Perioperative Morbidity and Mortality of Same-admission Staged Bilateral TKA

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Abstract

Background Controversy continues regarding the optimal timing of surgery for patients with symptomatic bilateral degenerative knee arthritis who are not considered eligible for same-day bilateral TKA (BTkA).

Questions/purposes We compared (1) 30-day mortality; (2) rates of in-hospital complications; and (3) blood transfusion rates between patients undergoing same-admission staged BTkA and patients undergoing BTkA

staged within 1 year in a highly specialized center where specific guidelines have been implemented for same-day BTkA patient selection.

Methods We analyzed institutional data for 149 patients undergoing same-admission staged and 1557 patients undergoing staged BTkA diagnosed with bilateral knee idiopathic osteoarthritis from 1998 to 2011. Although patients in both groups presented with bilateral knee disease, same-admission staged patients had more medical comorbidities and did not qualify for same-day BTkA. Specifically, patients with coronary artery disease with inducible ischemia, congestive heart failure, advanced chronic obstructive pulmonary disease, uncontrolled diabetes, peripheral vascular disease, renal failure, morbid obesity, history of venous thromboembolism, or those who were older than 75 years were not considered eligible for same-day BTkA. Patient demographics and Deyo comorbidity index were tabulated. The groups were similar in age, but same-admission staged patients were more likely to be male and had a higher overall comorbidity burden. The complications were categorized into systemic (medical) and local (orthopaedic). Furthermore, the systemic complications were subcategorized into major (required complex surgical or medical intervention or were deemed life-threatening) and minor (necessitated additional observation or required medical treatment), depending on their severity. Regression models were conducted to examine the association between surgery type and development of complications.

Results There was no difference in 30-day mortality between the groups (0% versus 0.06%; $p = 0.754$). There was no difference in the local complication rates (0.7% versus 0.8%; $p = 1.000$). However, multivariable regression analysis adjusting for age, sex, and Deyo comorbidity index showed that same-admission staged patients were

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Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

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three and two times more likely than staged to develop a minor (odds ratio [OR], 3.02; 95% confidence interval [CI], 1.25–3.25; $p = 0.004$) and major (OR, 2.02; 95% CI, 2.09–4.37; $p < 0.001$) complication, respectively. The same-admission group experienced more acute postoperative anemia (11% versus 3%; $p < 0.001$) and blood transfusions (93% versus 54%; $p < 0.001$).

Conclusions These results suggest that patients who are not appropriate candidates for same-day BTKA as a result of increased overall comorbidity burden may be better served by undergoing staged BTKA within 1 year rather than same-admission staged because of the associated higher perioperative morbidity observed in the same-admission BTKA group.

Level of Evidence Level III, therapeutic study. See Instructions for Authors for a complete description of levels of evidence.

Introduction

Many patients who present with symptomatic bilateral knee osteoarthritis elect to undergo bilateral TKA (BTKA) [24]. In 2007, approximately 7% of all TKAs performed in the United States were same-day bilateral (under a single anesthetic session) [10] and 15% staged BTKAs (two sequential unilateral TKAs performed within 1 year) [1]. It has been postulated that same-day BTKA results in greater pathophysiological insult than that from separate unilateral procedures [18, 25]. Although controversy still persists regarding the safety of same-day BTKA [12, 13, 17, 23, 27], large institutional series have shown that same-day BTKA can be performed safely without increased perioperative morbidity and mortality compared with staged BTKA if a selective preoperative screening process for same-day BTKA candidates is used [11, 13, 14, 19]. When a BTKA candidate is not considered eligible for same-day BTKA, treatment options include same-admission staged BTKA (managed as separate procedures during a single hospitalization) or staged BTKA during two separate hospitalizations, usually performed within 1 year [25, 26]. Same-admission staged BTKA has been used as a treatment option with the intent to reduce the perioperative complication rate compared with same-day BTKA. However, the few studies reporting on this approach have conflicting results, possibly as a result of differences in study design and patient selection process [5, 6, 15, 28].

The purpose of this study was to compare the (1) 30-day mortality; (2) rates of in-hospital complications; and (3) blood transfusion rates between patients undergoing same-admission staged BTKA and patients undergoing BTKA staged within 1 year in a highly specialized center for total

joint arthroplasty where specific guidelines have been implemented for same-day BTKA patient selection.

Materials and Methods

Data Collection

We performed a review of a large computerized patient database based on hospital discharge data to identify admissions with an International Classification of Diseases, 9th Revision, Clinical Modification (ICD-9-CM) procedure code for primary TKA (81.54) from 1998 through 2011. This study included patients with idiopathic osteoarthritis who underwent staged BTKA within 1 year. Patients who had both TKAs during a single hospital admission were classified as having same-admission staged BTKA, whereas patients undergoing two TKAs during separate hospitalizations within 1 year were classified as having staged BTKA. This study was approved by our institutional review board.

Administrative data collected for this study consisted of ICD-9-CM [7] diagnosis and procedure codes, patient characteristics, and hospital length of stay. Patient characteristics included age, sex, and race (white, black, Hispanic, other, and unknown). Patient comorbidity burden was evaluated using the Deyo modification of the Charlson Comorbidity Score for administrative diagnoses codes [4]. Additional comorbidity indicators were created for hypertension, diabetes mellitus, obesity, hypercholesterolemia, pulmonary disease, renal disease, coronary artery disease (CAD), congestive heart failure (CHF), sleep apnea, pulmonary hypertension, liver disease, and coagulopathy (Appendix 1) [7].

Outcomes of interest identified using ICD-9-CM diagnosis and procedure codes [7] included in-hospital complications, classified as local, minor or major, and blood transfusions. Local (orthopaedic) complications included peripheral nerve and vascular injuries, hemorrhage, hematoma, or seroma complicating the procedure, accidental puncture or laceration during the procedure, and disruption and nonhealing of the surgical wound; they were identified using codes for complications of surgical and medical care (956.XX, 997.XX–998.XX). The list of specific local complications and ICD-9-CM codes are provided (Appendix 1).

An additional 19 acute systemic complications were identified using ICD-9-CM codes [7] (Appendix 1) and classified as minor or major. Minor complications included those that necessitated additional observation or required medical treatment: (1) hypotension; (2) syncope and collapse; (3) tachycardia; (4) delirium; (5) urinary tract infection; (6) urinary retention; (7) superficial incisional

surgical site infections and cellulitis; (8) paralytic ileus; and (9) pleural effusion. Complications were considered major if they required complex surgical or medical intervention or if they were deemed life-threatening or resulted in functional impairment; they included (1) central nervous system infarction (ischemic stroke); (2) pulmonary compromise; (3) sepsis; (4) shock/cardiorespiratory arrest; (5) acute myocardial infarction (MI); (6) major cardiac (except MI); (7) pneumonia; (8) pulmonary embolism (PE); (9) deep vein thrombosis; and (10) deep periprosthetic infection.

Thirty-day mortality was determined by submitting protected information for the study subjects to the Social Security Death Index (SSDI) to obtain patient survivorship information through September 2012. Patient medical records were reviewed to verify infections identified by ICD-9-CM coding and determine 30-day mortality for patients not matched to the SSDI.

Study Population

Between January 1998 and December 2011, there were 1706 patients with idiopathic osteoarthritis who underwent bilateral TKA: 149 patients undergoing same-admission staged BTKA and 1557 patients undergoing staged BTKA with a mean interval between procedures of 6.5 days (range, 1–14 days) and 205.5 days (range, 6–365 days), respectively. The selection process for same-day or staged BTKA was based on the comorbidity profile of the candidates and surgeon's decision. Patients with substantial cardiopulmonary or other serious comorbidities generally underwent staged procedures after receiving medical clearance from an internist. Specifically, CAD with inducible ischemia, CHF, advanced chronic obstructive pulmonary disease, uncontrolled diabetes, peripheral vascular disease, renal failure, morbid obesity, history of venous thromboembolism, and age > 75 years were considered contraindications for same-day BTKA. If the preoperative workup concluded that the patient was not deemed an appropriate candidate for same-day BTKA but presented with major bilateral knee deformities requiring simultaneous correction—for accelerated postoperative rehabilitation—the same-admission staged approach was recommended to the patient. If the patient had recovered without any systemic or local complications and was medically stable postoperatively after the first knee, the second knee was replaced during the same hospitalization, typically 5 to 7 days later. If the patient declined to proceed with same-admission staged BTKA or experienced a major complication postoperatively after the first knee, the patient underwent TKA on the contralateral side at a later date within 1 year from the index procedure [13, 29].

Table 1. Demographics and comorbidity profile of the bilateral TKA cohorts

Variable	Same-admission staged (n = 149)	Staged (n = 1557)	p value
Age (years), median (range)	71.3 (38.5–86.6)	69.7 (25.2–91.5)	0.078
Race, number (%)			
White	127 (85.2)	1252 (80.4)	0.495
Black	11 (7.4)	123 (7.9)	
Hispanic	3 (2.0)	70 (4.5)	
Other	8 (5.4)	111 (7.1)	
Unknown	0 (0)	1 (0.1)	
Female sex, number (%)	72 (48.3)	1023 (65.7)	< 0.001
Charlson-Deyo Index, median (range)	1 (0–7)	0 (0–9)	0.002
Comorbidities, number (%)			
Hypertension	93 (62.4)	1035 (66.5)	0.320
Diabetes	29 (19.5)	238 (15.3)	0.193
Hypercholesteremia	64 (42.9)	669 (43)	1.000
Obesity	57 (38.3)	461 (29.6)	0.032
Pulmonary disease	27 (18.1)	193 (12.4)	0.054
Renal disease	5 (3.4)	33 (2.1)	0.374
Coronary artery disease	44 (29.5)	293 (18.8)	0.002
Congestive heart failure	7 (4.7)	32 (2.1)	0.075
Sleep apnea	6 (4.0)	49 (3.1)	0.473
Pulmonary hypertension	5 (3.4)	40 (2.6)	0.588
Liver disease	0 (0.0)	0 (0.0)	N/A
Coagulopathy	0 (0)	6 (0.4)	1.000

N/A = not applicable.

Same-admission staged patients were the same age as separate-admission staged patients (71 [range, 39–87] versus 70 [range, 25–92] years; $p = 0.078$) but were more likely to be male (52% versus 34%; $p < 0.001$), obese (38% versus 30%; $p = 0.032$), and had a higher overall comorbidity burden (1 [range, 0–7] versus 0 [range, 0–9]; $p = 0.002$). They were more likely to have pulmonary disease (18% versus 12%; $p = 0.054$) and CAD (30% versus 19%; $p = 0.002$) (Table 1).

Statistical Analysis

Descriptive statistics were calculated to examine patient characteristics and outcomes of interest by procedure type. Medians and ranges are reported for continuous variables, whereas categorical variables are summarized with

Table 2. Local complication rates in the bilateral TKA groups

Variable	Same-admission staged (n = 149)		Staged (n = 1557)		p value
	Number	Percent	Number	Percent	
Any local complication	1	0.7	12	0.8	1.000
Peripheral nerve injuries	0	0	0	0	N/A
Peripheral vascular complications	1	0.7	3	0.9	0.306
Hemorrhage complicating a procedure	0	0	0	0	N/A
Hematoma complicating a procedure	0	0	4	0.26	1.000
Seroma complicating a procedure	0	0	1	0.1	1.000
Accidental puncture or laceration during a procedure	0	0	3	0.2	1.000
Disruption of operative wound	0	0	0	0	N/A
Disruption of internal operation wound	0	0	0	0	N/A
Disruption of external operation wound	0	0	2	0.1	1.000
Nonhealing surgical wound	0	0	1	0.1	1.000

N/A = not applicable.

frequencies and percentages. Between-group comparisons were performed using the Wilcoxon rank-sum test for continuous variables and the chi-square test or Fisher's exact test for categorical variables. Based on the results of the univariate analyses, multivariable logistic regression modeling, adjusting for patient characteristics, were developed to examine the association between surgery type and development of (1) any minor complication; and (2) any major complication. Statistical significance was set at $p < 0.05$. All analyses were performed using SAS software Version 9.3 (SAS Institute, Inc, Cary, NC, USA).

Results

There was no difference in 30-day mortality rate between the same-admission staged and staged BTKA patients (zero of 149 [0%] versus one of 1557 [0.06%]; $p = 0.754$).

There was no difference in the percentage of any local complication (one of 149 [0.7%] versus 12 of 1557 [0.8%]; $p = 1.000$) among the groups (Table 2). However, there was a difference in the percentage of any minor (Table 3) or major (Table 4) complication between the BTKA

Table 3. Minor complication rates in bilateral TKA groups

Variable	Same-admission staged (n = 149)		Staged (n = 1557)		p value
	Number	Percent	Number	Percent	
Any minor complication	53	35.6	243	15.6	< 0.001
Hypotension	10	6.7	26	1.7	0.001
Syncope and collapse	9	6.0	27	1.7	0.003
Tachycardia	4	2.7	57	3.7	0.816
Delirium	1	0.7	19	1.2	1.000
Urinary tract infection	19	12.8	77	5.0	0.001
Urinary retention	2	1.3	11	0.7	0.316
Superficial incisional surgical site infection and cellulitis*	6	4.0	21	1.4	0.002
Paralytic ileus	15	10.1	48	3.1	< 0.001
Pleural effusion	2	1.3	6	0.4	0.206

* In-hospital infections are included only.

Table 4. Major complication rates in the bilateral TKA groups

Variables	Same-admission staged (n = 149)		Staged (n = 1557)		p value
	Number	Percent	Number	Percent	
Any major complication	24	16.1	140	9.0	0.008
Central nervous system (infarction complication)	0	0	0	0	N/A
Pulmonary compromise	9	6.0	55	3.5	0.170
Sepsis	0	0	2	0.1	1.000
Shock/ cardiorespiratory arrest	0	0	1	0.1	1.000
Acute myocardial infarction	1	0.7	2	0.1	0.240
Cardiac complications*	3	2.0	18	1.7	0.421
Pneumonia	0	0	4	0.3	1.000
Pulmonary embolism	4	2.7	9	0.6	0.021
Deep vein thrombosis	11	7.4	59	3.8	0.048
Deep periprosthetic infection	0	0	0	0	N/A

* Except acute myocardial infarction; N/A = not applicable.

groups. Multivariable regression analysis adjusting for age, sex, and Deyo comorbidity index showed that same-admission staged patients were three and two times more

Table 5. Odds ratios from the multivariable logistic regression model examining risk of minor complication

Variable	OR	Lower CL	Upper CL	p value
Age	1.01	0.99	1.03	0.058
Female versus male	1.29	0.98	1.69	0.073
Charlson-Deyo comorbidity score	1.13	1.02	1.26	0.022
Same-admission staged versus staged	3.02	2.09	4.37	< 0.001

OR = odds ratio; CL = confidence level.

Table 6. Odds ratios from the multivariable logistic regression model examining risk of major complication

Variable	OR	Lower CL	Upper CL	p value
Age	1.01	0.99	1.03	0.426
Female versus male	1.43	1	2.04	0.05
Charlson-Deyo comorbidity score	1.10	0.96	1.25	0.187
Same-admission staged versus staged	2.02	1.25	3.25	0.004

OR = odds ratio; CL = confidence level.

likely than staged to develop a minor (odds ratio [OR], 3.02; 95% confidence interval [CI], 1.25–3.25; $p = 0.004$) (Table 5) and major (OR, 2.02; 95% CI, 2.09–4.37; $p < 0.001$) (Table 6) complication, respectively.

Patients undergoing staged BTKA were associated with a lower incidence of acute posthemorrhagic anemia (16 of 149 [10.7%] versus 42 of 1557 [2.7%]; $p < 0.001$), blood transfusion (835 of 1557 [54%] versus 139 of 149 [93%]; $p < 0.001$), and allogeneic blood transfusion (250 of 1557 [16%] versus 96 of 149 [64%]; $p < 0.001$) compared with the same-admission staged patients (Table 7).

Discussion

It is common practice to perform bilateral procedures separately with an interval of several weeks to months. Despite higher blood loss, risk for cardiopulmonary complications, and overall higher physiologic insult compared with staged procedures, recent studies have suggested that same-day BTKA can be performed safely in appropriately selected patients with perioperative complication rates no higher, or even lower, than staged bilateral procedures [11, 13, 14, 19, 26]. Same-day BTKA (either simultaneously or sequentially) is considered when severe bilateral knee deformity and symptomatology, certain patient expectations, or socioeconomic pressures are present [6, 8, 20, 25]. In such situations, and when the patient is not considered medically eligible for same-day BTKA, same-admission

Table 7. Procedure time, blood transfusion rates, length of stay, discharge disposition, and need for mechanical ventilation for both bilateral TKA cohorts (analysis per patient)

Variable	Same-admission staged (n = 149)	Staged (n = 1557)	p value
Procedure time (minutes), median (range)*	262.5 (188–371)	260 (163–670)	0.295
Acute posthemorrhagic anemia, number (%)	16 (10.7)	42 (2.7)	< 0.001
Blood transfusion, number (%)	139 (93.3)	835 (53.6)	< 0.001
Allogeneic blood transfusion, number (%)	96 (64.4)	250 (16.1)	< 0.001
Length of stay (days), median (range)	11 (4–29)	9 (2–35)	< 0.001
Discharge disposition			
Rehabilitation center, number (%)	126 (84.6)	714 (45.9)	
Higher level of care (intensive care unit), number (%)	1 (0.7)	19 (1.2)	< 0.001
Other (eg, home), number (%)	22 (14.8)	824 (52.9)	
Mechanical ventilation, number (%)	2 (1.3)	10 (0.6)	0.897

* Procedure time was recorded in 82 of 149 same-admission staged and 1071 of 1557 staged bilateral TKA cases.

staged BTKA, although representing a compromise, may be considered as a treatment option. However, few studies have approached this controversial approach [5, 6, 15, 28]. Thus, we compared 30-day mortality, in-hospital complications rates, and blood transfusion rates between same-admission staged and staged-within 1 year BTKA at a high-volume institution where specific guidelines have been implemented encouraging same-day BTKA in younger and healthier patients.

Our study has several important limitations. First, selection bias is an important issue. Some patients may have refused to undergo same-admission staged BTKA for medical reasons because the perioperative complication risk may have been considered too high. In addition, the selection process for same-day and consequently for both staged BTKA groups may have been altered over the study period because of socioeconomic, patient-related factors and change in patients' expectations and demands. Therefore, any change in the decision-making process may have affected the perioperative outcomes for both staged groups. However, in our cohort, same-admission staged patients were similar in age and diagnosis but were associated with higher overall comorbidity burden predisposing them potentially to higher risk for

perioperative adverse events compared with the staged group. To address this dissimilarity at baseline, we performed a multivariate regression analysis adjusting for age, sex, and Deyo comorbidity index and found that same-admission staged patients were three and two times more likely to develop a minor and major complication, respectively, underlining the significant effect of surgery type on perioperative outcomes. Second, another limiting factor is the bias associated with the retrospective nature of our study. Specifically, the study timeframe is very long; many elements of care have changed, and there is no way to know with certainty whether these changes would have affected the study groups. Furthermore, length of stay and discharge to a rehabilitation center have decreased over the study period, and those trends would influence the groups dissimilarly. Nevertheless, some key aspects in the perioperative care, including anesthetic technique, surveillance, and pain management, have not changed over time and, therefore, our study may provide valid information on outcomes associated with the management of patients undergoing BTKA. The present analysis presents a single institution's experience, from 1998 to 2011, encompassing 1710 patients and 3420 TKAs and no patients were lost to 30-day followup. This large series may provide a more accurate estimate of low-incidence outcomes surrounding BTKA than various prospective studies that are limited in sample size. Third, we used ICD-9 coding and SSDI to identify comorbidities, complications, and provide complete 30-day followup. It is possible that coding errors may have occurred. Nevertheless, ICD-9-CM coding has been widely used in multiple studies lately and has been accepted as a valid method to identify and analyze perioperative events [2, 3, 30]. Finally, same-admission BTKAs were not performed in the same proportions over time. This may reflect the change in the decision-making process across the study period, and more specifically the decrease in trend may imply the associated higher perioperative morbidity.

We found no difference in mortality between same-admission staged BTKA and mortality among patients whose BTKAs were staged several months apart. Our results are consistent with the findings of published studies comparing perioperative mortality between same-admission staged and staged BTKAs [5, 6, 28].

In our cohort, the local complication rate was similar among the groups. However, same-admission staged patients were more likely to develop any minor or major complication compared with staged patients. Sliva et al. [28] reported, in a series of 332 consecutive patients undergoing BTKA, that the odds of a patient developing a minor complication was 2.64 times greater in the staged than in the same-admission staged 4 to 7 days apart group. A possible explanation for this difference may be that in our study, the same-admission group was associated with higher overall comorbidity burden compared with the staged group in

contrast to the study of Sliva et al. [28] in which patients in both staged groups were matched for age and comorbidity. However, we performed a multivariate regression analysis adjusting for age, sex, and Deyo comorbidity index and found that same-admission staged patients were three and two times more likely to develop a minor and major complication, respectively, underlining the significant effect of surgery type on perioperative outcomes in our cohort. Specifically, the higher incidence of cardiac (hypotension, syncope, and collapse) and thromboembolic (PE and deep vein thrombosis) events in the same-admission staged group compared with the staged group may be justified by the greater prevalence of male sex, CAD, and pulmonary disease, all of which have been found to be independent risk factors for perioperative morbidity and mortality after unilateral or BTKA [9, 14, 16, 19]. The extended hospital stay may explain the higher in-hospital infection rate in the same-admission staged cohort, because large institutional series have shown that longer hospitalization is a significant predictor for prosthetic joint infection [21, 22]. Same-admission staged BTKA was performed with a mean interval between procedures of 6.5 days in our study in comparison to the study of Sliva et al. [28] in which the average interval was 4.5 days. When further examining the effect of time interval between BTKAs performed during the same hospitalization, Wu et al. [31] reported a similar incidence of major (acute MI, PE, etc) and minor complications (transient hypotension or low SpO₂) throughout hospitalization when procedures were performed 2 (n = 46) or 7 days (n = 33) apart. In addition, no significant difference in the occurrence of the investigated complications was found between the first and second operations in both groups. However, authors pointed out that the lack of power secondary to their small sample size of 79 patients was a major limitation.

The frequency of acute posthemorrhagic anemia and blood transfusion was higher in the same-admission staged BTKA group. Our results are in line with the findings of Sliva et al. [28] who reported that 54% of the patients undergoing same-day sequential BTKA, 58% of the patients undergoing staggered BTKA performed 4 to 7 days apart (average, 4.5 days) during a single hospitalization, and 17% of the staged spaced an average of 70.5 weeks apart (range, 1.6–270.9 weeks) required allogeneic or autologous blood transfusion, respectively [28]. The increased need for blood transfusion in the patients undergoing same-admission staged BTKA compared with patients undergoing simultaneous BTKA has been supported as well by a nationally representative data analysis of 43,350 patients undergoing BTKA from 1998 to 2006 [15].

In summary, despite the theoretical advantage of less physiological insult and potential for assessing the patient's response to the first operation before proceeding with the second side, patients undergoing same-admission staged

BTKA were associated with increased perioperative morbidity compared with staged within 1 year BTKA. Our results suggest that for patients who are not appropriate candidates for same-day BTKA based on a selective pre-operative screening process in a high-volume subspecialty setting, it is preferable to undergo the procedure as a staged intervention over 1 year and avoid same-admission staged BTKA because of a higher frequency of perioperative adverse events. Same-admission staged BTKA should be performed with caution when the orthopaedic need for simultaneous correction of deformity prevails over the medical safety. However, because of the baseline dissimilarity in comorbidity profile between the groups, our study may offer pilot data for larger, multicenter prospective studies that control for this key issue.

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Appendix 1

ICD-9-CM diagnosis codes used in the study

Variables	ICD-9 codes
Mechanical ventilation	93.90, 96.70, 96.71
Blood transfusion	99.02, 99.03, 99.04, 99.05, 99.06, 99.07, 99.09
Acute posthemorrhagic anemia	285.1
Osteoarthritis	715.16
Inflammatory arthritis	099.3, 136.1, 446.0, 446.4, 446.5, 446.7, 44.76, 696.0, 701.0, 710.0, 710.1, 710.2, 710.3, 710.4, 710.8, 710.9, 711.1X*, 713.1, 713.3, 714.0, 714.2, 714.3, 714.9, 720.0X, 725
Comorbidities	
Hypertension	401.9, 402.90, 403.9X
Diabetes	250.X
Hypercholesteremia	272.0
Obesity	278.0X
Pulmonary disease	490, 491.X, 492.X, 493.X, 494.0, 496
Renal disease	403.9X, 585.9
Coronary artery disease	416.0, 416.8
Congestive heart failure	428.0, 428.31
Sleep apnea	780.57
Pulmonary hypertension	416.0, 416.8
Liver disease	571.0, 573.0, 576.8
Coagulopathy	286.X

Appendix continued

Variables	ICD-9 codes
Local complications	
Injury to peripheral nerve(s) of pelvic girdle and lower limb	956.X
Peripheral vascular complications	997.2
Hemorrhage complicating a procedure	998.11
Hematoma complicating a procedure	998.12
Seroma complicating a procedure	998.13
Accidental puncture or laceration during a procedure	998.2
Disruption of operative wound	998.3
Disruption of internal operation wound	998.31
Disruption of external operation wound	998.32
Nonhealing surgical wound	998.83
Minor complications	
Hypotension	458.2, 458.29, 458.9
Syncope and collapse	780.2
Tachycardia	785.0
Delirium	292.81, 293.0, 293.1
Urinary tract infection	599.0
Urinary retention	788.2X
Postoperative infection and cellulitis	998.5X, 999.3X, 682.6
Paralytic ileus	560.1
Pleural effusion	511.9
Major complications	
Central nervous system infarction	997.01, 997.02
Pulmonary compromise	518.X, 997.3X
Sepsis	038.X, 785.52, 785.59, 790.7, 995.91, 995.92, 998.0
Shock/cardiorespiratory arrest	427.5, 799.1
Acute myocardial infarction	410.01, 410.11, 410.21, 410.31, 410.41, 410.51, 410.61, 410.71, 410.81, 410.91
Cardiac complications	997.1X
Pneumonia	480.X, 481, 482.X, 483.X, 485, 486, 487.0, 507.0
Pulmonary embolism	415.11, 415.12, 415.19
Embolism/thrombosis—deep vein thrombosis	453.8, 453.41, 453.42

* An X indicates that the variable includes all codes starting with the numbers preceding the X.; ICD-9-CM = International Classification of Diseases, 9th Revision, Clinical Modification.

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