient mortality.[26] AIMS data have been used to statistically calculate perioperative and intraoperative risk factors, including hypotension in women undergoing cesarean section using spinal anesthesia,[23] the prediction of antiemetic rescue treatment as an indicator for postoperative nausea and vomiting,[27] and a model to predict intraoperative cardiovascular events.[28] The potential to use AIMS data in epidemiologic studies has been shown in a study that showed undertreatment and gender differences in the medical treatment of patients with coronary artery disease who presented for surgical treatment.[29] A bayesian model concluded that a 20% to 25% reduction in average time from case end to extubation can be realized when using desflurane compared with sevoflurane.[24] In addition, atypical drug transactions recorded in AIMS have been used to discover drug diversion by providers.[25]

Retrospective data analysis has the potential to influence professional liability.[30] Through a statistical analysis of the minimum heart rate, maximum heart rate, minimum arterial oxyhemoglobin saturation (Sao_2), minimum mean arterial pressure (MAP), maximum MAP, decrease in MAP, and increase in MAP, the investigators of one study calculated reference limits for vital signs during cesarean section. Based on their data, the investigators suggested that adverse outcomes were unlikely to be caused by the anesthesiologist as long as the vital signs remained within these calculated reference limits. This theory has yet to be tested in a prospective trial, but offers an interesting look at the profession's future ability to define normal and effective practice.

In addition to retrospective data analysis, the prospective capture of physiologic data has been leveraged in novel ways for operating room management,[31] compliance,[32] risk management,[33] and revenue generation. The accuracy of operating room occupancy can be inferred in real time from vital sign data transmitted by AIMS.[31] In this study, a bayesian method was used to estimate the remaining case time by incorporating historical case duration data, scheduled case duration and elapsed times, and a series of pop-up messages displayed on the AIMS screen.[34] In another study, an algorithm was developed to trigger an electronic alarm within the AIMS when pulsatile flow returned after disabling monitor alarms during cardiopulmonary bypass.[33]

Automated intraoperative monitoring of physiologic data has been used to improve compliance and revenue generation.[32] In this study, an algorithm was developed that monitored the AIMS record and determined whether the anesthesia provider was using an invasive arterial blood pressure catheter. An e-mail and page was sent to

providers who had not added a procedure note during or after surgery. The control group and study group had compliance rates of 84% and 99% respectively, showing the potential to identify increased revenue opportunities from previously unbilled procedures. Similarly, nonphysiologic perioperative data have been scanned intraoperatively using AIMS. In one study, text messages were automatically sent to providers who had not completed the allergy field in the AIMS record, improving the compliance rate for completion of this specific field.[35]

Multiple studies have shown the potential of AIMS to enhance anesthesia workflow for perioperative and quality assurance data collection,[36] staff recall,[37] and revenue generation.[38] Handheld computers have been successfully integrated into the data collection process before surgery and during pain rounds.[36,39,40] Using a list of predefined indicators on an electronic form, the collection rate of quality assurance data increased from 48% to 78%.[36] AIMS have been used to convert a manual phone tree for mass casualty recall to an automated system by automatically sending SMS messages to providers' cell phones.[37] In addition, a decrease in billing time from 3.0 days to 1.1 days was shown in a study that used an algorithm to continuously poll the AIMS database for documentation errors and then alert providers via page.[38]

A common workflow feature of an AIMS is the ability to trigger perioperative and intraoperative event reminders. This capability has been used to decrease the incidence of deviations from standard of care, such as reminding clinicians to administer prophylactic antibiotics to prevent surgical site infection (SSI).[41,42] The use of a multiprong strategy for disseminating prophylactic antibiotic compliance results to providers improved compliance from 69% to 92% in one study.[41] First, e-mail was used to provide individual provider feedback. Second, departmental results were posted in highly visible locations. Third, department leaders sought out staff who had repeated lapses. Based on an analysis of the data, anesthesia providers were instructed to modify the timing of prophylactic antibiotic administration to increase compliance (eg, dosing shortly after entering the room rather than during surgical prep).

Similar to other information technology implementations, challenges occur during the adoption of an AIMS. The quality of captured data is affected by the configuration of the system. The use of free text fields instead of structured text fields and a lack of question linking (eg, use of follow-on questions based on answers to previous questions) has resulted in decreased compliance and usefulness of data.[43] The automatic reconciliation of dispensed versus administered medications may be impractical because of data entry issues with AIMS and challenges integrating interfaces with the pharmacy system.[44] The ergonomics of an additional monitor and keyboard in the operating room is critical for user acceptance. At one hospital, a rear-view mirror was used to maintain visual contact with the patient in a tightly spaced endoscopic suite.[45] There have been several preventable malpractice claims in which the fault lay with either technical glitches or changes in anesthesia workflow. In one claim, staff did not recognize the loss of incoming AIMS data and did not manually enter captured data from the physiologic monitors.[46] Another claim described how the AIMS audit trail was used to suggest that an attending physician was not present at extubation because of preattested documentation.[47] Overall, however, AIMS are believed to reduce the risk of legislation by offering more complete documentation, increased legibility, and fewer lost records.

BENEFITS OF NACOR

The purpose of a national registry of anesthesia case information is to multiply the local benefits of an AIMS (described earlier) across hundreds of anesthesia practices and

health care facilities and the millions of anesthetics performed in the United States each year. Data from NACOR will be used for quality improvement, comparative effectiveness research, and national advocacy.

The most immediate use of AQI data will be on behalf of the anesthesia practices participating in NACOR data collection. A survey conducted by Audet and colleagues[7] found that only 33% of providers receive feedback in the form of data on the quality of the care they deliver to patients. By participating with NACOR, these groups will receive regular reports from the AQI that summarize their own case data in a standardized format and then benchmark aspects of their practice to an anonymous cohort of peer groups. This process will be done either for the practice as a whole or for individual facilities that the group covers. For example anesthesia time for an upper abdominal laparoscopy case might be compared within cohorts of ambulatory surgery centers, private inpatient hospitals, and academic medical centers. The mean and standard deviation of each center's cases would be displayed on a chart that ranks the centers from shortest to longest time. High outliers would be those centers with case times significantly shorter than the norm, whereas low outliers would be the opposite. Low outliers will benefit from knowledge of their standing, thus motivating efforts to improve, which could include internal efforts to improve anesthesia processes and practice, possibly drawing on resources provided by the ASA and AQI (eg, guidelines for preoperative testing), as well as use of the data to make external changes (eg, using the data as a lever to persuade the hospital to hire more housekeepers).

In time, AQI data will become a rich source for retrospective clinical research in anesthesiology, especially when comparing outcomes in similar groups of patients treated in 2 different ways (eg, regional vs general anesthesia for total hip arthroplasty). This comparative effectiveness research differs from the more traditional (and more precise) prospective randomized clinical trial because it is not possible to control for all of the biases that may influence any given clinical decision (eg, if sicker patients were more likely to receive regional anesthesia). Some of these biases can be identified and managed in the data collected (eg, by adjusting results based on ASA physical status) and some cannot. However, comparative effectiveness research enables the study of much larger numbers of patients than prospective trials and has an advantage in applicability because it is based in real-world practice. The US government is increasingly interested in the results of comparative effectiveness research to guide decisions about which procedures, processes, and medications to reimburse. The ability of the AQI to support academic uses of its data depends in large part on the depth and density of what is collected. As links to hospital EHR become more robust, it will become progressively easier to collect important risk-adjustment information such as comorbid conditions, preoperative laboratory values, and past medical history.

Data from NACOR will become an important resource for the leaders of ASA and for its committees, subspecialty societies, and foundations (**Fig. 3**). Aggregated national data will provide an understanding of the kinds and quantity of anesthetics performed, the most common cases done and populations served, and the overall safety of anesthesia practice. Identification of significant variations in outcome will prompt development of practice advisories and guidelines. Knowledge of which complications are most common, in which populations of patients, will guide both safety efforts and clinical research. NACOR will facilitate the ongoing work of other groups and individuals interested in anesthesia outcomes by providing, for example, denominator information to go with the malpractice numerators collected by the Closed Claims project. There is also the prospect of linking data from NACOR to the database and registry projects of

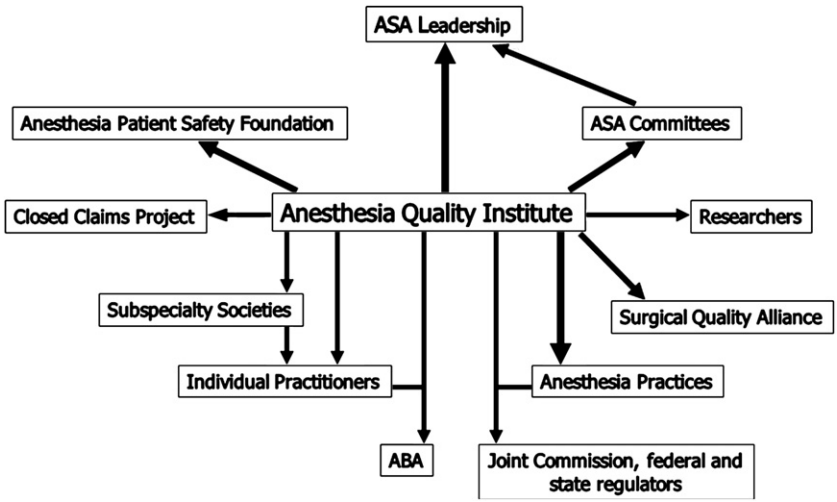

Fig. 3. AQI reporting of data from the NACOR.

other specialties, which will be done in the short term by synchronizing data definitions and electronic formats, and in the long term by actual exchange of matched (but still not identified) data. Q10

POTENTIAL PITFALLS IN THE AQI PROCESS

Although the goals and approach of the AQI would seem a natural fit for the information age, there are some potential pitfalls that have to be overcome. For example, encouraging the collection of postoperative outcome information will increase the apparent rate of complications by including events that had not previously been discovered or reported. This effect can hamper the movement of professional culture toward one of open and honest reporting, particularly if short-term results are used publicly by opponents of the process. A similar impediment can arise from publicity surrounding isolated bad outcomes. Although management by anecdote is never a good strategy for QM systems, there exists a strong potential in human nature for hysterical response to negative events, which can include a desire to blame the bearer of bad news (in this case the AQI).

Another pitfall can arise from overeager analysis of collected data. By their nature, anesthesiologists are used to seeing rapid results from their actions. Although successful medical registries of the past have taken as long as 7 years to achieve useful results, it is likely that the AQI will be expected to begin reporting far sooner than this. Judgment and restraint will be required to avoid releasing data that are not well understood. For serious complications (fortunately rare in anesthesiology) this will require large numbers of cases, documented at sufficient depth of reporting and consistency of definition, to adequately interpret the results. Because anesthesia is a service industry, our outcomes are closely linked to factors brought to the table by our patients, our surgeons and our systems. Even an outcome as innocuous as postoperative nausea and vomiting is strongly confounded by the nature of the practice, and will be higher in a group with more strabismus and endometrial surgery than in one dealing mostly with older orthopedic patients. Reporting intelligently on such an outcome requires adjustment for preoperative risk; risk adjustment in turn requires

an increase in the depth and consistency of the data collected. For complications such as perioperative mortality, myocardial infarction, or permanent neurologic injury, a huge number of confounding variables must be included to complete an appropriate risk adjustment.

Many organizations are protective of their data because of multiple factors including legal, privacy, or competitive concerns. The sharing of data between anesthesiology groups and NACOR could range from full and open access, to limited access, to only a few data elements. The ultimate success of NACOR will be based partially on the inclusion of as much comparative data as possible. Although NACOR advocates the passive collection of data, as described earlier, anesthesiology providers could theoretically use technical filters to prevent the release of certain types of cases or outcomes, which could ultimately skew data analysis.

Box 1 lists the data elements required for comparison of anesthetic mortality between different anesthesia practices, and helps to explain why this seemingly simple outcome is so hard to pin down. In a busy urban trauma center in which anesthesiologists care for every admission, the all-cause 30-day mortality is about 4 per 100.[48] At the other end of the spectrum, the periprocedure mortality caused by anesthesia in healthy patients undergoing elective ambulatory procedures is as low as 7 per million,[49] or 4 orders of magnitude different. Ironically, the trauma publication shows that the center's risk-adjusted mortality is among the best ever reported, and

Box 1
Calculating mortality for anesthesia

Although an obvious choice, calculation of mortality that allows comparison between practices is hard to do well, and illustrates several of the pitfalls inherent in the use of registry data.

1. Definitions must be consistent between practices
   a. Time to death: intraoperative, perioperative, less than 24 hours, less than 48 hours, less than 30 days?
   b. Patients included: every case? Every nonemergent case? Organ donors?
   c. Relationship to anesthesia: all cause? Anesthesia-related only? Who decides?
2. All cases must be included. Because the event (death) is rare, any missing event has an exaggerated effect on the final analysis
   a. No exclusion of some cases (automated passive systems help avoid this bias)
   b. Unknown mortality status must be investigated, not simply dropped. Missing data can be significant
3. Risk adjustment is required, to account for as many potential confounders as possible. Useful data include:
   a. Patient age and sex
   b. ASA physical status
   c. Scheduled surgery
   d. Emergency versus elective cases
   e. Comorbid conditions
   f. Preoperative medication use
   g. Preoperative laboratory values
   h. Preoperative physiology (vital signs or other diagnostics)

has improved significantly in the past decade, whereas the ambulatory publication expressed concern about an excess mortality for procedures performed in physician's offices. For outcomes that are more subjectively determined than mortality (eg, postoperative pain), the difficulty in creating meaningful comparisons becomes even greater, and the quantity and quality of data required to do it well becomes even larger.

The final pitfall inherent in any electronic system is the principle of garbage in, garbage out. Although the AQI can and will encourage practices to collect outcome data and report it using standard methods and standard definitions, the quality of NACOR ultimately depends on the quality of data collected at the patient level. If there is no recontact with the patient following PACU discharge, then no data can exist. If queries are imprecise or superficial, then data will be fuzzy. If outright fraud occurs, perhaps the result of overzealous pursuit of government incentives or a desire to gain a commercial advantage, then the validity of the system as a whole is threatened. There will always be a need for human review of submissions, and for a random auditing mechanism. The continuous and automated nature of NACOR offers some advantages in identifying suspect data through screening for statistically improbable results. In turn, this screening will allow for targeted auditing by human eyes, which will be necessary as NACOR matures. The deterrent value of these mechanisms should be sufficient to preserve the overall quality of AQI data, as well as a willingness to publicly confront those who are cheating the system, but eternal vigilance will be required.

SUMMARY

The AQI has created the NACOR based on the premise that anesthesia practice, and health care in general, will become increasingly digitized in the next 2 decades. NACOR will be the next-level destination for automatically generated data from AIMS and related EHR, and will enable data analysis and benchmarking based on millions of cases nationally rather than thousands of cases locally. Data from NACOR will provide the leaders of anesthesiology with aggregated information about national practice, and will enable more precise estimation of the scope of care provided by anesthesiologists, the overall effectiveness of that care, and the rate of serious complications. The AQI itself has the potential to become the central source in anesthesiology for defining process and outcome. Perhaps even more importantly, the AQI will be able to leverage data from NACOR to create change at the local level, by exporting best practices from high-performing practices to those with deficiencies. Less flashy than avoiding rare extreme outcomes, routine improvement in outcomes such as emergence time, hospital length of stay, postoperative nausea and vomiting, and severe pain will help to cement the reputation of anesthesiology as a safe and patient-oriented profession.

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