Opioid Variation in Anesthesia Practice

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SPEAKER DISCLOSURE

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Disclosures

I am a co-investigator on project funding to my institution:
Blue Cross Blue Shield of Michigan (BCBSM)
Patient-Centered Outcomes Research Institute (PCORI)

I am a co-inventor on patent No. 11,288,445 B2:
"Automated System and Method for Assigning Billing Codes to Medical Procedures," related to the use of machine learning techniques for medical procedural billing.

I am a co-founder of the AI medical billing company **Decimal Code, Inc.**

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Learning Objectives

- **Interpret** variation in perioperative pain management practices with focus on patient, provider, and institutional contribution.
- **Describe** the importance of opioid management and importance of perioperative pain management.
- **Critique** approaches for controlled and uncontrolled pain and demonstrate an evaluation framework for your own practice.
- **Evaluate** peri-operative pain control on post-operative outcomes.

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Enhanced Recovery After Surgery (ERAS)

Evidence-based recovery strategies / protocols for periOp period

- Designed to reduce the length of hospital stay
  - reducing complications
  - facilitating early recovery
  - helps coordinate care throughout surgical process
- Significant Outcomes
  - decreased the average hospital length of stay by 2.3 days [19]
  - Reduction of stress induced by surgery (IL-6 and c-reactive protein)
  - Improved patient satisfaction; quicker recovery; less sick days taken
  - Reduced postOp complications; prevention of pulm complications
  - Earlier return of organ function; reduction of postOp ileus

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Procedure and Topic	Year of Publication
Colonic resection	2012
Rectal resection	2012
Pancreaticoduodenectomy	2012
Cystectomy	2013
Gastric resection	2014
Anesthesia protocols	2015
Anesthesia pathophysiology	2015
Major gynecology (parts 1 and 2)	2015
Bariatric surgery	2016
Liver resection	2016
Head and neck cancer surgery	2016
Breast reconstruction	2017
Hip and knee replacement	Under production
Thoracic noncardiac surgery	Under production
Esophageal resection	Under production

Abbreviation: ERAS, Enhanced Recovery After Surgery.

+ thoracic, cardiac, urologic surgery, spine, neurosurgery, and vascular[3,4]

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Interventions

PreOp
Pt Optimization
Sx/anes planning
Pt Education

IntraOp
Regional / multimodal analgesia
Minimize tubes
Lung protective ventilation
Prophylactic (VTE, abx, PONV)
Euvolemia, normothermia
Glycemic control
Sterile technique

PostOp
Early mobilization/ambulation
Early PO intake
Multimodal analgesia

Measured Outcomes

mortality
length of hospital stay
pain
glycemic control
readmission
intensive care stay
return of organ function
complications:
- pulmonary
- thromboembolic
- cardiologic
- PONV

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Variable Effectiveness of ERAS

- Rigid protocols
- Adherence variability
- Resource constraints
- Increasing complexity
  - example, for colorectal surgery -> 16 elements comprise the ERAS guidelines
  - difficulty implementing protocols
  - room for error as components may be missed or forgotten

Potential for AI

Predictive assessment (risk stratification)
Clinical decision support tools
Data quality
Data classification
Design of ERAS
Identification of variable (feature) importance
Personalized planning: retrospective clinical trial / digital twinning

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Is there variability in intraoperative pain treatment?

JAMA Network Open

Original Investigation | Anesthesiology

Variation in Intraoperative Opioid Administration by Patient, Clinician, and Hospital Contribution

Michael L. Burns, PhD, MD[1]; Paul Hilliard, MD[1]; John Vandervest, MS[1]; et al

Author Affiliations | Article Information

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Methods

Data Source:

Data from Multicenter Perioperative Outcomes Group (MPOG), covering >20 million anesthesia records from diverse U.S. hospitals. Records automatically extracted from EHRs and quality-checked; audited quarterly for high accuracy.

Design, Setting, and Participants:

1,011,268 surgical procedures at 46 hospitals across the US involving 2911 anesthesiologists, 2291 surgeons, and 8 surgical and 4 analgesic categories.

Patients without ambulatory opioid prescriptions or use history undergoing an elective surgical procedure between January 1, 2014, and September 11, 2020, were included. Data were analyzed from January 2022 to July 2023.

Main Outcomes and Measures:

The rate of intraoperative opioid administration as a continuous measure of oral morphine equivalents (OMEs) normalized to patient weight and case duration was assessed.

Attributable variance was estimated in a hierarchical structure using patient, clinician, and hospital levels and adjusted intraclass correlations (ICCs).

Analgesic Groups:

Analgesics categorized as neuraxial, peripheral nerve block, remifentanil, adjuvant, or opioid only (opioid only = no other techniques). Categories not mutually exclusive except opioid only.

Supplemental Material 6 Analgesic Adjuvant Medications:

Acetaminophen, Aspirin, Celecoxib, Diclofenac, Dexamethasone, Dexmedetomidine, Gabapentin, Ibuprofen, Ketamine, Ketorolac, Indomethacin, Magnesium Sulfate, Lidocaine, Pregabalin

Documented between 1 hour before anesthesia start to anesthesia end.

Delivered using one of the following routes: intravenous (IV), oral, or by enteric tube.

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Methods

Study cohort:
Included adults (age ≥18) undergoing major surgery (base unit ≥6), in 8 surgical categories identified by CPT codes: upper/lower abdomen, cardiac, hysterectomy, orthopedic hip/knee/spine, vascular. Single anesthesiologist and surgeon assigned per procedure (based on most time signed in).

Exclusion criteria:
<30 days apart for same patient; missing data for independent variables; History of substance use (opioid, cocaine, amphetamine, antidepressant, psychedelic, alcohol); Age <18; Insufficient data for opioid administration; Low surgical counts (<25 for anesthesiologists; <100 for hospitals); ASA status 5, 6, missing, or unknown NPI used to track anesthesiologists at multiple hospitals; surgeons treated as unique clinicians with ≥25 procedures.

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Table. Fold Variation Across Anesthesia, Clinician, and Hospital Factors*

Factor	Surgical category	No.	Fold variation overall[b]	Opioid administration, mean (95% CI), OME/kg/h		Fold variation by percentile	
				Minimum	Maximum	95th vs 5th	75th vs 25th
Hospital	All	46	5.0	0.09 (0.09-0.09)	0.45 (0.44-0.46)	2.2	1.3
	Upper abdomen	46	6.1	0.09 (0.08-0.09)	0.52 (0.51-0.53)	2.6	1.5
	Lower abdomen	46	6.7	0.08 (0.08-0.09)	0.55 (0.53-0.56)	2.4	1.3
	Cardiac	40	8.9	0.07 (0.07-0.07)	0.60 (0.58-0.61)	2.7	1.4
	Hysterectomy	46	6.7	0.07 (0.07-0.09)	0.47 (0.42-0.52)	2.9	1.7
	Hip	46	5.8	0.06 (0.06-0.07)	0.37 (0.36-0.39)	3.4	1.5
	Knee	46	6.9	0.05 (0.04-0.05)	0.32 (0.29-0.34)	4.3	1.6
	Spine	46	8.3	0.04 (0.04-0.05)	0.43 (0.41-0.46)	2.2	1.3
	Vascular	43	4.8	0.08 (0.08-0.08)	0.38 (0.33-0.42)	2.8	1.4
Anesthesiologist	All	2911	34.3	0.02 (0.01-0.03)	0.74 (0.70-0.77)	3.3	1.5
	Upper abdomen	2869	15.0	0.05 (0.00-0.09)	0.70 (0.60-0.79)	2.7	1.5
	Lower abdomen	2837	23.9	0.03 (0.01-0.05)	0.73 (0.65-0.81)	2.7	1.4
	Cardiac	909	36.3	0.23 (0.23-0.23)	0.84 (0.84-0.84)	7.4	2.1
	Hysterectomy	2233	50.2	0.02 (0.00-0.04)	0.84 (0.84-0.84)	4.2	1.6
	Hip	2117	208.2	0.00 (0.00-0.01)	0.85 (0.85-0.85)	7.2	1.9
	Knee	2110	345.5	0.00 (0.00-0.01)	0.85 (0.85-0.85)	7.7	1.9
	Spine	2697	16.3	0.02 (0.02-0.02)	0.77 (0.77-0.77)	3.3	1.6
	Vascular	1154	43.0	0.02 (0.00-0.04)	0.63 (0.63-0.63)	5.8	2.0
Surgeon	All	2291	23.0	0.03 (0.02-0.03)	0.62 (0.60-0.65)	4.3	1.7
	Upper abdomen	1433	344.4	0.00 (0.00-0.01)	0.78 (0.78-0.78)	4.5	1.7
	Lower abdomen	1576	42.8	0.02 (0.02-0.02)	0.64 (0.64-0.64)	3.4	1.6
	Cardiac	254	30.6	0.03 (0.03-0.03)	0.83 (0.83-0.83)	3.8	1.6
	Hysterectomy	555	35.3	0.02 (0.02-0.02)	0.85 (0.85-0.85)	4.7	1.8
	Hip	276	18.4	0.02 (0.00-0.06)	0.54 (0.54-0.54)	5.3	1.8
	Knee	275	14.3	0.03 (0.01-0.05)	0.52 (0.31-0.73)	6.0	2.3
	Spine	567	50.3	0.02 (0.00-0.03)	0.81 (0.81-0.81)	6.7	1.6
	Vascular	139	70.8	0.01 (0.01-0.01)	0.78 (0.78-0.78)	8.0	2.1

Abbreviation: OME, oral morphine equivalent.

* Intraoperative opioid administration fold variation is given by hospital and clinician (surgeon or anesthesiologist), partitioned by surgical type. The minimum and maximum unadjusted intraoperative opioid administration levels are presented. Fold variations are represented overall and for 95th vs fifth and 75th vs 25th percentile.

[b] Folds do not exactly represent minimum and maximum values from the table due to rounding; folds were calculated without rounding, while the table shows rounded minimum and maximum values.

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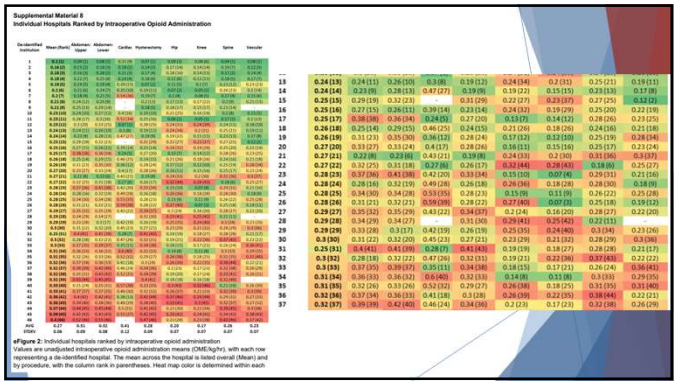

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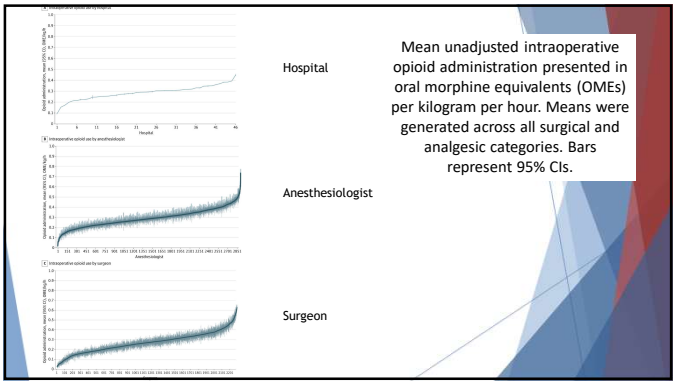

Mean unadjusted intraoperative opioid administration presented in oral morphine equivalents (OMEs) per kilogram per hour. Means were generated across all surgical and analgesic categories. Bars represent 95% CIs.

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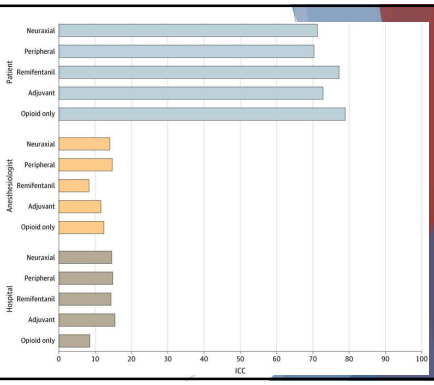
IntraOp OME

Adjusted intraclass correlation coefficients (ICCs) of adjusted intraoperative opioid administration are displayed by analgesic category and **patient, anesthesiologist, and hospital**.



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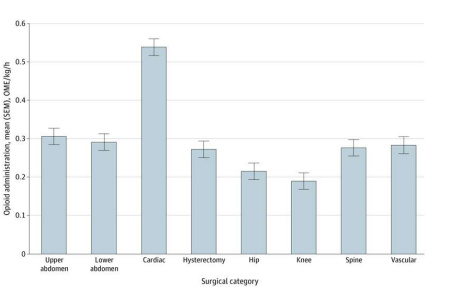

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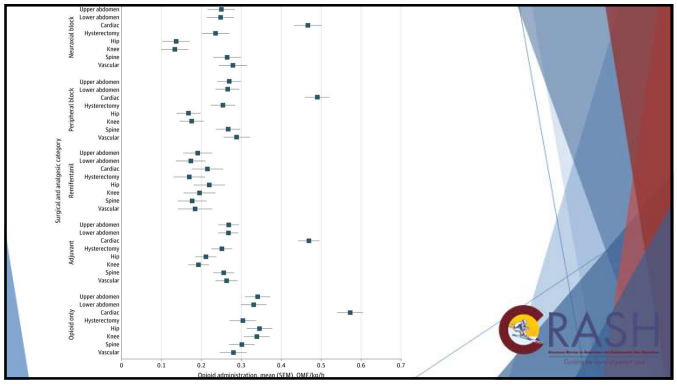

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Does the variability in intraoperative pain treatment matter?

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Methods

Variable Assessment:
- Continuous variables described using mean, SD, median, and interquartile range.
- Categorical variables summarized as counts and percentages.
- Population characteristics compared using absolute standardized differences (ASD); ASD > 0.2 indicates imbalance.

Collinearity & Screening:
- Multicollinearity assessed using variance inflation factor (VIF); cutoff VIF > 10 for concern.
- Clinical significance also considered during variable screening.

Population Distribution & Grouping:
- 51.8% of cases had zero PACU pain scores; data treated as zero-inflated.
- Two-step modeling strategy:
  - Phase 1: Seemingly Unrelated Regression (SUR) + Generalized Estimating Equations (GEE).
  - Groups classified by predicted probability (median cutoff = 0.466) and pre-op pain score (cutoff = 7):
    - G1: Low pre-op, low post-op pain (n=120,699)
    - G2: Low pre-op, high post-op pain (Uncontrolled Pain, n=115,200)
    - G3: High pre-op, low post-op pain (n=2,373)
    - G4: High pre-op, high post-op pain (n=7,872)
  - Phase 2: we ran four SUR models for the four groups separately, using the continuous pain score as the outcome and the probability of pain as the weights for each separate group.

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Methods

Analysis Approach:
- Univariate analysis between G1 and G2 for group differences (using ASD).
- SUR modeling used due to correlation between intra- and post-operative exposures; GEE applied.
- Four SUR models run for each group in Phase 2, outcomes weighted by predicted pain probability.

Covariates & Variables:
- Included demographic, patient, anesthesia, and surgical factors (e.g., age, BMI, comorbidities, anesthesia type, CPT code, procedure classification).

Sensitivity Analyses:
- Three alternate binary outcomes checked for robustness:
  1. Presence of postoperative pain score.
  2. Postoperative oral morphine equivalent (OME) usage.
  3. Either postoperative pain score or OME use.
- Compared group assignments between main and sensitivity models.

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Phase 1 – Binary Pain Prediction

	Predicted value < median (0.466)	Predicted value >= median
Pain Max <7	G1 (n=120,699)	G2 (uncontrolled pain) (n=115,200)
Pain Max >=7	G3 (n=2,373)	G4 (n=7,872)

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Phase 1 – Binary Pain Prediction

Group 1 vs Group 2 comparison (variables with SD>0.2):

49.3% cases in G2 were minor compared to 81.3% in G1
G2 avg 3x longer cases than G1 (case, anesthesia, patient in room duration)
G2 has on average 10x larger pain score in 2 hours after surgery; 82% of cases reported pain vs 14% in G1
86% of cases in G2 had general anesthesia compared to 21% in G1
12% of cases in G2 had sedation compared to 78% in G1

G2 10.4% (mean=0.048) received intraOp OME vs 27.7% (mean=0.073) for G1
G2 0.2% received intraOp adjuvant vs 3.4% G1
33% of cases in G2 had remifentanil compared to 3% of G1

G2 46.5% (mean=0.032) received postOp OME vs 0.07% (mean=0.00) for G1
G2 13.9% received postOp adjuvant vs 1.9% for G1
58% of cases in G2 were outpatient compared to 83% in G1

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Phase 1 – Binary Pain Prediction

	Predicted value < median (0.466)	Predicted value >= median
Pain Max <7	G1 (n=120,699)	G2 (uncontrolled pain) (n=115,200)
Pain Max >=7	G3 (n=2,373)	G4 (n=7,872)

(n = 246,144)	G1 (n= 120,699)	G2 (n=115,200)	G3 (n=2,373)	G4 (n=7,872)
Cases with at least one pain score >=7	2180	43631	388	3942
Proportion (%)	1.81	37.87	16.35	50.08
Cases with at least one PostOME administered	83	72071	1	4118
Proportion (%)	0.07	62.56	0.04	52.31
Cases with both one pain score>=7 **and** PostOME	44	39758	1	3326
Proportion (%)	0.04	34.51	0.04	42.25
Cases with both one pain score>=7 **or** PostOME	2219	75944	388	4734
Proportion (%)	1.84	65.92	16.35	60.14
Note: the denominator of the proportion is the total number of cases for each group				

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Phase 2 – Pain as a Continuous Variable

Group 1	Estimate	Std err	P value	Group 2	Estimate	Std err	P value
IntraOp Adj	0.308	0.042	0.000	IntraOp Adj	1.005	0.285	0.000
IntraOp OME	0.008	0.062	0.898	IntraOp OME	1.540	0.210	0.000
IntraOp Both	-0.058	0.041	0.158	IntraOp Both	1.356	0.132	0.000
Remifentanil	-0.492	0.017	0.000	Remifentanil	-0.246	0.086	0.004
PostOp Adj	1.564	0.089	0.000	PostOp Adj	0.857	0.219	0.000
PostOp OME	3.074	0.115	0.000	PostOp OME	2.970	0.214	0.000
PostOp Both	5.432	0.135	0.000	PostOp Both	3.678	0.218	0.000
Age Years	-0.004	0.001	0.013	Age Years	-0.003	0.003	0.300
BMI	-0.001	0.000	0.000	BMI	0.000	0.001	0.719
Anes Duration	0.000	0.000	0.000	Anes Duration	0.000	0.000	0.354

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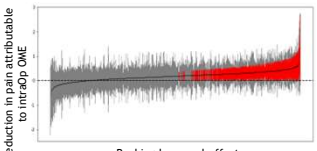
Perioperative OME – Causal Effect

Variable	Coefficient
Factors associated with paradoxical response	
Obstetric Anesthesia	1.12
Chronic overlapping pain condition – IBS	1.05
Psychosis	0.21
Cognitopathy	0.20
Chronic overlapping pain condition – Fibromyalgia	0.17
Factors protective against paradoxical response	
Chronic overlapping pain condition – Bladder Pain Syndrome	-0.71
IIIV	-0.61
Chronic overlapping pain condition – Migraine	-0.32
Major procedure in the head	-0.29
Major cardiac procedure	-0.26



- 23.4% experience a paradoxical effect

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Summary

- **Substantial variability in intraoperative opioid administration exists across patients, clinicians, and hospitals**
  - *This variability is not random and has measurable downstream effects on perioperative pain and outcomes*
  - *This variability matters – affecting the postoperative experience of patients*
- **Understanding where variability matters is more important than eliminating variability itself**
  - *Rigid protocols reduce variance, but cannot account for individual patient response*
  - *More opioid is not always better — a meaningful subset of patients experience paradoxical effects*
- **Clinical judgment remains essential — decision support should augment, not replace, clinicians**
  - *Data-driven methods and AI offer an opportunity to identify signal within variation and support personalized perioperative pain management*

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Thank you! Questions?

Feel free to contact me:

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Reverences

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