Anesthesia Information Management Systems: An Underutilized Tool for Outcomes Research

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Perioperative outcomes research using anesthesia information management systems (AIMS) is an emerging research method that has not been comprehensively reviewed. This review reports an initial analysis of the use of AIMS for perioperative patient outcomes research from articles published between January 1980 and January 2013. Perioperative patient outcomes research based on AIMS has increased greatly since 2001. Although risk stratification studies involving large study populations were most commonly reported, AIMS were also used to report a rare life-threatening anesthesia-related complication, malignant hyperthermia. Use of AIMS for perioperative outcomes research can address clinically relevant topics that traditional research methods have been unable to adequately address, mainly because of the innate challenges presented by perioperative anesthesia practice. It is expected that perioperative effectiveness and outcomes research using large AIMS databases will be more widely embraced in the future to generate useful evidence and knowledge to improve anesthesia care.

Keywords: Anesthesia information management systems, observational study, perioperative outcomes research, risk factors.

Since the US Congress enacted the Health Information Technology for Economic and Clinical Health (HITECH) Act to promote the adoption and meaningful use of health information technology in 2009, there has been a substantial increase in adoption of electronic health records among hospitals. Concurrently, anesthesia information management systems (AIMS) have become integral components in the complex health information systems in today’s healthcare environment. The benefits of AIMS have been noted in key areas such as cost containment, operations management, reimbursement, quality of care, safety, documentation, and outcomes research.

Anesthesia information management systems use electronic connections among physiologic monitoring devices, health system databases, and local input devices to gather, organize, display, store, and retrieve perioperative surgical patient care information. This information can be subsequently used for analysis. These systems record all clinical interventions in the intraoperative phase, including milestone events such as placement of instruments, state-of-art physiologic monitoring data, and derived measurements. Modern AIMS include 2 basic components of an automated anesthesia record and a perioperative database for patient-specific clinical information. The most comprehensive AIMS consist of a preanesthesia evaluation component and an electronic data warehouse stored with de-identified patient information from the perioperative database to create and arrange anonymous physiologic data for outcomes research.

The expansion of the use of AIMS provides opportunities and challenges to users for the meaningful use of data and optimization of healthcare delivery. Although AIMS are gaining popularity in the perioperative setting, their potential values have not yet been fully appreciated and used by institutions who have already adopted AIMS. Many of these institutions have not yet used AIMS data for research. To this end, this review summarizes the existing studies using AIMS for patient outcomes research and synthesizes their key features and benefits for future research.

History and Review of the Literature

The value of aggregating perioperative surgical and anesthesia data to report clinical outcomes was recognized as early as 1934. With the advent of mini- and micro-computers in the 1980s, the use of small computers in an operating room to collect data automatically became possible. A 1983 study described an early computer-assisted patient evaluation (CAPE) system, which involved paper-based input into a partly clinical, partly research database. With CAPE, the authors retrospectively analyzed clinical outcomes related to anesthetic techniques. The commercialization of computer systems in the 1990s promoted a new direction toward automating anesthesia documentation. The first study using a completely automated clinical record-keeping system to report perioperative outcomes was published in 1995. The authors evaluated the effects of mean arterial pressure during cardiopulmonary bypass and the rate of rewarming on cognitive function decline after cardiac surgery.
Interest increased among the vendors in 2001 when the Anesthesia Patient Safety Foundation (APSF) advocated using automated record keeping in the perioperative period. This permitted retrieval and analysis of records to improve patient safety. Endorsing AIMS as a means of collecting data, the APSF has recognized the need for aggregate databases in outcomes research.

In 2001, less than 1% of all anesthesia departments in the United States were using AIMS. The digitization of other practice areas such as radiology and pharmacy in 2007 catalyzed more academic anesthesia departments in the United States in adopting AIMS. By 2008, at least 14% of the US anesthesia departments were using AIMS. A survey in 2011 revealed that 15% of the anesthesia departments of European university-affiliated hospitals had adopted AIMS. An updated survey in 2013 reported that 67% of US academic anesthesiology departments are currently using AIMS and the adoption rate will increase to 75% by 2014. However, the adoption of AIMS outside academic programs has been slow; 24% of the respondents to a 2011 survey of members of the American Society of Anesthesiologists indicated that they were currently using AIMS. Regardless, since 2001, the increase in the adoption of AIMS has led to the proliferation of using AIMS data for perioperative patient outcomes research.

Materials and Methods

• Search Strategy. PubMed was searched to identify English-language articles related to AIMS-based perioperative patient outcomes research published between January 1980 and January 2013. Using anesthesia information management systems as a key search term, the search yielded 300 citations for articles worldwide. After reviewing the titles and abstracts, articles relating to AIMS implementation and adoption, clinical decision support, perioperative quality improvement, administrative management, and AIMS’ data quality were excluded. Additional articles were identified from the reference lists of retrieved articles.

Of the 21 articles included for the review, 20 were AIMS-based clinical patient outcomes studies, and 1 was a case report describing a rare life-threatening condition captured by AIMS. The key data elements of the studies were extracted and are shown in the Table. The studies were published in clinical journals for their respective disciplines or in research-focused journals.

• Definition. For the purpose of this review, perioperative clinical patient outcomes were broadly defined as any response variables assessed in the context of perioperative patient care. Study data reviewed were AIMS-based data used by anesthesia providers for patient care. Other forms of electronic health data or subsets of data used for research, such as surveillance databases or data registries, were not considered for this review.

Results

• Dates of Data Analyzed. Data analyzed ranged from 1981 to 2012. The earliest study analyzed data from 1980 to 1981 using one of the prototype AIMS, the CAPE system. The remaining studies analyzed data from the 1990s to 2000s, reflecting both an increase in the adoption of AIMS and the ease and speed of using AIMS data for patient outcomes research. Compared with claims data, which are not available until the point of reimbursement because of the lag time of submitting claims, AIMS data are immediately accessible in real-time at the point of care.

• Sample Size and Study Setting. The sample sizes varied from 237 to more than 70,000 patients, and all the studies were conducted at academic university hospitals. Use of large-scale datasets to evaluate many patients at a time was most common for most of the studies reviewed. All the studies reviewed were conducted at a single center with the exception of 2 studies. Of the 2 studies, 1 of them analyzed AIMS data transferred from a different center and the other used a national dataset developed by the American College of Surgeons, which included 121 centers and nearly 76,000 cases. Larger academic healthcare institutions, rather than smaller practices, conducted research with AIMS data. Most of the studies identified were conducted at 2 university hospitals in the United States and Germany. The researchers’ familiarity and expertise with AIMS data enabled them to conduct perioperative outcomes research with relative ease and speed.

• Supplemental Data Sources. Although AIMS data are exceptionally detailed compared with manual records, data elements necessary for research may be unavailable. This could be due to the lack of interoperability of AIMS with other systems collecting patient-level data (eg, billing, pharmacy, or laboratory databases) or the inability of AIMS to provide the pertinent data needed for research. Some investigators of the studies supplemented data. For example, one study added neurophysiologic tests to evaluate the cognitive decline after cardiac surgery, another study took mortality data from the hospital information system to analyze intraoperative hypotension and 1-year mortality after noncardiac surgery, and another study extracted data from the operating room information management system to evaluate extubation time.

• Reported Outcomes. Reported outcomes varied across studies, depending on the study objectives, AIMS functionality, and configuration. Only one study used preanesthesia clinic AIMS data to provide an epidemiologic perspective of community care on patients with coronary artery disease presenting for surgery. The case report included in this review illustrated the first ever such case report recorded, and it stored precise changes in physiologic data of a human experiencing a rare life-threatening condition of malignant hyperthermia. AIMS are able to capture the progression of physiologic
changes of the disease condition with a higher degree of precision and frequency.\textsuperscript{13}

Junger et al\textsuperscript{16} added 3 anesthesia-related variables as predictive for postoperative nausea vomiting (PONV) in addition to previously described patient-related risk factors and operative variables. In a meta-analysis of randomized control trials, other researchers found that desflurane reduced the mean and variability of extubation times relative to sevoflurane.\textsuperscript{13} Three studies reported outcomes related to the management of oxygenation such as incidence and independent risk factors for impossible mask ventilation, predictors of cervical spine limitation associated with difficult laryngoscopy and difficult intubation, and predictors of hypoxemia during one lung ventilation.\textsuperscript{17-19} Study interests in the potential impact of hemodynamic management on short-term and long-term outcomes align with AIMS' ability to record and store more accurate and objective hemodynamic data. Using AIMS, researchers reported the incidence, risk factors, and outcomes related to patients' variables (comorbidities); intraoperative interventions; and intraoperative hemodynamic aberrations.\textsuperscript{11,12,20-25}

**Data Quality and Data Validation.** Anesthesia information management systems are able to collect data automatically and reliably to create an accurate record at all times, especially the highly reliable physiologic monitoring data transferred from the monitors. Data from AIMS eliminate recall bias that may occur when situations do not allow anesthesia providers simultaneously to write down the vital signs and deliver care to the patient. Paper records are subject to inaccuracies and smoothing of vital-signs data.\textsuperscript{2,9,11,16,20,22,26} However, artifacts recorded by AIMS may influence research results. Investigators reported various measures to check data integrity for data validation.\textsuperscript{10,5,16-18,20,22,23,25,26} For instance, researchers who performed visual verification for plausible data not only associated an event with a numeric reading but also included therapeutic intervention to eliminate the risk of falsely detected artifacts.\textsuperscript{26} Sticher et al\textsuperscript{19} visually checked every record with an oxygen saturation measured by pulse oximetry ($SpO_2$) below 90\% to verify the automatically detected incidence of hypoxemia. To eliminate possible artifacts, the investigators compared the pulse rate measured by a pulse oximeter to the corresponding heart rate, the arterial oxygen saturation when blood gas analysis was available, and the documented commentary by anesthesia providers. The median and mean values with a duration of 1- to 5-minute epochs were the most commonly used methods for the analysis of physiologic monitoring data.\textsuperscript{11,12,20-25} The use of a median value filters out monitoring artifacts that limit clinical significance.\textsuperscript{27,28} Kool et al\textsuperscript{28} reported that storing a median value each minute provides reliable data for heart rate and oxygen saturation and acceptable reliability for noninvasive blood pressure data.

**Study Design and Statistical Analysis.** Excluding 1 case report and 1 prospective randomized controlled trial, 19 studies reviewed were either prospective or retrospective observational designs. The prospective randomized controlled trial was the first effectiveness trial on the prevention of intraoperative awareness.\textsuperscript{29} Sixteen studies used predictive models to provide quantitative estimation of clinical outcomes.\textsuperscript{9,12,14,16-23,25-27} Regression analysis was used for the predictive models, including multivariate linear regression and multivariate logistic regression. Two studies used Cox proportional hazards regression models to analyze time-to-outcome data for long-term survival rate.\textsuperscript{10,12} The predictive models that analyze binary outcomes and time-to-outcome data were assessed for accuracy by discrimination and calibration performances. The most frequently used measure of discrimination was the receiver operating characteristic curve,\textsuperscript{9,10,16,17,19,21,22,25-27} and the most frequently used measure of calibration was the Hosmer-Lemeshow goodness-of-fit test.\textsuperscript{9,31,22,26} Three studies\textsuperscript{10,18,27} used advanced statistical methods of propensity score for patient risk stratification and patient matching to complement conventional multivariable regression methods to improve statistical efficiency and to control biases in the observational studies.

**Discussion**

**Overview.** The wealth of data stored in AIMS not only can provide insight into the efficacy of perioperative care but also offers the capability to leverage clinical research. The data are suitable to address diverse clinical questions for patient outcomes research. Preanesthesia clinic AIMS databases provided epidemiologic perspectives of community care by showing that the sex disparities on coronary artery disease management have diminished significantly.\textsuperscript{14} Using perioperative AIMS data, investigators linked patients' and process variables to clinical outcomes for PONV, cardiac adverse events, acute kidney injury, airway management, and liver transplant. Study outcomes on intraoperative hemodynamic aberrations have challenged the commonly held view that transient marked abnormal hemodynamic parameters are inconsequential to outcomes.\textsuperscript{10,12,20,24,23,27} Furthermore, AIMS-based studies have offered much-needed updates to the perioperative anesthesia prediction literature, such as studies on impossible mask ventilation,\textsuperscript{17} acute kidney injury after noncardiac surgery,\textsuperscript{10,27} and perioperative cardiac adverse event after general, vascular, and urologic surgery.\textsuperscript{25}

**Effectiveness.** Comparative effectiveness research (CER), as promoted under the 2009 American Recovery and Reinvestment Act, presents a major opportunity in healthcare by producing useful evidence to promote best practices.\textsuperscript{30} The role of CER in perioperative research has been evaluated for a future path and new directions for perioperative effectiveness research are being explored.
<table>
<thead>
<tr>
<th>Source</th>
<th>Design/time</th>
<th>N</th>
<th>Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chase et al.</td>
<td>Retrospective observational/1980-1981</td>
<td>960</td>
<td>Duration of hospital stay and respiratory treatment was prolonged in patients who received general anesthesia compared with regional anesthesia for simple total abdominal hysterectomy ($P &lt; .01$).</td>
</tr>
<tr>
<td>Jost et al.</td>
<td>Retrospective observational/1998-2001</td>
<td>1,672</td>
<td>For elective CABG, 9.4% of patients received positive inotropic drugs. Predictors for need of positive inotropic drugs were age &gt; 65 years, CHF, and history of preexisting myocardial infarction.</td>
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<tr>
<td>Kheterpal et al.</td>
<td>Prospective observational/2005-2006</td>
<td>75,952</td>
<td>Among patients undergoing general surgery, 1% of cases were complicated by AKI. Independent preoperative predictors were age &gt; 56 years, male gender, emergency and intrapleural surgery, diabetes mellitus requiring therapy, active CHF, ascites, hypertension, and mild and moderate preoperative renal insufficiency. Patients with AKI had an 8-fold increase in 30-day mortality.</td>
</tr>
<tr>
<td>Newman et al.</td>
<td>Prospective observational/NA</td>
<td>237</td>
<td>MAP and rewarming rate were not related to cognitive decline during CPB. Hypotension and rapid rewarming contributed significantly to cognitive dysfunction in the elderly.</td>
</tr>
<tr>
<td>Bijker et al.</td>
<td>Retrospective observational/2002-2003</td>
<td>1,705</td>
<td>Mortality within 1 year after noncardiac surgery was 5.2%. No causal relation was found between intraoperative hypotension and 1-year mortality after noncardiac surgery. Mortality risk increased for elderly patients when duration of intraoperative hypotension became long enough.</td>
</tr>
<tr>
<td>Dexter et al.</td>
<td>Meta-analysis/2005-2008</td>
<td>32,792</td>
<td>Desflurane reduced mean and variability of extubation time by 20%-25% relative to sevoflurane.</td>
</tr>
<tr>
<td>Vigode et al.</td>
<td>Retrospective observational/2004-2006</td>
<td>21,039</td>
<td>Epidemiologic trend showed that use of aspirin ($P &lt; .01$) and β-blockers ($P &lt; .0005$) was increased among women with CAD.</td>
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<tr>
<td>Maile et al.</td>
<td>Case report/NA</td>
<td>1</td>
<td>AIMS captured accuracy and high frequency of physiologic data for malignant hyperthermia.</td>
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<tr>
<td>Junger et al.</td>
<td>Retrospective observational/1997-1999</td>
<td>27,626</td>
<td>Incidence rate of PONV was 7.7%. Risk factors for PONV in PACU were female gender, OR = 2.45; smoker, OR = 0.53; age, OR = 0.996; duration of surgery, OR = 1.005; intraoperative use of opioids, OR = 4.18; use of N₂O, OR = 2.24; and IV anesthesia with propofol, OR = 0.40.</td>
</tr>
<tr>
<td>Kheterpal et al.</td>
<td>Prospective observational/2004-2008</td>
<td>53,041</td>
<td>Frequency of 0.15% with impossible mask ventilation was observed. Independent predictors were neck radiation changes, male gender, sleep apnea, Mallampati class 3 or 4, and presence of beard. Of patients with impossible mask ventilation, 19 patients demonstrated difficult intubation, 15 were intubated successfully, 2 had surgical airways, and 2 patients underwent successful fiberoptic intubation.</td>
</tr>
<tr>
<td>Mashour et al.</td>
<td>Retrospective observational/24 months</td>
<td>14,053</td>
<td>Of patients, 8.1% documented some form of cervical spine limitation. Age &gt; 48 years, Mallampati class 3 or 4, and thyromental distance &lt; 6 cm were independent preoperative risk factors for difficult intubation in patients with cervical spine limitation.</td>
</tr>
<tr>
<td>Sticher et al.</td>
<td>Retrospective observational/1997-2000</td>
<td>705</td>
<td>During one-lung ventilation, 9.5% of patients developed hypoxemia. Independent predictors for hypoxemia were BMI ($P = .018$) and preoperative existing pneumonia ($P = .043$).</td>
</tr>
<tr>
<td>Reich et al.</td>
<td>Retrospective observational/1999-2000</td>
<td>4,096</td>
<td>Of patients, 9% experienced severe hypotension 0-10 minutes after induction of general anesthesia. ASA classes III-V, baseline MAP &lt; 70 mm Hg, age ≥ 50 years, use of propofol for induction of anesthesia, and increased induction dosage of fentanyl were predictors of hypotension 0-10 minutes after anesthetic induction.</td>
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Brenck et al.\textsuperscript{21} 2009 Retrospective observational/2002-2004 503 Hypotension was found in 56.5\% of cases. Neonate’s weight, mother’s age, BMI, and peak sensory block height were associated with hypotension. BMI, age, and sensory block height were independent factors for hypotension (OR = 1.61 each).

Hartmann et al.\textsuperscript{22} 2002 Retrospective observational/1997-2000 3,315 After induction of spinal anesthesia, 99.2\% of patients developed different degrees of hypotension. Independent factors for hypotension after spinal anesthesia were chronic alcohol consumption, OR = 3.05; history of hypertension, OR = 2.21; BMI, OR = 1.08; sensory block height, OR = 2.32; and urgency of surgery, OR = 2.84.

Lesser et al.\textsuperscript{23} 2003 Retrospective observational/2 years 6,663 Baseline heart rate < 60/min ($P = .0001$) and male gender ($P = .05$) were risk factors for a severe bradycardia episode. Risk factors for moderate bradycardia were age < 37 years (OR = 1.4), male gender (OR = 1.4), nonemergency status (OR = 1.7), $\beta$-blockers (OR = 1.6), and case duration (OR = 2.0).

Reich et al.\textsuperscript{24} 2003 Retrospective observational/1991-2000 789 Of 789 patients, 18\% had negative surgical outcomes after liver transplant. MAP < 40 mm Hg occurred at least once during the procedure (OR = 2.39, $P = .0016$) and MAP > 40 mm Hg at least 3 times (OR = 2.2, $P = .035$) were associated with negative surgical outcomes.

Kheterpal et al.\textsuperscript{25} 2009 Prospective observational/2003-2007 7,740 Independent predictors for cardiac adverse events after noncardiac surgery were age $\geq$ 68 years, BMI $\geq$ 30 kg/m$^2$, emergent surgery, previous coronary intervention or cardiac surgery, active CHF, cerebrovascular disease, hypertension, operative duration $\geq$ 3.8 hours, and administration of $\geq$ 1 U of packed red blood cells intraoperatively. High-risk patients experiencing a cardiac adverse event were more likely to experience an episode of MAP < 50 mm Hg, an episode of 40\% decrease in MAP, and an episode of heart rate > 100/min.

Röhrig et al.\textsuperscript{26} 2004 Retrospective observational/1997-2000 58,458 In 17.8\% of the evaluation and 7.3\% of the validation cohorts, a minimum of 1 cardiovascular event was detected. Cardiovascular events were associated with significantly more frequent in-hospital mortality (2.1\% vs 1.0\%; $P < .01$).

Kheterpal et al.\textsuperscript{27} 2007 Prospective observational/2003-2006 15,102 ARF developed in 0.8\% of patients after noncardiac surgery. Independent preoperative predictors were age, emergent surgery, liver disease, high-risk surgery, and peripheral vascular occlusive disease. Intraoperative independent predictors of ARF were total vasopressor dose administered, use of a vasopressor infusion, and diuretic administration. ARF was associated with increased 30-day, 60-day, and 1-year cause mortality.

Mashour et al.\textsuperscript{29} 2012 Prospective randomized controlled trial/2008-2010 21,601 Incidence of definite awareness was 0.12\% in the anesthetic concentration group and 0.08\% in the bispectral index monitoring group ($P = .48$). No significant difference was found between the 2 groups for postanesthetic recovery variables (recovery room discharge and incidence of PONV). Bispectral index monitoring may decrease intraoperative awareness compared with routine care without a protocol by post hoc analysis.

### Table. Summary Information on Studies Reviewed

Abbreviations: AIMS, anesthesia information management system; AKI, acute kidney injury; ARF, acute renal failure; BMI, body mass index; CABG, coronary artery bypass grafting; CAD, coronary artery disease; CHF, congestive heart failure; CPB, cardiopulmonary bypass; IV, intravenous; MAP, mean arterial pressure; NA, not available; N$\text{\textsubscript{2}}$O, nitrous oxide; OR, odds ratio; PONV, postoperative nausea and vomiting.
at a rapid rate.\textsuperscript{30} The benefit of aggregated AIMS data for perioperative effectiveness and outcomes research is detailed accurate information through the systems’ ability to capture granularity of data on the patient’s response to anesthesia and surgery by recording procedures, physiologic changes, key events, and pharmacologic administration that occur throughout the perioperative period. Automatic recording of physiologic data avoids error-prone transcription by providers, and it permits recording and storing high-sample frequency of minute-to-minute meaningful vital-signs data suitable for research.

• Efficiency. The decision to promote CER stems from the need to control the increases in healthcare expenditures. Given the rising costs of healthcare, an emphasis has been placed on identifying research methods that are effective and efficient. The aggregated AIMS data not only offer the effectiveness for perioperative outcomes research but also are cost-effective. Studies reviewed using AIMS data took less time and less labor even though possessing a large sample size of more than 10,000. In contrast to the timely and readily accessible AIMS data to all AIMS users for research, Stabile and Cooper\textsuperscript{31} reported that some large-scale studies that relied on paper-based technology had taken more than 30 years to assess the effect of intervention strategies on the rate of medication errors in anesthesia. The insights derived from such studies did not provide opportunities for improvement for anesthesia practice. The significant reduction in the risk of anesthesia has led to unique challenges in studying adverse events because of their infrequency.\textsuperscript{32} To ensure a study is adequately powered to derive meaningful conclusions, a large sample size is needed, and acquiring a large sample size is often cost-prohibitive. For instance, the cost per patient enrolled may be quite high in well-conducted prospective trials in addition to the trials placed on the allocation time on operative efficiency and operating room turnover.\textsuperscript{32} The AIMS data from across institutions can help to utilize the large volumes of available data to determine targets for such future research.\textsuperscript{32}

• Limitations and Challenges. Because AIMS are not created for the sole purpose of research, use of AIMS data for research has limitations. There might be missing and incomplete data entries and some of the existing data might not be precisely defined for research purposes. Although AIMS can provide a wealth of structured data defined as easily searchable with consistency and accuracy, the accuracy of some data, such as artifacts of vital signs, must be verified and analyzed in the appropriate clinical context.\textsuperscript{30} In addition, AIMS can have an extensive amount of unstructured, free-text data that require extensive review. For large databases, data trimming can be a time-consuming task. Developing a system to validate data for conducting outcomes research using large datasets to ensure that the datasets represent the population at large is challenging.\textsuperscript{2} Confirming the datasets’ validity and resemble the distribution of population will increase the generalizability of outcomes research using large datasets.\textsuperscript{2} The new insights and meaningful conclusions derived from such studies will optimally improve patient care.

• Future. Some national institutions have taken efforts to leverage the capability of AIMS databases for research. The American College of Surgeons recognized this potential and collaborated with the APSF to study the feasibility of incorporating perioperative AIMS data into the American College of Surgeons National Surgical Quality Improvement Program.\textsuperscript{2} These data will relate preoperative patient risk and surgical factors to the adverse events following surgery.\textsuperscript{2} The Multicenter Perioperative Outcomes Group based at the University of Michigan, Ann Arbor, aggregates de-identified AIMS data from multiple institutions to create a powerful research database and to use this large volume of data to determine targets for future research.\textsuperscript{2} The rigorous statistical techniques used for perioperative effectiveness and outcomes research is beyond the scope of this review, but some insights recommended by experts merit mentioning. For instance, propensity scoring and various types of modeling such as Bayesian approaches address issues of confounding and measurement bias in outcomes research.\textsuperscript{30}

Conclusion

The potential value brought by AIMS exceeds the simple automation of the paper anesthesia record. To identify benefits of AIMS-based research, this review summarized published studies focusing on use of AIMS data for perioperative patient outcomes research. The new research methods such as using large databases and effectiveness research techniques will lead to an improved understanding and delivery of perioperative care, and efficiency in research will play a larger role in the future in guiding healthcare. As these occur, AIMS will complement the traditional research methods to generate useful evidence and knowledge for improving clinical guidelines and the delivery of anesthesia care.\textsuperscript{32}

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