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Original Research

Automating Anesthesiology Resident Case Logs Reduces Reporting Variability

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Introduction

The Accreditation Council for Graduate Medical Education (ACGME) outlines minimum case and procedure requirements for residents in accredited anesthesiology training programs.[1,2] Residents are responsible for documenting cases and procedures in the ACGME Case Log System. Documentation is a manual process that relies on residents to accurately recall, report, and appropriately categorize case participation and procedure performance.[3] We believe case categorization and assignment of case credit are the 2 largest sources of variability.

The ACGME provides broad guidance for categorizing surgical procedures as pediatric, cardiac, intrathoracic noncardiac, major vascular, intracerebral, or obstetric. Without discrete descriptors, categorization of some surgical procedures can be ambiguous and require subjective interpretation. While this ambiguity accommodates a wide breadth of surgical procedures as well as institutional variability, resident case log practices likely vary within each institution and between programs across the nation.[4] Current Procedural Terminology (CPT) codes may provide a mechanism for categorizing surgical procedures and reduce the variability associated with case log documentation.

The ACGME does not provide guidelines for the assignment of case log credit in anesthesiology.[1,5] By comparison, the *credit roles* for general surgery are well defined. For example, case credit is attributed when a resident functions as the *surgeon*, defined as significant participation in the determination or confirmation of the diagnosis, provision of preoperative care, selection, and accomplishment of the appropriate operative procedure, and direction of the postoperative care.[6] Establishing commensurate *credit roles* for anesthesiology may also reduce variability in case log documentation.

Variability in reporting practices not only impairs assessment of an individual trainee's experience and progression, but it also impairs equitable distribution of cases among trainees.[2] Fortunately, the emergence of electronic health care records (EHR) with anesthesia information management systems (AIMS) introduces a new resource for verifiable documentation of resident training. Case logs can be automated from anesthesia information management systems using parsing and common procedural terminology mapping methods, and when compared to manual classification, automation classifies cases into ACGME categories with 95% accuracy.[3] Our primary objective was to develop a systematic process for generating automated, real-time ACGME case logs using data elements extracted from the EHR. We hypothesized that case log automation using discrete criteria for attributing case credit and a classification system for case categorization based on Anesthesia CPT codes would improve reporting accuracy and reduce variability in resident reporting practices.

Materials and Methods

Process Development

This study was reviewed by the institutional review board and classified as exempt. A task force composed of chief residents, anesthesiology program directors, and technology committee members established criteria for assigning credit roles and categorizing cases as described below. The comparative analysis included a cohort of 42 categorical anesthesiology residents from the 2018, 2019, and 2020 graduate classes. The classes were composed of 14, 15, and 13 residents, respectively. The case counts from the automatically extracted case logs were compared to the Archived Resident Procedure Summary by Year report produced from the ACGME case log system. Case counts are presented as median and interquartile range. The Wilcoxon signed-rank test was used to compare paired difference of the 2 case log methods. The significance test was 2-sided, and the significance level was set at 0.05. Intraclass correlation coefficients were calculated for absolute agreement (2-way random model, single measure) and consistency to assess reliability (2-way mixed model, single measure).[7,8] Statistical analysis was performed using SAS software (version 9.4; SAS Institute Inc., Cary, NC, USA) and Intraclass correlation coefficient was calculated using the Stats and Psych

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Packages in R (version 4.2.0; R Foundation for Statistical Computing, Vienna, Austria). When validation was completed, real-time training dashboards were launched for all 54 anesthesiology residents and fellows currently in training.

Case Classification and Data Extraction

The American Society of Anesthesiologists (ASA) Crosswalk 2018 was used to transform Anesthesia CPT codes into CPT codes for the associated surgical procedure.[9] Surgical procedures were categorized based on broad guidance from ACGME[1,10] and committee consensus. Data Governance approved data extraction from the EHR. The task force collaborated with extraction, transformation, and loading developers and data stewards to construct the structured query language and validate the data extraction. Data was extracted from the EHR, transferred to an enterprise data warehouse, then analyzed and visualized using business intelligence tools (Figure 1). A prototype case log was created from a static extraction and subsequently, a live experimental enterprise data warehouse was created to refine and validate dashboards.

Filters and Logic

Criteria for assigning credit roles were agreed upon by the task force. The credit role was assigned to a resident if they were present at anesthesia start or stop, participated in more than 50% of intraoperative care, or were present for at least 50 intraoperative minutes. Credit roles can be assigned to more than 1 resident for an individual case. Attending supervision was assigned to the anesthesiology faculty present at *anesthesia start*.

Anesthesia CPT codes and the ASA Crosswalk were used to identify the associated surgical procedure and assign ACGME case log categories (Table 1). When available, smart text identifiers were used to clarify ambiguous CPT coding. Grouping logic permitted classification of individual cases into multiple ACGME categories. For example, a heart transplantation can be categorized as *cardiac with bypass* as well as *major vascular open*. Intracerebral endovascular procedures could not be delineated from other endovascular procedures because of the limitations of CPT coding. Heart, liver, and kidney transplantation were also reported, although solid organ transplantation is not currently an option for ACGME case categorization.

Credit roles and case categorization for obstetric cases required additional consideration, as multiple providers may share responsibility for a single labor epidural and labor epidurals may also be used as the primary anesthetic for a cesarean section. When a labor epidural is used as the primary anesthetic for a cesarean delivery, the case is coded the same as a stand-alone labor epidural (Anesthesia CPT code 01967). Therefore, cesarean section case categorization requires both CPT code 01967 and *cesarean* or *section* within the procedure name. The credit role for a labor epidural was only assigned to a resident if they were present at *anesthesia start*. When a labor epidural was used as the primary anesthetic for a cesarean section, the credit role for the cesarean section was only assigned to the resident present at *anesthesia stop* (Table 2).

Data Sources and Staging

Data are extracted, transformed, and loaded from the Epic EHR (Epic Systems Corporation, Verona, WI) to Caboodle, Epic's enterprise data warehouse, using structured query language. All anesthesia records with an anesthesiology resident provider were included in the extraction query. Data elements were collected nightly from the anesthesia record and migrated into Caboodle. Resident demographic data is exported annually from MedHub Graduate Medical Education Management portal (MedHub; Minneapolis, MN) to a shared drive on the institution network. Resident demographics from MedHub are merged with EHR data to generate the filters required for analysis and summaries (Figure 1). Dashboard visualizations and analytics were created using Tableau (Tableau Software, LLC; Seattle, WA).

Data Validation

To assure the internal validity of the data extraction, logs from 5 graduating anesthesiology residents from the class of 2020 were manually audited by systematically sampling 1 month of concurrent cases and 100 cases from each categorical year accounting for around 25% of the 5 residents' caseloads. The sample data set was then compared to an internal report from the EHR to assess extraction accuracy, and classification matrices were used to assess categorization and credit role assignments. Indeed, credit roles and ACGME categories were assigned with complete agreement to task-force consensus with no detectable errors. A validation dashboard was also created to ensure the ongoing integrity of the programming logic.

Results

Resident Reported Case Log

Table 2 shows the median number of cases reported to the ACGME by residents in each of the following ACGME categories: emergent, pediatric, cardiac, intrathoracic noncardiac, major vascular, intracerebral, and obstetric cases.

Automated Case Log

The algorithm for the automated case log-assigned credit roles and cases classified into ACGME categories using Anesthesia CPT codes is shown in Figure 2. The median number of cases identified by the automated algorithm is reported for each resident across all the major ACGME case categories (Table 2). However, CPT codes could not distinguish endovascular cases as either major vascular or intracerebral, as such endovascular subclassifications were not reported.

Comparison of Automated and Resident Reported Case Logs

The median number of cases identified using the automated algorithm was significantly higher across all major ACGME case categories as compared to the resident report (Table 2). Only the 0 to 3 month and 0 to 3 year pediatric subclassifications were comparable between both groups. Notably, the resident-reported median number of intracerebral vascular open cases was significantly higher than identified by the automated algorithm. The variability in case category reporting decreased with automation. Comparison of the interquartile ranges between the resident-reported and automated case logs shows an overall narrowing with automated reporting (Figure 3). Notably,

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the interquartile range was greater with automated reporting for the emergent case classification, however there was a nearly 3-fold increase in the median number of emergent cases identified by automated reporting. Additionally, the distribution of resident-reported case counts is skewed, and with automation, the case count distribution normalizes.

Agreement and Consistency

The agreement and consistency between automated and resident-reported case logs was moderate to substantial for the pediatric and cardiac with bypass case categories. Otherwise, the agreement and consistency was poor to fair (Table 3).

Discussion

The ACGME establishes requirements to ensure minimum training standards.[1] The ACGME Case Log system is used as evidence that training programs fulfill the established curriculum and that each resident achieves the minimum requirements.[5] Ostensibly, establishing uniform criteria for assigning credit roles and categorizing cases would reduce reporting variability between and within residency programs. Automatically aggregating case log data also reduces the recall and reporting bias inherent to the current system.[11] Automated case log reporting has become increasingly feasible with adoption of EHRs with anesthesia information management systems. We present a framework for automatically extracting case log data, assigning credit roles, and categorizing cases.

Anesthesia CPT codes were used to categorize cases into ACGME categories and automate resident case log reporting. When the automated case logs were compared to resident-reported ACGME case logs, the total number of anesthetic cases performed increased significantly. Residents reported fewer emergent, cardiac, intrathoracic noncardiac, major vascular, and obstetric cases than were identified by the automated case log. The discrepancy in case counts may reflect the inherent limitations of resident reporting. In our institution, residents often complete case logs retrospectively, therefore, case logs are subject to reporting and recall bias. Although reporting practices may vary between residents and institutions, we suspect this reporting paradigm is prevalent among anesthesiology resident training programs. The findings of Satoshi et al support this assertion and suggest that some residents stop reporting cases when the minimum case log requirements have been fulfilled.[4,11] Premature reporting cessation has been observed in other training programs; in Emergency Medicine it is estimated that residents underreport procedure performance by as much as 40%.[12]

Automated case reporting identified significantly more cases performed than the resident-reported log; as such, it is not surprising that agreement and consistency were only slight between the 2 reporting mechanisms. Moreover, in a survey of otolaryngology residents and program directors, the perceived accuracy of ACGME case logs was low. Among those surveyed, only 26.5% of residents and 34.6% of program directors believed that case logs were very accurate.[11] In our study, resident-reported case counts were skewed with data outliers, suggesting that some residents underreport case participation. The automated algorithm, however, identified participation in significantly more cases than the resident-reported case log. Reporting variability was also reduced as evidenced by normalization of the distribution of cases performed and narrowing of the interquartile range. We surmise that automating case logs reduces reporting variability because automation requires a well-defined framework for categorizing cases and assigning case credit. Additionally, automation addresses reporting bias and underreporting, thereby providing a more accurate representation of training than the resident-reported ACGME Case Log System.

As mentioned earlier, the primary aim of this project was to improve the accuracy of case logs by developing objective criteria for assigning credit roles and categorizing cases. However, improved case log accuracy was also foundational for providing our residency program with a comprehensive assessment of the resident experience. We used the extracted data to create dashboards to ensure equitable distribution of cases among trainees. The faculty completing case assignments can access the dashboards to identify trainees who have not achieved the minimum requirements. Dashboards are also used to facilitate directed distribution of evaluations through identification of attending and resident assignments.

Limitations

The criteria used to assign credit roles and categorization of cases based on Anesthesia CPT codes are the primary limitations of this study. The parameters used to assign credit roles may be considered overly inclusive. However, credit roles have not been explicitly described by the ACGME for anesthesiology. Coding practices may vary between institutions and CPT code-based categorizations may not be generalizable. Reporting accuracy remains a concern even with automation, as case log data relies heavily on EHR documentation and CPT coding, and both remain subject to error. Airway management techniques, vascular access, and regional procedures were not captured in this iteration but will be included in the future. Nevertheless, we believe our framework welcomes progression toward objective criteria for assigning credit roles and introduces the potential for automated case log reporting directly to the ACGME.

Conclusion

Developing an automated case log system requires collaboration with Data Governance and an understanding of the enterprise data architecture. Data Governance presides over data use and has an intimate understanding of data architecture and security. Requesting data requires insight into data sources and architecture, as well as the processes involved with migrating data between platforms. The filters and logic needed to organize data into an automated case log require objective criteria for assigning credit roles and categorizing cases. We developed parameters for assigning credit roles for anesthesiology trainees, and Anesthesia CPT codes provide an objective means for case categorization. The resultant case logs provide a current assessment of trainee progression on a platform that is easily accessible for residents and faculty. As we expand the scope of automated case log reporting, we hope to inspire an open dialogue to hone reporting parameters and

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promote automated reporting throughout graduate medical education.

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Abstract

Background: The Accreditation Council for Graduate Medical Education (ACGME) case log system for anesthesiology resident training relies on subjective categorization of surgical procedures and lacks clear guidelines for assigning credit roles. Therefore, resident reporting practices likely vary within and between institutions. Our primary aim was to develop a systematic process for generating automated case logs using data elements extracted from the electronic health care record. We hypothesized that automated case log reporting would improve accuracy and reduce reporting variability.

Methods: We developed a systematic approach for automating anesthesiology resident case logs from the electronic health care record using a discrete classification system for assigning credit roles and Anesthesia Current Procedure Terminology codes to categorize cases. The median number of cases performed was compared between the automated case log and resident-reported ACGME case log.

Results: Case log elements were identified in the electronic health care record and automatically extracted. A total of 42 individual case logs were generated from the extracted data and visualized in an external dashboard. Automated reporting captured a median of 1226.5 (interquartile range: 1097-1366) total anesthetic cases in contrast to 1134.5 (interquartile range: 899-1208) reported to ACGME by residents ($P = .0014$). Automation also decreased the case count interquartile range and the distribution approached normality, suggesting that automation reduces reporting variability.

Conclusions: Automated case log reporting uniformly captures the resident training experience and reduces reporting variability. We hope this work provides a foundation for aggregating graduate medical education data from the electronic health care record and advances adoption of case log automation.

Keywords: Anesthesiology training, technology in education

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Tables

Table 1. *ACGME Case Categories and Corresponding Anesthesia Current Procedure Terminology Codes*

Anesthesia Current Procedure Terminology Codes With or Without Modifiers	
Cardiac	
With Bypass	00580, 00561, 00562, 00563, 00567, 01990
Without Bypass	00530, 00534, 00537, 00560, 00566
Intrathoracic Noncardiac	00500, 00520, 00522, 00528, 00529, 00539, 00540, 00541, 00542, 00546, 00548, 00550, 00756
Major Vascular	
Open	00350, 00352, 00561. 00563, 00580, 00770, 00796, 00868, 00880, 00882, 01260, 01270, 01272, 01274, 01444, 01500, 01502, 01522, 01650, 01652, 01654, 01656, 01670, 01770, 01772, 01782, 01840, 01842, 01844, 01990
Intracerebral	
Nonvascular Open	00210, 00211, 00212, 00214, 00218, 00222, 00215, 00220
Vascular Open	00216
Endovascular[a]	01916, 01920, 01925, 01924, 01926, 01933, (00560 and [*CVL* or *Transcatheter*])
Vaginal Delivery	01960, 01967 and *Present at Anesthesia Start*
Cesarean Section	01961, 01963, 01968, 01969, 01967 and (*Cesarean* or *Section*) and *Present at Anesthesia Stop*

Abbreviation: CVL, cardiovascular laboratory.

[a] Includes both intracerebral and major vascular procedures.

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Table 2. *Comparison of Resident Reported and Automated Case Logs*

Resident Case Log			
	Resident Reported	Automated	*P* Value
	N = 42	N = 42	
	Median (IQR)		
Emergent Cases	54.5 (29 - 69)	151 (131 - 181)	**<.0001**
Pediatric			
0 - 3 Months	21.5 (13 - 28)	22 (16 - 28)	.6226
0 - 3 Years	78.5 (54 - 97)	84 (71 - 97)	.0958
0 - 12 Years	187 (150 - 228)	218 (180 - 233)	**.0017**
Cardiac			
With Bypass	40 (27 - 44)	41.5 (36 - 51)	**.008**
Without Bypass	17 (11 - 34)	43 (32 - 54)	**<.0001**
Intrathoracic Noncardiac	24 (21 - 28)	37 (33 - 42)	**<.0001**
Major Vascular			
Open	35 (26 - 52)	61.5 (57 - 72)	**<.0001**
Endovascular	16 (10 - 21)	…	…
Intracerebral			
Nonvascular Open	30 (21 - 38)	64 (56 - 71)	**<.0001**
Vascular Open	6 (3 - 9)	5 (4 - 6)	**<.0001**
Endovascular	4 (3 - 6)	…	…
Vaginal Delivery	83 (65 - 104)	105 (93 - 117)	**<.0001**
Cesarean Section	54 (44 - 66)	70 (61 - 83)	**<.0001**
Total Anesthetics	1134.5 (899 - 1208)	1226.5 (1097 - 1366)	**.0014**

Abbreviation: IQR, interquartile range.

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Table 3. *Consistency and Agreement Between Resident Reported and Automated Case Logs*

	Consistency	Agreement
	ICC (95% CI)	
Emergent Cases	0.05 (−0.25 - 0.35)	0.01 (−0.06 - 0.12)
Pediatric		
0 - 3 Months	0.75 (0.59 - 0.86)	0.75 (0.59 - 0.86)
0 - 3 Years	0.56 (0.32 - 0.74)	0.56 (0.32 - 0.74)
0 - 12 Years	0.50 (0.24 - 0.70)	0.47 (0.19 - 0.67)
Cardiac		
With Bypass	0.63 (0.41 - 0.78)	0.56 (0.24 - 0.76)
Without Bypass	0.26 (−0.05 - 0.52)	0.14 (−0.08 - 0.39)
Intrathoracic Noncardiac	0.00 (−0.03 - 0.30)	0.00 (−0.12 - 0.17)
Major Vascular		
Open	0.00 (−0.03 - 0.30)	0.00 −0.16 - 0.21)
Intracerebral		
Nonvascular Open	0.13 (−0.18 - 0.41)	0.02 (−0.04 - 0.12)
Vascular Open	0.13 (−0.17 - 0.42)	0.13 (−0.16 - 0.40)
Vaginal Delivery	0.48 (0.21 - 0.68)	0.31 (−0.0793 - 0.60)
Cesarean Section	0.46 (0.18 - 0.67)	0.35 (−0.002 - 0.61)
Total Anesthetics	0.00 (−0.30 - 0.30)	0.00 (−0.21 - 0.25)

Abbreviations: CI, confidence interval; ICC, intraclass correlation coefficient.

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Figures

Figure 1. *Data architecture. Data are extracted from the Epic Electronic Health Care Record (EHR) and housed in Caboodle. Resident demographics are extracted from MedHub and stored in an Excel document on the network shared drive. EHR elements are joined with resident demographics, filtered, analyzed, and visualized.*

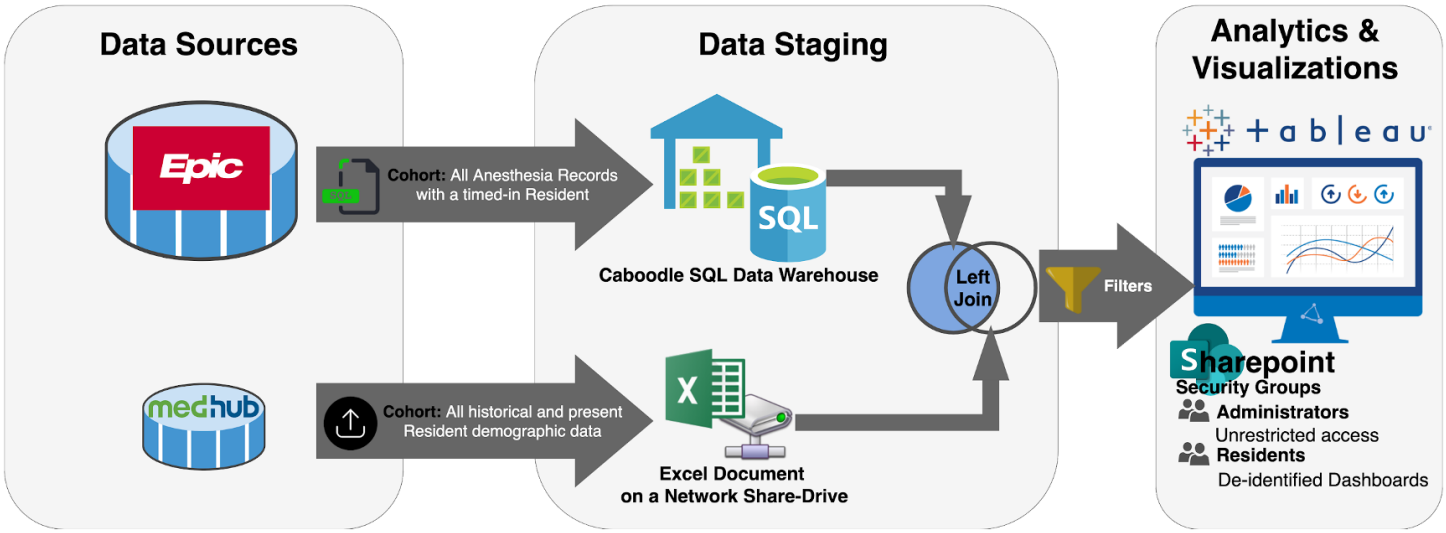

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Figure 2. *Resident case log.* ***A.*** *This dashboard contains a deidentified summary of case counts, patient demographics, total number of cases, case by surgical specialties, and counts of attending supervision. Residents can compare their progress with their peers or filter results by their electronic health care record identification number to generate a table of anesthesia cases with all data fields required for Accreditation Council for Graduate Medical Education submission.* ***B.*** *Graphical summary of case counts by surgical procedure.*

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Figure 3. *Case count distribution. With automation, the interquartile range decreases and the distribution of cases approaches normality, especially in large volume categories, this suggests that automation reduces reporting variability. Comparatively, resident reported case counts were skewed with data outliers; this may be suggestive of underreporting. The automated algorithm reported participation in significantly more cases than the resident reported case log, lending additional support to our concerns of underreporting.*