Intraoperative Care Transitions Are Not Associated with Postoperative Adverse Outcomes

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ABSTRACT

Background: Whether anesthesia care transitions and provision of short breaks affect patient outcomes remains unclear.

Methods: The authors determined the number of anesthesia handovers and breaks during each case for adults admitted between 2005 and 2014, along with age, sex, race, American Society of Anesthesiologists physical status, start time and duration of surgery, and diagnosis and procedure codes. The authors defined a collapsed composite of in-hospital mortality and major morbidities based on primary and secondary diagnoses. The relationship between the total number of anesthesia handovers during a case and the collapsed composite outcome was assessed with a multivariable logistic regression. The relationship between the total number of anesthesia handovers during a case and the components of the composite outcome was assessed using multivariate generalized estimating equation methods. Additionally, the authors analyzed major complications and/or death within 30 days of surgery based on the American College of Surgeons National Surgical Quality Improvement Program–defined events.

Results: A total of 140,754 anesthetics were identified for the primary analysis. The number of anesthesia handovers was not found to be associated ($P = 0.19$) with increased odds of postoperative mortality and serious complications, as measured by the collapsed composite, with odds ratio for a one unit increase in handovers of 0.957; 95% CI, 0.895 to 1.022, when controlled for potential confounding variables. A total of 8,404 anesthetics were identified for the NSQIP analysis (collapsed composite odds ratio, 0.868; 95% CI, 0.718 to 1.049 for handovers).

Conclusions: In the analysis of intraoperative handovers, anesthesia care transitions were not associated with an increased risk of postoperative adverse outcomes. **(Anesthesiology 2016; 125:690-9)**

WHETHER anesthesia care transitions and provision of short breaks affect patient outcomes remains unclear. During the handover process, transfer of responsibility and information about patients from one set of caregivers to another can result in a loss of important information, potentially impacting patient safety. In the absence of a standardized preoperative handover process, communication failure is one of the most common root causes of medical error.[1,2]

No national patient handover guidelines are currently in place, implying that each institution may have its own handover protocols. Care transition practices differ among institutions, making handovers not a consistent exposure across hospitals. Recent single-center evaluation studies[3–5] that investigated anesthesia care transitions have demonstrated an association between the number of handovers and postoperative adverse outcomes. Handover practices at these institutions may be different compared to handovers at our institution. It remains unknown whether worse patient outcomes are associated with care transitions in a team-based model of anesthesia care, if they can be explained by other potential confounding factors, or if they are impacted by anesthesia staff breaks, which were not evaluated. As a result, single-center data from the previous literature are augmented by the current study.

We hypothesized that handovers would have no impact on patient outcomes. The goal of this study was to assess the relationship between intraoperative anesthesia transitions of

What We Already Know about This Topic

- Transitions of care can be associated with worse patient outcomes, especially if the quality of handover is poor, and previous work demonstrates an association between the number of anesthesia care transitions and worse patient outcomes

What This Article Tells Us That Is New

- In a review of over 100,000 anesthetics at Vanderbilt University, anesthesia care transitions were not associated with increased 30-day mortality or a composite morbidity outcome
- Short breaks were associated with a small (less than 7%) reduction in these outcomes

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care, anesthesia staff breaks, and postoperative outcomes at our institution.

Materials and Methods

This study received institutional review board approval from the Vanderbilt University Human Research Protection Program in Nashville, Tennessee. At our institution, patient care is provided by anesthesia care teams led by attending anesthesiologists with anesthesia residents, fellows, certified registered nurse anesthetists (CRNAs), and/or student registered nurse anesthetists (SRNAs). Anesthesia provider breaks at our institution are electronically documented in the anesthesia information management system separately from handovers and require entry of user credentials for both check-in and check-out from a case. After the break, the same anesthesia team members continue to provide care to the patient, so the effect of breaks is different from handovers. For in-room providers, standard breaks include a 15-min break in the morning, a 30-min lunch break, and a 15-min afternoon break. The timing of breaks varies. Providers do not always receive a morning or afternoon break during cases and can take breaks between cases.

Data Sources

We utilized data from the Vanderbilt Department of Anesthesiology's (Nashville, Tennessee) Perioperative Data Warehouse (PDW), quality improvement data from the American College of Surgeons National Surgical Quality Improvement Program (ACS-NSQIP), and the Anesthesia Quality Institute's (Schaumburg, Illinois) National Anesthesia Clinical Outcomes Registry (NACOR).[6] NACOR data were analyzed to understand the generalizability of our handover practice relative to national handover practices. ACS-NSQIP is a nationally validated, risk-adjusted, outcomes-based program to measure and improve the quality of surgical care.

The PDW is a secure, centralized data warehouse that contains patient encounter data from multiple information systems across Vanderbilt University Medical Center (VUMC; Nashville, Tennessee). The PDW links patients to the National Death Index, a central index of death record information maintained by the National Center for Health Statistics (Hyattsville, Maryland) division of the Centers for Disease Control and also contains in-hospital mortality data.

Patient Population

To assess the relationship between transitions of care and patient outcomes, the authors identified adult (18 yr of age or older) patients who were admitted between 2005 and 2014. Both emergency and off-hour surgery cases were included. After determining the patient population of interest, we calculated the number of anesthesia handovers during a case and determined age, sex, race, American Society of Anesthesiologists (ASA) physical status, start time of surgery, duration of surgery, principal diagnosis and procedure, and anesthesia provider breaks from the PDW. In case patients had multiple cases during an admission, only the first case was included in the analysis. Subsequent cases were excluded, knowing that the second operation may be a complication itself. ASA physical status 6 patients, duplicate entries, and observations with missing data were excluded from the analysis.

Outcomes

We then defined a collapsed composite (any *vs.* none) of in-hospital mortality and six major morbidities considered either life-threatening or potentially resulting in permanent functional disability. Morbidities included serious cardiac, respiratory, gastrointestinal, urinary, bleeding, and infectious complications based on secondary diagnosis codes in addition to the primary diagnosis (table 1). This definition of a collapsed composite is consistent with previous literature.[3] The components of the composite are preventable or manageable complications, which are important to patients, the healthcare system, and providers aiming to improve outcomes. Since the current study is not limited to a subset of patients that underwent a specific procedure, but rather consists of a broad patient population that underwent various procedures, utilization of a composite outcome allows us to capture morbidity in a comprehensive fashion compared to using an outcome defined based on just one organ system. Overall, such outcome definition is important because of its practical implication for patient safety, level of care, and cost reduction.

Exposure

The total number of anesthesia handovers includes handovers among attending anesthesiologists and handovers among in-room anesthesia providers including residents and fellows, CRNAs, and SRNAs. The number of handovers was defined as a sum of transitions of care during the case timeline within the in-room provider group and within the attending anesthesiologist group. For example, the handover count increased when a resident checked out of the case and a fellow checked in. The handover count further increased when an attending anesthesiologist checked out and another attending anesthesiologist checked in. Duplicate entries and observations with missing data were excluded from the analysis. The handover count was not changed when two in-room providers were both providing care to the patient (*i.e.*, a CRNA and an SRNA checked in at the beginning of the case and checked out later during the case). We separately analyzed the anesthesia providers who provided breaks and assessed the proportion of breaks provided by our resident, CRNA, and SRNA in-room provider groups.

Confounders

To adjust the risk of the adverse outcome for severity of the surgical procedure, we characterized each patient's primary procedure using the U.S. Agency for Healthcare Research and Quality's (Rockville, Maryland) single-level Clinical Classifications Software for *Clinical Classifications Software for*

Table 1. Composite Outcome ICD-9 Diagnosis Codes

Outcome	ICD-9	ICD-9 Diagnosis Description	Count (%)
Infection	519.01	Infection of tracheostomy: Use additional code to identify type of infection, such as abscess or cellulitis of neck (682.1), septicemia (038.0–038.9). Use additional code to identify organism (041.00–041.9)	2,717 (1.93%)
	536.41	Infection of gastrostomy: Use additional code to identify type of infection, such as abscess or cellulitis of abdomen (682.2), septicemia (038.0–038.9). Use additional code to identify organism (041.00–041.9)	
	530.86	Infection of esophagostomy. Use additional code to specify infection	
	997.62	Infection (chronic). Use additional code to identify the organism	
	998.5	Postoperative infection excludes bleb-associated endophthalmitis (379.63); infection due to implanted device (996.60–996.69); infusion, perfusion, or transfusion (999.31–999.39); postoperative obstetrical wound infection (674.3)	
	998.51	Infected postoperative seroma. Use additional code to identify organism	
	998.59	Other postoperative infection: abscess: postoperative, intraabdominal postoperative, stitch postoperative, subphrenic postoperative, wound postoperative, septicemia postoperative. Use additional code to identify infection	
	999.3	Other infection: infection after infusion, injection, transfusion, or vaccination; sepsis after infusion, injection, transfusion, or vaccination; septicemia after infusion, injection, transfusion, or vaccination. Use additional code to identify the specified infection, such as septicemia (038.0–038.9). Excludes: the listed conditions when specified as: due to implanted device (996.60–996.69), postoperative NOS (998.51–998.59)	
Bleeding	998.1	Hemorrhage or hematoma or seroma complicating a procedure excludes: hemorrhage, hematoma, or seroma: complicating cesarean section or puerperal perineal wound (674.3) due to implanted device or graft (996.70–996.79)	2,301 (1.63%)
	998.11	Hemorrhage complicating a procedure	
	998.12	Hematoma complicating a procedure	
	998.13	Seroma complicating a procedure	
Cardiac	429.4	Functional disturbances after cardiac surgery, cardiac insufficiency after cardiac surgery or due to prosthesis, heart failure after cardiac surgery or due to prosthesis. Postcardiotomy syndrome, postvalvulotomy syndrome Excludes: cardiac failure in the immediate postoperative period (997.1)	1,915 (1.36%)
	458.21	Hypotension of hemodialysis, intradialytic hypotension	
	458.29	Other iatrogenic hypotension, postoperative hypotension	
	997.1	Cardiac: arrest during or resulting from a procedure insufficiency during or resulting from a procedure, cardiorespiratory failure during or resulting from a procedure, heart failure during or resulting from a procedure. Excludes the listed conditions as long-term effects of cardiac surgery or due to the presence of cardiac prosthetic device (429.4)	
Gastrointestinal	564.2	Postgastric surgery syndromes: Dumping syndrome, jejunal syndrome, postgastrectomy syndrome, postvagotomy syndrome. Excludes: malnutrition after gastrointestinal surgery (579.3), postgastrojejunostomy ulcer (534.0–534.9)	1,864 (1.32%)
	564.3	Vomiting after gastrointestinal surgery. Vomiting (bilious) after gastrointestinal surgery	
	564.4	Other postoperative functional disorders: diarrhea after gastrointestinal surgery. Excludes colostomy and enterostomy complications (569.60–569.69)	
	569.6	Colostomy and enterostomy complications	
	569.71	Other and unspecified postsurgical nonabsorption	
	569.79		
	579.3	Hypoglycemia after gastrointestinal surgery	
		Malnutrition after gastrointestinal surgery	
	997.4	Digestive system complications: complications of intestinal (internal) anastomosis and bypass, not elsewhere classified, except that involving urinary tract; hepatic failure specified as due to a procedure; hepatorenal syndrome specified as due to a procedure; intestinal obstruction NOS specified as due to a procedure. Excludes: specified gastrointestinal complications classified elsewhere, such as: Blind loop syndrome (579.2), colostomy or enterostomy complications (569.60–569.69), gastrojejunal ulcer (534.0–534.9), gastrostomy complications (536.40–536.49), infection of esophagostomy (530.86), infection of external stoma (569.61), mechanical complication of esophagostomy (530.87), pelvic peritoneal adhesions, female (614.6); peritoneal adhesions (568.0), peritoneal adhesions with obstruction (560.81), postcholecystectomy syndrome (576.0), postgastric surgery syndromes (564.2), vomiting after gastrointestinal surgery (564.3)	

(*Continued*)

Table 1. (Continued)

Outcome	ICD-9	ICD-9 Diagnosis Description	Count (%)
Respiratory	518.7	TRALI	815 (0.58%)
	997.3	Respiratory complications. Excludes iatrogenic (postoperative) pneumothorax (512.1), iatrogenic pulmonary embolism (415.11), Mendelson syndrome in labor and delivery (668.0), specified complications classified elsewhere, such as adult respiratory distress syndrome (518.5), pulmonary edema, postoperative (518.4), respiratory insufficiency, acute, postoperative (518.5), shock lung (518.5), tracheostomy complications (519.00–519.09), TRALI (518.7)	
	997.31	Ventilator-associated pneumonia. Use additional code to identify organism	
	997.39	Other respiratory complications: Mendelson syndrome resulting from a procedure, pneumonia (aspiration) resulting from a procedure	
Urinary	997.5	Urinary complications: complications of external stoma of urinary tract, internal anastomosis and bypass of urinary tract, including that involving intestinal tract, oliguria or anuria specified as due to procedure; renal: failure (acute) specified as due to procedure, insufficiency (acute) specified as due to procedure, tubular necrosis (acute) specified as due to procedure. Excludes: specified complications classified elsewhere, such as postoperative stricture of ureter (593.3), urethra (598.2)	364 (0.26%)

Gastrointestinal category does not include postoperative nausea and vomiting (787.01 nausea with vomiting).

ICD-9 = *International Classification of Diseases, 9th Revision, Clinical Modification* diagnosis codes; NOS = not otherwise specified; TRALI = transfusion-related acute lung injury.

International Classification of Diseases, 9th Revision, Clinical Modification (CCS) procedure codes.[7] CCS provides a way to classify diagnoses and procedures by aggregating individual *International Classification of Diseases, 9th Revision, Clinical Modification* codes into a limited number of mutually exclusive, clinically appropriate broad diagnosis and procedure groups to facilitate statistical analysis and reporting. Based on a large number of CCS categories in our patient cohort, we adjusted for severity of procedure as a standardized continuous covariate by using the incidence of the collapsed composite outcome for each CCS category. The sparsely represented CCS categories with fewer than 20 cases were collapsed into one category. Diagnosis-related risk for the collapsed composite outcome was estimated and adjusted for in the analysis in a similar manner.

ACS-NSQIP Analysis

To assess the relationship between intraoperative anesthesia transitions of care, anesthesia staff breaks, and postoperative outcomes, we analyzed major complications and/or death within 30 days of surgery based on the ACS-NSQIP–defined outcomes. The NSQIP composite outcome was defined to represent events of acute renal failure, bleeding that requires transfusion of 4+ packed erythrocytes, cardiac arrest, coma, myocardial infarction, unplanned intubation, prolonged (more than 48 h) ventilation, pneumonia, stroke, wound disruption, surgical site infection, sepsis, and systemic inflammatory response syndrome. The outcomes were obtained from VUMC data submitted to the ACS NSQIP, which include sampled general and vascular surgery procedures.

Statistical Analysis

The relationship between the total number of anesthesia handovers during a case and the collapsed composite outcome was assessed with a multivariable logistic regression adjusted for potential confounding variables, which included patient's age, sex, race, ASA physical status, start time of surgery, principal diagnosis and procedure, anesthesia provider breaks modeled as a categorical variable with two levels, and duration of surgery. Duration of surgery was modeled as a cubic spline with four knots (at 5th, 35th, 65th, and 95th percentile)[8] to account for a possible nonlinear relationship with time. We also assessed the relationship between the total number of anesthesia handovers during a case and the components of the composite outcome using multivariate (*i.e.*, one record per component per patient) generalized estimating equation (GEE) methods. GEE analyses served two purposes: sensitivity analysis on collapsed composite analysis and a method to check heterogeneity across components. The GEE method models the individual component data for each subject outcome directly, instead of first summarizing results within each subject as does the collapsed composite. It has been previously shown that the GEE has advantages over standard methods for composite endpoints consisting of several binary events, such as distinct perioperative complications.[9] Specifically, we performed individual component analysis adjusting for multiple comparisons, a common-effect GEE model, and a distinct-effects model with treatment–outcome interaction. To assess the heterogeneity in the components of the outcome, we conducted a heterogeneity test in a distinct-effects GEE model assessing the handover-by-component interaction.

We estimated power for both GEE common effect and collapsed composite models using the Power Calculations for Tests on a Vector of Binary Outcomes (MULTBINPOW; Department of Quantitative Health Sciences, Cleveland Clinic, Cleveland, Ohio)[10] at $\alpha = 0.05$ to compare 2 vectors of 7 proportions each, based on the study by Saager *et al.*, with percent reduction for each component as follows: in-hospital mortality 0.33%, cardiac 1.55%, respiratory 0.17%, gastrointestinal 2.13%, urinary 0.33%, bleeding 1.52%, and infection 0.99%, resulting in a group sample size between 500 and 1,500, depending on the within-subject correlation of 0.10, 0.30, and 0.50 and test methodology.[11] Given the sample size, the current study was sufficiently powered to detect the hypothesized treatment effect.

Sensitivity Analyses

We further conducted primary and secondary sensitivity analyses. Three primary sensitivity analyses were performed. First, regression modeling was performed on a subset of cases with only one case per hospital admission. Second, we included an interaction term between anesthesia provider breaks and duration of surgery to assess the effect of breaks across operating room length. Third, a subgroup analysis was performed on elective cases and emergency cases. Secondary sensitivity analysis included comparing each positive number of handovers (1, 2, and more than or equal to 3) with 0 handovers using propensity score matching to adjust for potential confounders (*i.e.*, a total of three propensity score matching analyses). Cases that had handovers were matched to those that did not have handovers in a 1:1 ratio using 8 to 1 greedy matching. This algorithm first matches the exposed to the unexposed on 8 digits of the propensity score. For those that do not match on 8 digits, the exposed are then matched to the unexposed on 7 digits of the propensity score. The algorithm proceeds sequentially to the lowest digit match on propensity score (1 digit). Balance between the matched cohorts was assessed using the standardized difference before and after propensity score matching.

Additionally, we compared handover prevalence at VUMC to the national handover practices based on the NACOR data. Queries of the AQI participant user file from 2010 to 2014 identified anesthetics with distinct provider data that had valid anesthesiologist, resident, and CRNA provider counts. We calculated the number of handovers per case using a case-wise analysis on all possible combinations of provider counts. Unreported counts were imputed as 0, and anesthesiologists were assumed to be working in only an oversight role when performing cases with residents and CRNAs. We identified outlier practice patterns and removed these from our data set.[12] Specifically, of the 245 practices included, we identified 15 practices (6%) that reported four or more providers associated with cases with duration under an hour; the 1,313,548 cases (8%) from those practices were excluded from this analysis. We then analyzed the distribution of handovers per case and compared it to the distribution of handovers per case at VUMC.

Two sample Student's *t* test and Wilcoxon–Mann–Whitney (Wilcoxon rank sum) tests were used to test the null hypothesis that population means of continuous variables, including age, ASA status, operating room duration, and diagnosis and procedure severity, are equal across groups of cases that had handovers and those that did not have handovers. Chi-square test and Fisher exact tests were applied to test the null hypothesis of independence in relation to categorical variables, including gender, race, surgery hour, and breaks, across groups of cases that had handovers and those that did not have handovers. Cochran–Armitage Trend test was used to test for difference in outcomes across the levels of number of handovers. The Spearman correlation coefficient was calculated to assess the relationship between continuous variables. A two-sided α level of 0.05 was taken as reference to detect statistical significance in all analyses, except that a Bonferroni-corrected significance criterion of 0.007 was used for individual component analysis and 0.017 was used for the propensity score sensitivity analysis. Statistical programming was implemented in SAS 9.4 (SAS Institute Inc., USA).

Results

A total of 140,754 anesthetics were identified for the primary analysis (table 2). Factors associated with increased

Table 2. Patient Characteristics for the ICD-9 Composite Outcome Model

Total encounters in data set	140,754
Age (yr)	51.81 ± 17.47
Gender (female), %	49.66
Race (Caucasian), %	83.82
Breaks (%)	37.59
ASA physical status 1 (%)	2.39
ASA physical status 2 (%)	34.69
ASA physical status 3 (%)	49.01
ASA physical status 4 (%)	13.47
ASA physical status 5 (%)	0.45
Collapsed composite (%)	8.56
Death in hospital (%)	1.64
Infection (%)	1.93
Bleeding (%)	1.63
Cardiac (%)	1.36
Gastrointestinal (%)	1.32
Respiratory (%)	0.58
Urinary (%)	0.26
Top CCS diagnosis categories	
Complication of device; implant or graft (%)	5.09
Cancer of prostate (%)	3.67
Fracture of lower limb (%)	3.49
Osteoarthritis (%)	3.35
Spondylosis; intervertebral disc disorders; other back (%)	3.03
Top CCS procedure categories	
Cesarean section (%)	6.89
Spinal fusion (%)	4.35
Open prostatectomy (%)	3.62
Other OR therapeutic nervous system procedures (%)	2.85
Treatment; fracture or dislocation of lower extremity (other than hip or fem), %	2.74

Data are presented as mean ± SD unless noted otherwise.

ASA = American Society of Anesthesiologists; CCS = *Clinical Classifications Software for International Classification of Diseases, 9th Revision, Clinical Modification*; ICD-9 = *International Classification of Diseases, 9th Revision, Clinical Modification* diagnosis codes; OR = operating room.

odds of postoperative adverse outcomes included ASA physical status, diagnosis severity, procedure severity, age, gender, and start time of surgery (fig. 1). The number of anesthesia handovers was not found to be associated ($P = 0.19$) with increased odds of postoperative mortality and serious complications, as measured by the collapsed composite, with odds ratio (95% CI) for a one unit increase in handovers of 0.957; 95% CI, 0.895 to 1.022, when controlled for potential confounding variables. Breaks ($P < 0.0001$) were associated with a 6.7% reduction in odds of the composite outcome (odds ratio, 0.933; 95% CI, 0.890 to 0.977). The common-effect GEE model supported the findings, demonstrating an odds ratio of 0.951 (95% CI, 0.902 to 1.002) for handovers ($P = 0.06$), and 0.917 (95%

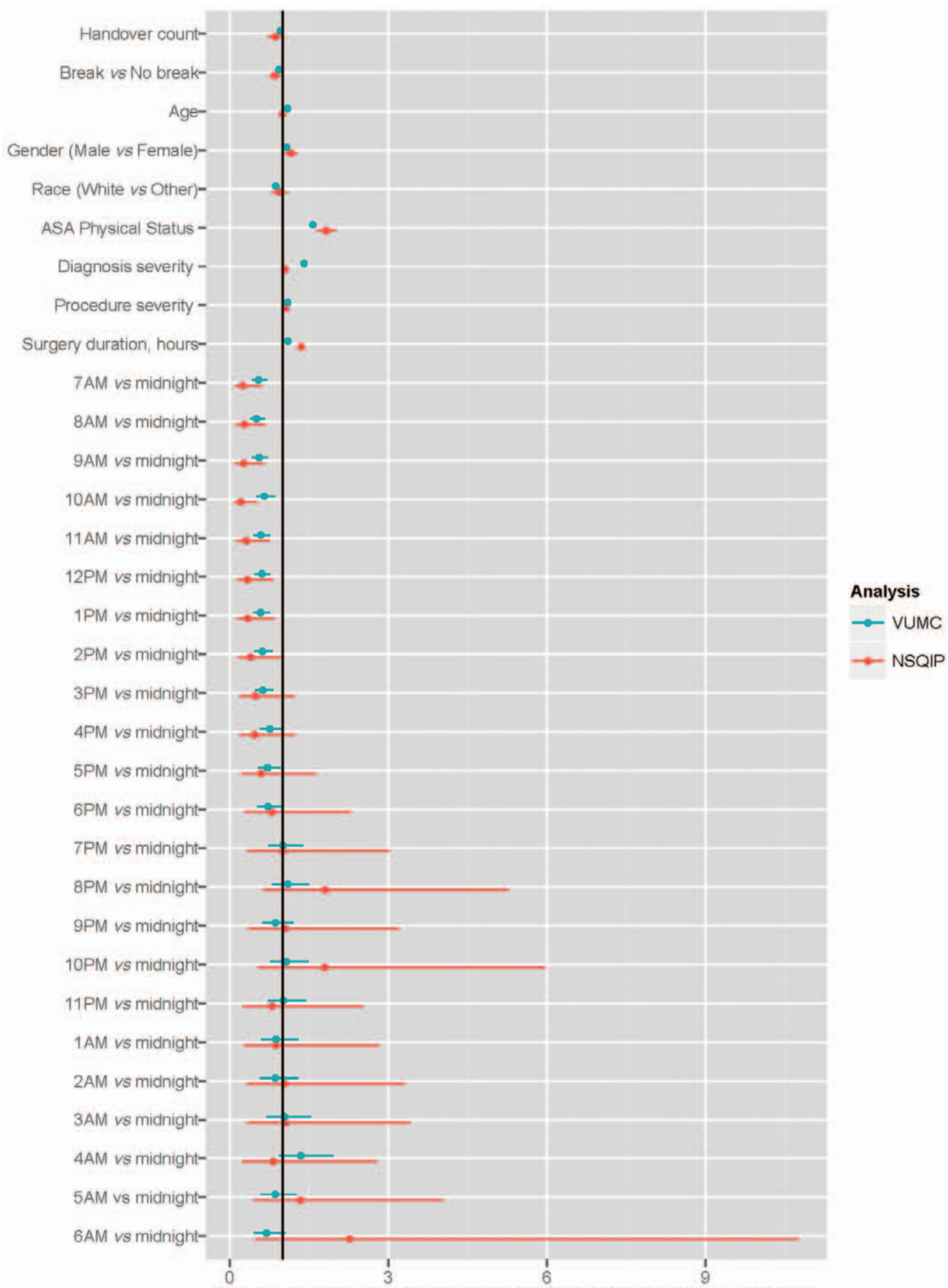

Fig. 1. Odds ratio estimates and Wald CIs for the composite outcome and National Surgical Quality Improvement Program (NSQIP) outcome model. ASA = American Society of Anesthesiologists physical status; VUMC = Vanderbilt University Medical Center.

CI, 0.884 to 0.952) for breaks ($P < 0.0001$). The relationship between handover and outcome differed across components of the outcome. Interaction between bleeding and handovers was found to be significant ($P = 0.0002$) in a GEE model. The significant heterogeneity test led us to test the individual treatment effects in addition to the global effect. Individual component analysis adjusting for multiple comparisons and within-subject correlation showed that for six of the seven components, the odds of having the complication were not significantly different across the levels of handovers; only one of seven estimates was in the opposite direction ($P = 0.0002$ for bleeding, significant at a Bonferroni-corrected significance criterion of 0.007). When most of the effects are in the same direction (here, six of seven), a significant test for heterogeneity does not necessarily indicate that results for global tests such as the average relative effect or common effect are not meaningful.[9]

In the sensitivity analysis on a subset of cases with only one case per hospital admission, intraoperative handovers were not associated with postoperative adverse outcomes ($P = 0.64$; collapsed composite odds ratio, 1.017; 95% CI, 0.947 to 1.092). The association of breaks with reductions in odds of composite outcome remained ($P < 0.0001$; odds ratio, 0.898; 95% CI, 0.853 to 0.945; fig. 2). The interaction term between anesthesia provider breaks and duration of surgery was found to be significant ($P < 0.0001$), and the association of breaks with reductions in odds of composite outcome at different quantiles of surgery length remained: 25% Q1 (127 min): odds ratio, 0.788; 95% CI, 0.736 to 0.844; 50% median (170 min): odds ratio, 0.828; 95% CI, 0.780 to 0.879; and 75% Q3 (275 min): odds ratio, 0.935; 95% CI, 0.889 to 0.985). Breaks ($P = 0.0009$) were associated with a reduction in odds of composite outcome (odds ratio, 0.907; 95% CI, 0.856 to 0.961) in the analysis of elective cases. Breaks ($P = 0.79$) were no longer associated with a reduction in odds of composite outcome (odds ratio, 1.026; 95% CI, 0.855 to 1.231) in the analysis of emergency cases. The *International Classification of Diseases, 9th Revision, Clinical Modification* composite outcome model had overall good discrimination characteristics with the value of area under the receiver operating curve/c-statistic of 0.765. The results of the secondary sensitivity analysis were consistent with the findings mentioned in the first paragraph of Results: no statistically significant difference was identified after performing propensity score matching to compare the incidence of the composite outcome between cases with 1 *versus* 0 handovers ($P = 0.46$), 2 *versus* 0 handovers ($P = 0.98$), and more than or equal to 3 *versus* 0 handovers ($P = 0.5$)

A total of 8,404 anesthetics for the NSQIP analysis were identified (table 3). The number of anesthesia handovers was not found to be associated ($P = 0.14$) with increased odds of postoperative mortality and serious complications (collapsed composite odds ratio, 0.868; 95% CI, 0.718 to 1.049), when controlled for potential confounding variables (fig. 1). Breaks ($P < 0.0095$) were associated with a 14.5% reduction in odds of composite outcome (odds ratio, 0.855; 95% CI, 0.760 to 0.962). Higher handover prevalence for cases at VUMC was identified (7.9% cases with one or more handovers), as compared to the overall national numbers (6.3%; table 4).

Discussion

In our analysis of intraoperative handovers, anesthesia care transitions were not associated with increased odds of postoperative adverse outcomes, whereas anesthesia staff breaks were associated with decreased odds of postoperative adverse outcomes. These effects were consistent between outcomes defined by administrative data as well as those identified through the NSQIP process. Additional sensitivity analyses supported the findings.

Previous research shows that there may be instances when short breaks can positively affect patient outcomes.[13] Fatigue is a consequence of cumulative acuity, resulting in decreased motor and cognitive powers. This results in impaired judgment, diminished vigilance, late and inadequate responses to clinical changes, poor communication, and inadequate record keeping.[14] It is not clear from this analysis whether there is a causal relationship between anesthesia staff breaks and patient outcomes or if the association observed is a result of unknown confounders or inadequate adjustment for confounding. At our institution, breaks are largely given by experienced CRNAs. We speculate that having a handover and case review with an experienced provider on the case may be helpful. Alternatively, it may be that the ability to give staff breaks is associated with having more personnel around to help with crises. Breaks may therefore be a marker for a better working environment for a particular case, rather than a direct cause of an improved outcome. Regarding the lack of effect observed from intraoperative handovers, we speculate that attention to postanesthesia care unit handovers at our institution in a form of multimodal intervention that included a new electronic handover report form, a didactic webinar, and mandatory simulation training[15] may have had a salutatory impact on our intraoperative handovers.

As shown in table 4, handover rate differs among institutions. Of the cases in our cohort, 7.9% were associated with one or more handovers, which is higher than cases reported nationally where only 6.3% had at least one handover. The frequency of handovers differs among hospitals, depending on specialty, structure, number of beds, case duration, and scheduling priorities. Our practice appears to be representative of practice in general, as compared to results shown previously,[3] where 39% of cases were associated with at least one handover, although we still have substantially more handovers than the average practice. Saager *et al.*[3] identified an association between handovers and a composite outcome that

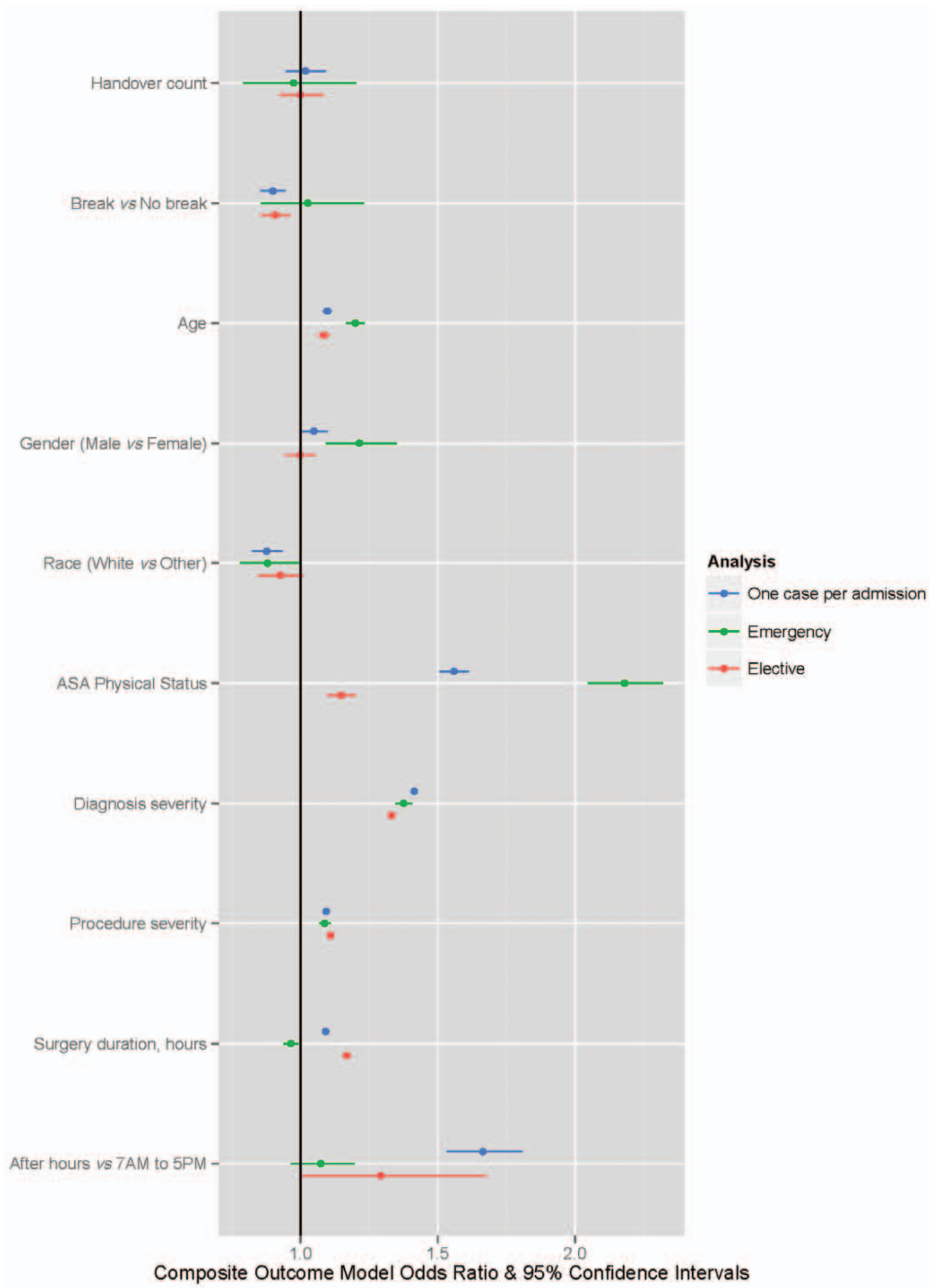

Fig. 2. Odds ratio estimates and Wald CIs for the composite outcome model sensitivity analyses. ASA = American Society of Anesthesiologists physical status.

includes in-hospital mortality, serious cardiac, respiratory, gastrointestinal, urinary, bleeding, and infectious complications, with similar effect sizes for attending anesthesia providers, residents, and nurse anesthetists. Although the authors adjusted for potential confounding variables that are included in the current analysis, the effect of breaks was not evaluated. A study by Hyder *et al.*[4] also challenged the assumption that anesthesia transitions are care neutral and not contributory to surgical outcomes. The authors performed analysis on a subset of patients that underwent elective colorectal procedures and identified that care by additional attending anesthesiologists and in-room providers was independently associated with increased odds of postoperative complications. Further analysis is needed to assess whether the findings hold if expanded to other procedures. The effect of provider breaks on the major complication and/or death rate within 30 days was not evaluated.

Table 3. Patient Characteristics for the NSQIP Outcome Model

Total encounters in data set	8,404
Age (yr)	53.83 ± 15.69
Gender (female), %	53.46
Race (Caucasian), %	87.79
Breaks (%)	53.59
ASA physical status 1 (%)	1.33
ASA physical status 2 (%)	29.53
ASA physical status 3 (%)	60.91
ASA physical status 4 (%)	7.91
ASA physical status 5 (%)	0.31
Death or complications (%)	23.94

Data are presented as mean ± SD unless noted otherwise.

ASA = American Society of Anesthesiologists; NSQIP = National Surgical Quality Improvement Program.

Table 4. Handover Prevalence Rate Comparison

No. of Handovers	Handover % at National AQI	Handover % at VUMC	*P* Value
0	93.72	92.11	*P* < 0.0001*
1	5.67	7.06	
2	0.50	0.80	
3	0.09	0.04	
≥ 4	0.01	0.00	

*Handover count by data source, measured with the Cochran–Armitage trend test.

AQI = Anesthesia Quality Institute; VUMC = Vanderbilt University Medical Center.

There are a number of limitations to our study that must be considered, in addition to those discussed in the second paragraph of Discussion. First, the current study has all the limitations of a retrospective study that includes administrative data. It is not clear from this analysis whether there is a causal relationship between anesthesia staff breaks and patient outcomes or if the association observed is a result of unknown confounders or inadequate adjustment for confounding. Additionally, we were unable to test the interaction term between anesthesia provider breaks and surgery start time on a per-hour basis, due to sample size considerations and a limited number of events, which reduced statistical power of the analysis. Some of the NSQIP definitions changed during the analysis timeframe. Most changes were made in 2011 when the ACS changed vendors. Furthermore, a fundamental issue of selection bias can be present, since breaks may be rarely given in complex cases. In addition to adjusting for the procedural and diagnostic severity, other intraoperative factors could be potentially adjusted for, including the surgical Apgar score, blood loss, hypotension, and use of vasopressors. Finally, we are limited by the fact that this study was a single-center evaluation.

In summary, anesthesia care transitions were not associated with increased odds of postoperative adverse outcomes, whereas anesthesia staff breaks were associated with decreased odds of postoperative adverse outcomes. Additional research is needed to further understand the relationship between anesthesia staff breaks and outcomes.

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Competing Interests

The authors declare no competing interests.

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