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Surgical team behaviors and patient outcomes

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Abstract

BACKGROUND: Little evidence exists that links teamwork to patient outcomes. We conducted this study to determine if patients of teams with good teamwork had better outcomes than those with poor teamwork.

METHODS: Observers used a standardized instrument to assess team behaviors. Retrospective chart review was performed to measure 30-day outcomes. Multiple logistic regressions were calculated to assess the independence of the association between teamwork with patient outcome after adjusting for American Society of Anesthesiologists (ASA) score.

RESULTS: In univariate analyses, patients had increased odds of complications or death when the following behaviors were exhibited less frequently: information sharing during intraoperative phases, briefing during handoff phases, and information sharing during handoff phases. Composite measures of teamwork across all operative phases were significantly associated with complication or death after adjusting for ASA score (odds ratio 4.82; 95% confidence interval, 1.30–17.87).

CONCLUSION: When teams exhibited infrequent team behaviors, patients were more likely to experience death or major complication.

As 1 of 5 principles for creating safe systems of health care delivery, the Institute of Medicine report on medical error[1] concluded that health care organizations need to "promote effective team functioning." Their recommendation for promoting team behavior was based primarily on qualitative research methodologies and approaches such as root cause analyses. In the airline industry, research linking effective team functioning to flight safety led to specific training in teamwork that was subsequently associated with improvements in safety. Health care settings involving a high risk of harm such as labor and delivery,[2] critical care,[3] and especially surgery[4,5] share many of the same fundamental elements of the airline industry where people are working with other people in a high-technology and high-risk work environment. To date, very little quantitative research has assessed the relationship between team behaviors and outcomes in healthcare. Despite a significant amount of rhetoric around teamwork, team training, and the impact of communication breakdowns, the evidence that directly links

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the interpersonal interactions of caregivers to the outcomes of their patients has not been well documented. To that end, we conducted this study to determine if patients of surgical teams who exhibited good teamwork had better outcomes than patients of teams with poor teamwork.

Methods

This study was conducted in the operating rooms of 2 medical centers and 2 ambulatory surgical centers affiliated with the Kaiser Foundation Health Plan. It involved structured observation of personnel (surgeons, anesthesiology providers, nurses, technicians, and others) doing surgical procedures at the 4 sites during the period from March to August 2005 and the assessment of 30-day postsurgical outcomes (by retrospective chart review) of patients whose surgical team had been observed.

Observed providers consented in writing to be observed. We approached 149 physicians, registered nurses, operating room technicians, and nurse anesthetists; 19 (12.7%) declined to participate. Provider consent was first sought after the presentation of information about the project at a regular meeting of the provider group. Some provider groups (surgeons, MD anesthesiologists, and CRNAs) voted at the information meeting to participate universally, although 2 of 44 of the physicians attending the informational meeting declined despite this group vote. Seventeen of 69 (25%) nurses and technicians attending the informational meeting initially declined to participate in the study, but some of these providers consented to have specific procedures observed when they were asked at the time the procedure was selected. Providers who did not attend the informational meetings were asked whether or not they consented to participate in having specific procedures observed, but the consent rate by provider was not tracked for these individuals. Patients were observed if they did not opt out of observation after being informed about the study during their preoperative visit (29 patients opted out of the study). The study sample size of 300 surgical cases was chosen based on resource and time availability. A statistical power analysis done a priori based on the sample size showed that the study had a power of 0.95 to detect a correlation of 0.20 or more between a rating of team behavior on a 4-point scale and rating of outcome on a 5-point scale using a 2-tailed statistical test. The study was reviewed and approved by the Kaiser Permanente Institutional Review Board for protection of human subjects.

Observers and training

Observers of the surgical procedures were all registered nurses. To ensure standardization of observations and calibration between observers, the observers attended a 2-day training session given at the Johns Hopkins University Quality and Safety Research Group. The training of 4 registered nurse observers included an overview of behavioral observation and perioperative teamwork and a series of calibration exercises whereby observers watched video clips of team behaviors, rated the frequency with which the behaviors occurred on the data collection form used in the study, and then debriefed the exercise to discuss discrepancies and verbally justify their ratings. This iterative process involved observing, rating, and debriefing 5 videos, during which time the real-time calibration level of the observers was calculated and shared with the observers using a within-group measure of interrater agreement (RWG[6]), requiring a .70 cutoff for acceptable agreement.

Behavioral markers

The study defined team function based on behavioral markers.[7] Behavioral markers are observable, nontechnical behaviors that have been shown empirically to contribute to performance in work environments, including the airline industry[8] and health care.[9] Behavioral marker data were collected by using a standard instrument adapted for this study.[10]

The instrument used in this study assessed the following 6 behavior domains: briefing, information sharing, inquiry, assertion, vigilance and awareness, and contingency management. Operational definitions for behaviors in each domain are given in Table 1. For each domain, the observer gave the surgical team a score from 0 to 4 on how often the specified behaviors related to that domain were observed. A score of 0 was given if the behaviors were never observed; 1 if the behaviors were observed rarely; 2 if there were isolated examples of the behavior; 3 if the behaviors were observed intermittently; and 4 if behaviors were observed frequently throughout the observation period. For each domain, separate team scores were assigned for the induction, intraoperative, and handoff (transition to the next level of care) phases of the procedure.

The selection of procedures for observation

Procedures were selected for observation on the morning of the surgery based on the consent of all team members to be observed, compatibility with the operational needs of the surgical suite, anticipated length of the procedure, and availability of the observer. Each selected procedure was observed by 1 observer who joined the team to begin observation when the patient was brought to the operating room. Observation ended when the patient was taken out of the operating room and handed off to the next level of care.

Adjustment variables and outcomes

The American Society of Anesthesiologists (ASA) score assigned by the anesthesiologist was recorded. The ASA score subjectively categorizes patients into 5 subgroups by preoperative physical fitness (Table 2). It was devised in 1941 by the ASA as a statistical tool for the retrospective

Table 1 Description of domains behavioral markers of team behavior assessed by the observers

Behavioral marker domain	Description
Used in univariate analysis and calculation of BMRI	
Briefing	Situation/relevant background shared; patient, procedure, site/side identified; plans are stated; questions asked; ongoing monitoring and communication encouraged
Information sharing	Information is shared; intentions are stated; mutual respect is evident; social conversations are appropriate
Inquiry	Asks for input and other relevant information
Vigilance and awareness	Tasks are prioritized; attention is focused; patient/equipment monitoring is maintained; tunnel vision is avoided; red flags are identified
Not used in univariate analysis calculation of BMRI	
Assertion	The members of the team are speaking up with their observations and recommendations during critical times
Contingency management	Relevant risks are identified; backup plans are made and executed

analysis of hospital records and has been revised periodically.[11] In 9 patients, the ASA score was not recorded in either the medical record or on the observation sheet. In these cases, an anesthesiologist independent of the study reviewed information on patient characteristics obtained from the medical record review and assigned an ASA score.

The surgical procedures were classified as low, medium, or high risk for postoperative complications according to American College of Cardiology (ACC) and American Heart Association (AHA) guidelines.[12] Low-risk procedures included biopsy, excision of mass, hernia repair, laparoscopic cholecystectomy; medium risk included open laparotomy, carotid endarterectomy, and thyroidectomy; and high risk included aortic aneurysm repair and femoral popliteal bypass. The 30-day outcome of each observed procedure was determined by medical record review using a standard instrument. The medical record reviewer was blinded to the behavioral risk index. Each reviewer had a list of common surgical complications (Appendix 1) and these complications and other significant outcomes were grouped into 5 outcome categories: (1) no complications; (2) 1 or more indicators of potential harm (change in procedure, intubation/reintubation/bilevel positive airway pressure in post anesthesia care unit (PACU), nonroutine x-ray intraoper-

Table 2 Definitions of measures: patient risk of complications

Measure	Definition	Example
ASA patient classification		
I	Completely healthy patient	A fit patient
II	Patient with mild systemic disease	Essential hypertension, mild diabetes without end-organ damage
III	Patient with severe systemic disease that is not incapacitating	Angina, moderate to severe COPD
IV	Patient with incapacitating disease that is a constant threat to life	Advanced COPD, cardiac failure
V	A moribund patient who is not expected to live 24 hours with or without surgery	Ruptured aortic aneurysm, massive pulmonary embolism
ACC/AHA procedure risk*		
Low	Low risk of noncardiac complications	Biopsy, excision of mass, hernia repair, laparoscopic cholecystectomy
Medium	Medium risk of noncardiac complications	Mastectomy, thoracotomy, thyroidectomy, exploratory laparotomy
High	High risk of noncardiac complications	Repair of abdominal aortic aneurysm
Outcome score		
1	No complications	
2	One or more indicators of potential harm	
3	Minor complication	
4	Major complication	
5	Death or permanent disability	

*Procedures listed as examples for the ACC/AHA procedure risk accounted for 85% of all procedures observed in this study.

atively or in PACU, intraoperative epinephrine or norepinephrine use, postoperative troponin level >0.5, change in anesthetic during surgery; consult requested in PACU, pathological report normal or unrelated to diagnosis, and insertion of arterial or central venous line during surgery); (3) minor complication characterized by one of the following: prolonged, unplanned operative time (eg, greater than 1.5× expected time), postoperative transfer to a higher level of care, unplanned return to surgery (within 72 hours), and unplanned ventilatory support for greater than 24 hours or more postoperatively; (4) major intra- or postoperative complication characterized by prolonged, unplanned operative time (eg, greater than 1.5× expected time), postoperative transfer to a higher level of care, unplanned return to surgery (within 72 hours), unplanned ventilatory support for greater than 24 hours or more postoperatively (ie, inability to extubate), and unplanned emergency intervention by the surgical team or code team; and (5) death or permanent disability.

Behavior marker risk index

For each procedure/team, the behavioral marker data were summarized by using a single score, the Behavioral Marker Risk Index (BMRI), following the approach used by researchers studying group interactions in high risk environments.[13] Based on inspection of the univariate behavioral marker data, we excluded the markers assertion and contingency management from the BMRI because they were rarely observed in these generally low-risk procedures performed on mostly low- and intermediate-risk patients.

The BMRI represents the percent of behavioral ratings made during the procedure that were less frequent than a rating of 3 or intermittent. BMRI was calculated by assigning a value of 1 if the observer rating for the domain was 0 (behavior never observed), 1 (behavior rarely observed), or 2 (isolated or minimal observation of the behavior). If the observer rating was 3 (intermittent observation of behavior) or 4 (frequent observation), then a value of 0 was assigned. These values were summed across all phases of surgery for the 4 behavioral marker domains and then divided by the total number of domains/phases in which an observation was made. Thus, the BMRI had a range from 0.0 to 1.0 where values closer to 0.0 indicated more frequent observations of team behavior. Those closer to 1.0 indicated less frequent observations of team behavior (or as the label implies "riskier" team behavior). The valence of the BMRI means that positive correlations of the BMRI with the patient outcome score reflect an association of failure to observe "good team behavior" with worse outcomes.

Analysis

Patient characteristics were summarized by using means, counts, and percent distributions as appropriate to the distribution of the variable. For descriptive analysis, patient outcomes were categorized into 2 categories: "complications or death" or "no complications or death." The first category included patients with both major and minor complications in addition to deaths. The second category included patients with 1 or more indicators of potential harm in addition to no complications. For each operative phase and behavioral marker domain, the increased odds of having complications or death associated with lower scores for team behavior (0-2) were estimated by calculating odds ratios (ORs) and 95% confidence intervals (CIs). Multiple logistic regressions were calculated to assess the independence of the associations of the behavioral marker domains with outcome after taking into account the ASA patient risk score. Two-way interactions involving the behavioral marker domains with the ASA patient risk were considered but were not significantly ($P > .20$) related to the outcome and not included in the final adjusted models.

Similar unadjusted and adjusted ORs and 95% confidence intervals were calculated by logistic regressions with the BMRI as the predictor variable, the ASA patient risk score as the covariate adjusted for in the adjusted model, and "complications or death" as the predicted outcome. Finally, we used the logistic regression model to calculate the predicted relationship between the BMRI and the OR for complications and death. Statistical analyses were conducted by using SPSS version 14.0.

Results

Observer calibration was achieved to an RWG of 0.9 for the 2 main observers and an RWG calibration of 0.85 for all observers at the conclusion of training. Three hundred patients/procedures were observed. The medical records for 7 patients could not be located so their observational data were excluded from the analysis. Table 3 shows characteristics of the 293 observed patients and procedures included in the analysis. The patients were mostly middle-aged. The sex and race/ethnicity distribution were generally representative of Kaiser Permanente members undergoing general surgery procedures at the participating hospitals. The patients were mostly low and medium risk; there were no patients in the ASA category V and only 5 in the ASA category IV. All but 4 of the procedures were American College of Cardiology/American Heart Association low or intermediate risk. More than one-half of the procedures had "no complications" as the outcome rating. Three patients had an outcome of death or disability. In about 25% of procedures, the BMRI was more than 0.50, indicating a high proportion of operative phases and domains with infrequent observation of good team behaviors.

For each operative phase (induction, intraoperative, and handoff) and behavioral marker domain, Table 4 shows the behavioral marker scores after dichotomizing them into categories of less frequent (0-2) or more frequent (3-4) observation of "good" team behaviors along with the percentage of more frequent observation of good team behav-

Table 3 Characteristics of 293 patients and procedures

Characteristics	N	%
Age range		
18–34	44	(15)
35–49	64	(22)
50–74	145	(49)
75+	40	(14)
Race/ethnicity		
Asian/Pacific Islander	10	(3)
Black	26	(9)
Hispanic	49	(17)
Non-Hispanic white	188	(64)
Missing	20	(7)
Sex		
Female	174	(59)
ASA classification		
I	47	(16)
II	155	(53)
III	86	(29)
IV	5	(2)
V	0	(0)
ACC/AHA procedure risk		
Low	233	(80)
Medium	56	(19)
High	4	(1)
Outcome		
No complications	158	(54)
One or more indicators of potential harm	71	(24)
Minor complication	48	(16)
Major complication	13	(4)
BMRI categoric ranges		
0.00–0.24	83	(28)
0.25–0.49	136	(46)
0.50–0.74	56	(19)
0.75–1.00	18	(6)

iors. The table also shows the number and percentage of patients/procedures with a complication (major or minor) or death according to these scores by operative phase and behavioral marker domain along with the ORs and 95% CIs for complication or death for patients/procedures with scores indicating less frequent observation of "good" team behavior. The referent in this analysis is patients with scores indicating more frequent observation of "good" team behaviors. Thus, an OR above 1.0 indicates an association of less frequent team behaviors with poorer outcome.

For most of the phases and domains, good team behaviors were observed frequently or always (scores 3-4) in a substantial percentage of procedures; however, for none of the phases or domains were good teams behaviors observed frequently or always all of the time.

The ORs for complication or death were greater than 1.0 when team behaviors were observed less frequently (scores 0-2) in all operative phases and behavioral domains except the briefing domain of the intraoperative phase and the vigilance domain of the handoff domain. The OR estimates for complication or death excluded 1.0 in association with low scores for the information sharing domain of the intraoperative phase (OR 2.45; 95% CI, 1.36–4.42) and for the briefing and information sharing domains of the handoff phase (OR 2.34; 95% CI, 1.23–4.46 and OR 2.21; 95% CI, 1.18–4.16, respectively). The elevated OR for complication or death was close to excluding 1.0 in association with a low score for the vigilance domain of the induction phase (OR 2.08; 95% CI, 0.99–4.35). There were no significant findings for the remaining behavioral markers.

Table 5 shows the results of the logistic regression models using the BMRI and ASA as predictors and surgical outcome as the dependent variable. As above, ORs above 1.0 indicate an association of less frequently observed "good" behavior with poorer outcome. The BMRI was significantly associated with any complication or death after adjusting for ASA score (adjusted OR 4.82; 95% CI, 1.30–17.87). In other words, when teamwork behaviors were relatively infrequent during surgical procedures, patients were more likely to experience death or a major complication. Figure 1 graphically shows the positive association between the BMRI (with a higher score indicating fewer instances of teamwork behavior) and poorer patient outcome as predicted by our logistic regression model.

Comments

Principal findings

We found that patients whose surgical teams exhibited less teamwork behaviors were at a higher risk for death or complications, even after adjusting for ASA risk category. This finding is a potentially important addition to the national conversation on teamwork in health care, providing quantitative evidence of a direct link between teamwork during the surgical case and subsequent patient outcome. In an environment in which hospitals, health care organizations, health care insurers, and private practitioners are organizing their efforts to reduce upwardly spiraling costs while maintaining and improving patient safety, they are skeptical about devoting precious resources, human and otherwise, to any new patient safety initiative that will not deliver on the promise. This study supports arguments in favor of human factors training for surgical teams.

Strengths and limitations

Our study had several strengths. It was conducted in a community setting that is likely to be representative of surgical procedures. A variety of procedures were observed, and the teams were diverse. The outcomes were ascertained with the reviewer blinded to the team behavior scores. Behavioral markers have been applied to health care settings such as neonatal resuscitation,[10] and this study builds on that work. We modified the behavioral markers and the observation tool to apply to the operating room environment and used the same calibration techniques for our nurse observers as those used in prior studies. Continuous communication among the observers

Table 4 Description of behavioral markers scores by operative phase, number and percentage of procedures with complication or death, and ORs and 95% CIs for complication or death for less frequent observation of "good" team behaviors

Operative phase and behavioral marker domain	Score	Teams/procedures		Major or minor complications or death			
		N	% of total	N	%	OR*	95% CI
Induction phase							
Briefing	0–2†	71		20	28	1.59	(0.86–2.93)
	3–4‡	222	76	44	20	Referent	—
Information sharing	0–2†	48		12	25	1.24	(0.60–2.55)
	3–4‡	145	84	52	21	Referent	—
Inquiry score	0–2†	118		28	24	1.20	(0.69–2.10)
	3–4‡	175	60	36	21	Referent	—
Vigilance	0–2†	38		13	34	2.08	(0.99–4.35)
	3–4‡	255	87	51	20	Referent	—
Intraoperative phase							
Briefing	0–2†	258		56	20	0.94	(0.40–2.17)
	3–4‡	35	12	8	23	Referent	—
Information sharing	0–2†	76		26	(34)	2.45	(1.36–4.42)
	3–4‡	217	74	38	(18)	Referent	—
Inquiry	0–2†	145		34	(23)	1.20	(0.69–2.10)
	3–4‡	147	50	30	(20)	Referent	—
Vigilance	0–2†	89		23	(26)	1.39	(0.77–2.49)
	3–4‡	204	70	41	(80)	Referent	—
Handoff phase							
Briefing	0–2†	54		19	(35)	2.34	(1.23–4.46)
	3–4‡	239	82	45	(19)	Referent	—
Information sharing	0–2†	59		20	(34)	2.21	(1.18–4.16)
	3–4‡	234	80	44	(19)	Referent	—
Inquiry	0–2†	175		43	(25)	1.50	(0.84–2.70)
	3–4‡	118	40	21	(18)	Referent	—
Vigilance	0–2†	84		18	(21)	0.97	(0.52–1.79)
	3–4‡	209	71	46	(22)	Referent	—

*OR for a major or minor complication or death in teams with a score of 0 to 2 for markers of team behavior relative to score of 3 to 4 for markers of team behaviors.

†Scores of 0 to 2 indicate that markers of "good" team behavior were never or rarely observed or there was isolated or minimal observation of the behaviors.

‡Scores of 3 to 4 indicate that markers of "good" team behavior were observed often or always.

throughout the study ensured a sustained level of interrater reliability.

The study has some important limitations. First, the study was observational, and we did not establish a cause-and-effect relationship between good team behavior and better outcome. Second, it is not possible to conclude which behaviors are most important or whether their influence varies by operative stage (induction and so on). Developing an intervention solely based on these findings would not be straightforward. Third, to obtain cooperation in conducting the study, we had to protect the identities of the members of the team, and we were thus not able to describe team characteristics (eg, training and experience) in detail. Research, including an extensive qualitative analysis based on observer comments, is ongoing with these data. Fourth, some of our analyses, notably our grouping of the outcomes into a dichotomous variable, were conducted post hoc.

Comparisons to other research

Previous studies of operating room teams have focused on the characteristics of surgeons such as "indi-

Table 5 The association of the BMRI with postoperative complications and death

	Unadjusted OR	95% CI on the unadjusted OR	*P* value (Wald test)	Adjusted# OR	95% CI on the adjusted OR	*P* value (Wald test)
Risk factor						
BMRI	5.61	1.53–20.54	0.009	4.82	1.30–17.87	0.019
ASA	1.59	1.06–2.38	0.024	1.51	1.00–2.27	0.049

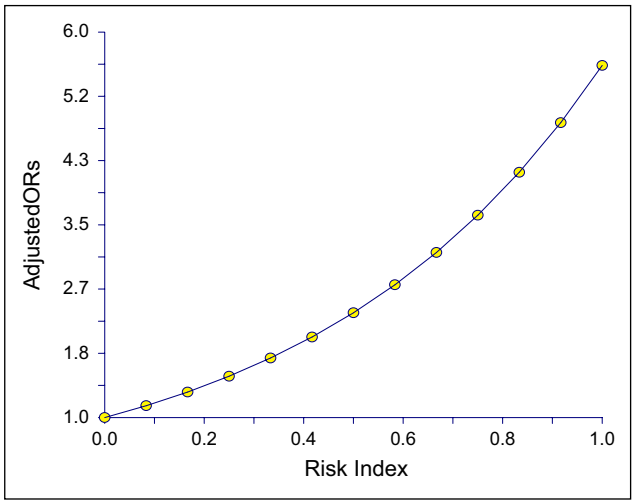

Figure 1 The predicted relationship between Behavioral Marker Risk Index and postoperative complications and death.

vidual excellence"[14] and technical competence.[15] They have also examined the impact of major and minor human failures on patient outcomes,[16] conducted qualitative analyses of major system features that influence team performance and patient safety,[17,18] and performed retrospective reviews of malpractice claims files.[19] Our methods and results complement and extend this literature in several ways. For example, we used direct observation of procedures and then used different study personnel to prospectively collect patient outcome data. This addresses limitations of malpractice claims file analyses[15] such as hindsight bias (knowledge of the bad outcome can bias reviewers to rate teamwork as lower) and sole reliance on the documents in claims files to make judgments about complicated and dynamic team behaviors. Compared with Carthy et al,[16] we studied a more generalizable and common group of surgical procedures, thus extending their findings to other types of surgeries. Greenberg et al[17] studied the entire spectrum of surgical care, not just intraoperative care, and identified communication breakdowns during surgeon communication with other caregivers. They recommended defined triggers that mandate communication with an attending surgeon, structured handoffs and transfer protocols, and standard use of read backs. Our work complements these studies by specifying the intraoperative team behaviors (briefings, information sharing, inquiry, and vigilance) that should be useful in preventing negative outcomes. Finally, a recent study reported a significant correlation between subjective ratings of teamwork with postoperative morbidity,[18] a finding that lends more support to our conclusions.

Implications

The development of interventions based on changing teamwork behavior and their evaluation is a logical next step for research in this arena. Our study provides general support for the development of team training programs for surgical teams. Such programs should be rigorously tested because they will require significant investments of time and money; some studies in other areas have found only marginal benefit for patients.[19] At Kaiser Permanente, we are implementing a comprehensive surgical safety program that includes practices such as preoperative briefings designed to increase collaboration and communication and provide the opportunity to discuss site and patient verification, prophylactic antibiotic administration, beta-blockade, glucose control, and normothermia. At the University of Texas, we have developed a team training curriculum for the Neonatal Resuscitation Program that increases the frequency of team behaviors during simulated resuscitations.[20]

In conclusion, our study supports further efforts to implement team training in the operating room with a focus on improved information sharing, inquiry, briefings, and vigilance.

Appendix 1 List of potential complications referred to by data abstractors when reviewing medical records

1. Accidental puncture or laceration
2. Surgical burn (heat producing equipment, chemical)
3. Adverse drug reaction
4. Wrong patient/procedure/site/side/device
5. Retention of foreign object
6. Transfusion reaction
7. Pressure ulcers
8. Peripheral nerve damage/short-term neurologic deficits
9. Complications of anesthesia (anesthetic medication error, reaction or endotracheal tube misplacement, regional anesthetic complications, broken teeth)
10. Iatrogenic pneumothorax
11. Pneumonia
12. Selected postoperative infections (International Classification of Diseases, Ninth Revision, Clinical Modification, codes 9993 or 00662)
13. Postoperative hemorrhage or hematoma
14. Postoperative pulmonary embolus or deep vein thrombosis
15. Postoperative disseminating intravascular coagulopathy
16. Postoperative respiratory failure (acute)
17. Postoperative sepsis
18. Postoperative wound dehiscence
19. Postoperative fracture (excluding unrelated postoperative falls)
20. Postoperative physiologic/metabolic derangement
21. Postoperative cardiac arrest
22. Postoperative hemodynamic instability
23. Myocardial infarction
24. Cerebrovascular accident
25. Other undesired outcome, not otherwise specified (eg, excessive and prolonged pain, unanticipated restriction in range of motion, musculoskeletal injury)

This list was not all-inclusive; abstractors recorded additional complications as indicated. Complications were grouped into outcome categories based on the impact on subsequent care and harm to patients.

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