

Association of Overlapping Surgery with Perioperative Outcomes

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Disclaimer

- The work I am discussing precedes my appointment to the staff of the Council of Economic Advisers
- I am speaking in my capacity as an assistant professor at Stanford University
- Nothing in this talk should be construed as representing the views of the Federal Government

Disclosures

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Motivation

- Overlapping surgery refers to a situation where 2+ procedures performed by the same surgeon are scheduled so that the start of one procedure overlaps with the end of the other
- Has received attention in the popular press and from policymakers due to concerns about worse patient outcomes
- Are these concerns warranted?



Preview of Results

- Large retrospective analysis (>60,000 cases) of surgeries from eight centers
- Overall, overlapping surgery was not associated with worse outcomes
 - In-hospital Mortality (1.9% overlapping vs. 1.6% nonoverlapping, $p=0.21$)
 - Complications (12.8% overlapping vs. 11.8% nonoverlapping, $p=0.08$)
- Overlapping surgery was associated with increased length (204 vs. 173 minutes, $p<0.001$)
- Increases in mortality and complications seen for
 - High Risk Patients (mortality 5.8 vs 4.7, $p=0.03$; complications 29.2% vs 27.0%, $p=0.03$)
 - CABG (mortality 4.0% vs. 2.2%, $p=0.009$; complications 34.5% vs. 30.2%, $p=0.007$)

Introduction

- Several studies have examined the association between overlapping surgeries and perioperative outcomes (Morris, 2017)
 - In general have found no association
- Limitations of prior studies
 - Small sample size—potentially underpowered, particularly for mortality
 - Focused on single procedure, single institution
 - Used overly stringent definition of overlap (i.e., 1 or more minutes) which may bias estimates downwards
 - Study design-compared *across* surgeons
 - May mask effects of overlapping surgery if surgeons who perform overlapping surgery are more experienced
 - One previous study found an association between concurrent surgery and perioperative complications compared cases *within* surgeon (Ravi et al., 2017)

Methods

- Benefits of MPOG Data
 - Contain data that are crucial to studying this question
 - **Surgical times**
 - Surgeon identifiers
 - Data on outcomes
 - Mortality, ICD codes → outcomes
 - Data for risk adjustment (ICD codes)
 - Large number of cases
 - Multiple Institutions

Methods

- MPOG Challenges
 - Data not consistently reported across institutions
 - Ultimately, only 8 institutions consistently reported data elements necessary for this study
 - Difficulty identifying surgery
 - Initial plan was to include all surgeries and adjust for surgical CPT code
 - However, surgical was very inconsistently reported (although this has changed)
 - In response, we made two changes to the plan
 - Restricted to 7 surgeries (TKA, THA, crani, CABG, L/C/T-spine surgery)
 - Identified these surgeries by parsing the free text descriptors (i.e. “L TKA”)

Methods

- Variables taken from MPOG
 - Surgery Start/Stop times
 - Masked Surgeon ID
 - Masked Institution ID
 - Free text description of surgery
 - In-hospital mortality
 - Diagnosis Codes
 - Patient Age
 - Patient Sex
 - ASA Score

Sample

- Inclusion criteria:
 - Age 18-90
 - Surgeries: TKA, THA, spine surgery (lumbar/thoracic/cervical), CABG, craniotomy
 - January 1, 2010 to May 31, 2018
 - 8 institutions reporting diagnosis codes >70% of cases

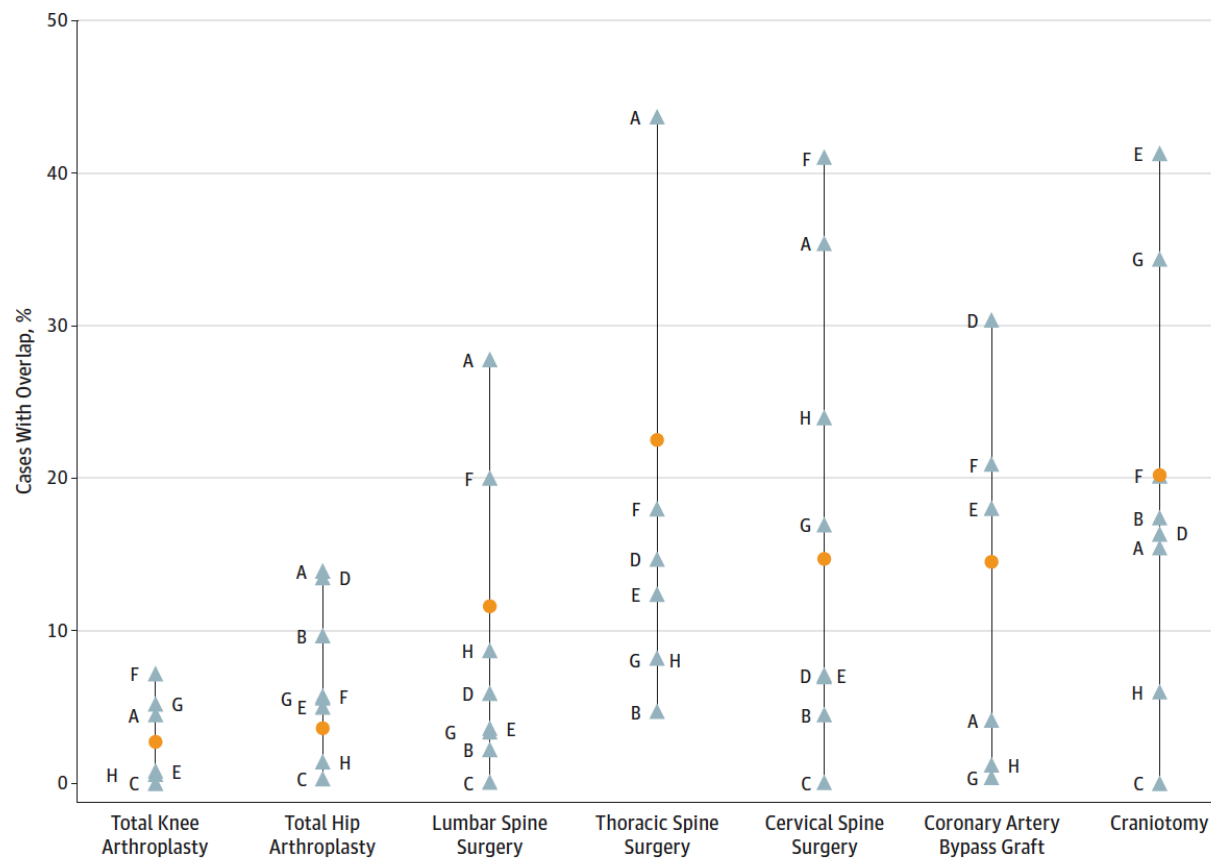
Sample

- Initial sample 87,560 cases
- Exclusion criteria:
 - Missing data
 - Diagnosis codes (n=7,023)
 - Mortality (n=1,070)
 - Surgery duration (n=4,728)
 - Sex (n=30)
 - ASA score (missing or=6; n=1,994)
 - >1 surgery type (n=4,167)
 - Surgeon-procedure combos with <20 observations (n=2,118)
 - Final sample 66,430 (8,224 overlapping)
 - 207 surgeons
 - 373 surgeon-procedure pairs

Empirical Approach

- Overlapping surgery defined as a case with 60+ minutes of overlap with surgeon's other cases
 - Or entirety of case if total duration ≤ 60 minutes
- Outcomes
 - In-hospital mortality
 - In-hospital complications
 - SSI, UTI, PNA, sepsis, DVT/PE, MI, stroke
 - Surgery Length
- Multivariable regression utilizing *surgeon-procedure* fixed effects
 - Our analysis explicitly compares outcomes between a given surgeon's overlapping and non-overlapping surgeries (of the same type)
 - e.g., Dr. Smith's overlapping vs non-overlapping TKAs and overlapping vs. non-overlapping THAs
 - Implicitly also adjusts for hospital-level factors
 - e.g. OR staff

Figure. Percentage of Surgical Cases With Overlap at Each Institution, by Surgery Type



Orange circles indicate weighted mean percentage of procedures performed with overlap across all institutions; vertical lines indicate range of case overlap; triangles indicate individual institutions (lettered A-H). For each procedure, the

weighted mean percentage was the average of the percentage of procedures performed with overlap for each institution, weighted by the number of procedures performed at each institution.

Sample Characteristics

Table 1. Patient Characteristics

Characteristic	Overlapping Surgery (n = 8224)	Nonoverlapping Surgery (n = 58 206)	Difference (95% CI)	
			Unadjusted	Adjusted ^a
Patient demographics				
Age, mean (SD), y	56.4 (15.2)	59.2 (14.8)	-2.7 (-4.7 to -0.7)	0.2 (-0.4 to 0.7)
Sex, No. (%)				
Men	4356 (53.0)	30 159 (51.8)	1.1 (-2.9 to 5.2)	0.6 (-0.7 to 1.9)
Women	3868 (47.0)	28 047 (48.2)	-1.1 (-5.2 to 2.9)	-0.6 (-1.9 to 0.7)
ASAPS score^b				
Numerical score, mean (SD)	2.7 (0.7)	2.6 (0.8)	0.1 (-0.0 to 0.19)	0.02 (-0.8 to 0.5)
Emergency status, No. (%)	446 (5.4)	4078 (7.0)	-1.6 (-3.0 to -0.1)	-1.4 (-3.0 to 0.2)
Patient comorbidities, No. (%)				
Hypertension, without complications	549 (46.4)	28 264 (48.6)	-2.1 (-4.6 to 0.4)	1.6 (0.0 to 3.1)
Obesity	1130 (13.7)	11 094 (19.1)	-5.3 (-9.6 to -1.6)	1.8 (-0.6 to 3.0)
Dysrhythmia	1213 (14.7)	9364 (16.1)	-1.3 (-4.5 to 1.9)	-0.5 (-1.7 to 0.7)
Depression	1277 (15.5)	9936 (16.1)	-0.6 (-2.1 to 0.9)	-0.1 (-1.2 to 0.9)
COPD	1256 (15.3)	9100 (15.6)	-0.3 (-1.8 to 1.1)	-0.1 (-1.1 to 0.8)
Fluid/electrolyte disorder	1689 (20.5)	9035 (15.5)	5.0 (0.2 to 9.8)	0.4 (-0.7 to 1.6)
Diabetes, without complications	851 (10.3)	7186 (12.3)	-2.0 (-4.2 to 0.2)	0.4 (-0.5 to 1.4)
Hypothyroidism	884 (10.7)	6869 (11.8)	-1.1 (-2.0 to -0.0)	0.0 (-1.0 to 0.9)
Neurologic disorders	1341 (16.3)	6588 (11.3)	5.0 (-0.0 to 10.0)	0.7 (-0.1 to 1.6)
Solid tumor	1159 (14.1)	5936 (10.2)	3.9 (-2.2 to 10.0)	0.9 (0.0 to 1.8)
Renal failure	569 (7.0)	4630 (8.0)	-1.0 (-3.0 to 0.9)	0.1 (-0.5 to 0.7)
Congestive heart failure	605 (7.4)	4539 (7.8)	-0.4 (-3.0 to 2.0)	0.0 (-0.6 to 0.7)
Hypertension, with complications	3820 (6.7)	4487 (7.7)	-1.0 (-2.9 to 0.9)	0.0 (-0.7 to 0.5)
Valvular disease	544 (6.6)	4177 (7.2)	-0.6 (-3.4 to 2.3)	-0.5 (-1.2 to 1.6)
Peripheral vascular disease	709 (8.6)	3733 (6.4)	2.2 (-1.0 to 5.5)	-0.0 (-0.9 to 0.8)
Metastatic cancer	491 (6.0)	3477 (6.0)	0.0 (-2.3 to 2.3)	-0.3 (-1.2 to 0.6)
Coagulopathy	474 (5.8)	3361 (5.8)	0.0 (-1.6 to 1.6)	-0.7 (-1.5 to 0.1)
Paralysis	495 (6.0)	2673 (4.6)	1.4 (-0.1 to 3.0)	0.0 (-0.7 to 0.6)
Rheumatoid arthritis	247 (3.0)	2345 (4.0)	-1.0 (-1.8 to -0.3)	0.0 (-0.4 to 0.4)
Pulmonary circulation disorder	314 (3.8)	1948 (3.3)	0.5 (-0.5 to 1.4)	0.4 (-0.2 to 0.9)
Weight loss	318 (3.9)	1943 (3.3)	0.6 (-0.3 to 1.3)	0.5 (-0.1 to 1.0)
Liver disease	223 (2.7)	1760 (3.0)	-0.3 (-0.9 to 0.3)	0.1 (-0.2 to 0.5)
Drug abuse	308 (3.7)	1671 (2.9)	0.8 (-0.2 to 1.9)	0.1 (-0.5 to 0.6)
Diabetes, with complications	146 (1.8)	1668 (2.9)	-1.0 (-1.8 to -0.4)	-0.0 (-0.4 to 0.2)
Iron-deficiency anemia	120 (1.5)	1093 (1.9)	-0.4 (-0.8 to -0.05)	0.3 (-0.1 to 0.6)
Alcohol abuse	182 (2.2)	1000 (1.7)	0.5 (0.2 to 0.8)	0.3 (-0.0 to 0.7)
Lymphoma	78 (0.9)	605 (1.0)	-0.1 (-0.3 to 0.2)	0.0 (-0.2 to 0.3)
Psychosis	107 (1.3)	574 (1.0)	0.3 (-0.0 to 0.6)	0.0 (-0.2 to 0.3)
Peptic ulcer disease	44 (0.5)	352 (0.6)	-0.1 (-0.3 to 0.1)	0.1 (-0.1 to 0.3)
Blood loss anemia	33 (0.4)	339 (0.6)	-0.2 (-0.4 to 0.0)	-0.0 (-0.2 to 0.1)
AIDS/HIV	20 (0.2)	84 (0.1)	0.1 (-0.0 to 0.2)	0.1 (-0.0 to 0.3)
Predicted mortality or complication risk, No. (%)^c				
Low risk	5212 (63.4)	40 361 (69.3)	-6.0 (-4.9 to 7.0)	0.0 (-1.8 to 1.8)
High risk	3012 (36.6)	17 845 (30.7)	6.0 (4.9 to 7.0)	0.0 (-1.8 to 1.8)

Sample Characteristics

- Generally speaking, few differences between overlapping and non-overlapping patients
 - Age, sex, ASA score
- Where there were differences, overlapping patients were generally sicker
 - 7 comorbidities more common in overlapping cases
 - 2 more common in nonoverlapping cases

Overlapping surgery and mortality

Table 2. Association Between Overlapping Surgery and In-Hospital Mortality

	In-Hospital Complications, % (95% CI)							
	Unadjusted				Adjusted ^a			
	Overlapping	Nonoverlapping	Difference	P Value ^b	Overlapping	Nonoverlapping	Difference	P Value ^b
Primary Analysis								
All operations combined (N = 66 430)	2.1 (1.5 to 2.6)	1.6 (1.2 to 2.0)	0.4 (-0.1 to 0.9)	.11	1.9 (1.5 to 2.3)	1.6 (1.6 to 1.7)	0.3 (-0.2 to 0.7)	.21
Exploratory Subgroup Analyses								
Surgery								
Total knee arthroplasty (n = 8282)	0.0 (0.0 to 0.0)	0.02 (0.0 to 0.06)	-0.02 (-0.06 to 0.01)	.14	0.01 (-0.03 to 0.05)	0.02 (0.02 to 0.03)	-0.02 (-0.06 to 0.02)	.37
Total hip arthroplasty (n = 9437)	0.6 (-0.0 to 1.5)	0.2 (0.1 to 0.3)	0.4 (-0.4 to 1.3)	.38	0.3 (-0.4 to 1.1)	0.2 (0.2 to 0.2)	0.1 (-0.6 to 0.8)	.80
Lumbar spine (n = 15 905)	0.3 (0.0 to 0.6)	0.3 (0.1 to 0.4)	0.04 (-0.2 to 0.3)	.76	0.4 (0.1 to 0.8)	0.3 (0.2 to 0.3)	0.1 (-0.2 to 0.5)	.45
Thoracic spine (n = 1868)	1.0 (0.3 to 1.6)	2.5 (1.6 to 3.4)	-1.5 (-2.8 to -0.2)	.02	1.6 (0.1 to 3.0)	2.3 (1.9 to 2.7)	-0.7 (-2.6 to 1.2)	.44
Cervical spine (n = 8567)	1.0 (0.4 to 1.5)	1.2 (0.8 to 1.7)	-0.3 (-0.9 to 0.4)	.41	1.1 (0.6 to 1.5)	1.2 (1.1 to 1.3)	-0.1 (-0.7 to 0.4)	.60
CABG surgery (n = 6539)	3.7 (2.1 to 5.2)	2.2 (1.6 to 2.8)	1.5 (-0.0 to 3.1)	.06	4.0 (2.8 to 5.1)	2.2 (2.0 to 2.4)	1.8 (0.5 to 3.2)	.009
Craniotomy (n = 15 832)	3.4 (2.3 to 4.6)	5.0 (4.0 to 6.0)	-1.5 (-2.6 to -0.4)	.007	5.0 (4.4 to 5.7)	4.6 (4.4 to 5.7)	0.5 (0.4 to 1.3)	.27
Predicted mortality or complication risk^c								
Low risk (n = 45 573)	0.3 (0.1 to 0.4)	0.2 (0.1 to 0.3)	0.1 (0.0 to 0.2)	.18	0.1 (0.0 to 0.2)	0.2 (0.2 to 0.3)	-0.1 (-0.2 to 0.0)	.07
High risk (n = 20 857)	5.1 (4.0 to 6.3)	4.8 (4.0 to 5.6)	0.3 (-0.8 to 1.5)	.15	5.8 (4.9 to 6.7)	4.7 (4.5 to 4.8)	1.2 (0.1 to 2.2)	.03

Overlapping Surgery and Complications

Table 3. Association Between Overlapping Surgery and In-Hospital Postoperative Complications

	In-Hospital Complications, % (95% CI)							
	Unadjusted				Adjusted ^a			
	Overlapping	Nonoverlapping	Difference	P Value ^b	Overlapping	Nonoverlapping	Difference	P Value ^b
Primary Analysis								
All operations combined (N = 66 430)	14.0 (10.8 to 17.0)	11.7 (10.1 to 13.3)	2.3 (-0.5 to 5.0)	.10	12.8 (11.9 to 13.7)	11.8 (11.7 to 12.0)	0.9 (-0.1 to 1.9)	.08
Exploratory Subgroup Analyses								
Surgery								
Total knee arthroplasty (n = 8282)	4.4 (2.0 to 6.8)	4.9 (3.0 to 6.9)	-0.5 (-3.4 to 2.4)	.77	5.2 (3.2 to 7.2)	4.9 (4.8 to 5.0)	0.3 (-1.8 to 2.3)	.79
Total hip arthroplasty (n = 9437)	7.0 (3.8 to 10.3)	6.0 (3.9 to 8.1)	1.0 (2.1 to 4.3)	.69	5.5 (2.4 to 8.6)	6.1 (5.9 to 6.2)	-0.6 (-3.8 to 2.7)	.72
Lumbar spine (n = 15 905)	6.8 (3.4 to 10.2)	6.2 (5.0 to 7.4)	0.6 (-2.4 to 3.6)	.80	5.9 (4.9 to 6.8)	6.4 (6.2 to 6.5)	-0.5 (-1.5 to 0.6)	.37
Thoracic spine (n = 1868)	16.6 (14.3 to 18.9)	21.4 (17.9 to 24.9)	-4.8 (-8.4 to -1.2)	.05	20.9 (17.0 to 24.8)	20.2 (19.0 to 21.3)	0.7 (-4.3 to 5.7)	.78
Cervical spine (n = 8567)	9.9 (5.8 to 14.1)	9.8 (8.2 to 11.5)	0.1 (-3.4 to 3.6)	.99	10.8 (8.9 to 12.7)	9.7 (9.4 to 10.0)	1.1 (-1.1 to 3.2)	.33
CABG surgery (n = 6539)	29.2 (24.0 to 34.4)	31.1 (27.9 to 34.2)	-1.8 (-7.2 to 3.4)	.49	34.5 (31.9 to 37.1)	30.2 (29.8 to 30.6)	4.3 (1.3 to 7.4)	.007
Craniotomy (n = 15 832)	16.2 (11.8 to 20.5)	17.5 (15.0 to 20.0)	-1.3 (-5.1 to 2.4)	.44	18.1 (16.7 to 19.5)	17.0 (16.6 to 17.3)	1.1 (-0.6 to 2.9)	.21
Predicted mortality or complication risk^c								
Low risk (n = 45 573)	5.9 (4.3 to 7.6)	4.8 (4.0 to 5.6)	1.1 (0.0 to 2.6)	.15	5.1 (4.2 to 5.9)	4.9 (4.8 to 5.0)	0.1 (-0.8 to 1.1)	.78
High risk (n = 20 857)	27.8 (24.5 to 31.1)	27.2 (25.3 to 29.1)	0.6 (-2.3 to 3.5)	.67	29.2 (27.5 to 30.9)	27.0 (26.7 to 27.2)	2.3 (0.3 to 4.3)	.03

Abbreviation: CABG, coronary artery bypass graft.

^amortality or postoperative complications on the basis of the characteristics

Overlapping Surgery and Surgery Times

Table 4. Association Between Overlapping Surgery and Surgery Length

	In-Hospital Complications, min (95% CI)							
	Unadjusted				Adjusted ^a			
	Overlapping	Nonoverlapping	Difference	P Value ^b	Overlapping	Nonoverlapping	Difference	P Value ^b
Primary Analysis								
All operations combined (N = 66 430)	237 (219 to 256)	169 (156 to 182)	68 (49 to 87)	<.001	204 (199 to 209)	173 (173 to 175)	30 (24 to 37)	<.001
Exploratory Subgroup Analyses								
Surgery								
Total knee arthroplasty (n = 8282)	126 (115 to 136)	104 (98 to 110)	22 (11 to 32)	<.001	122 (114 to 131)	104 (103 to 104)	18 (9 to 27)	<.001
Total hip arthroplasty (n = 9437)	157 (130 to 184)	105 (95 to 114)	52 (26 to 77)	<.001	127 (121 to 133)	106 (106 to 106)	21 (15 to 28)	<.001
Lumbar spine (n = 15 905)	209 (180 to 238)	159 (146 to 173)	49 (23 to 75)	<.001	191 (181 to 201)	162 (160 to 163)	30 (18 to 41)	<.001
Thoracic spine (n = 1868)	279 (246 to 311)	216 (198 to 232)	63 (32 to 94)	<.001	263 (248 to 278)	229 (215 to 224)	43 (24 to 61)	<.001
Cervical spine (n = 8567)	196 (179 to 214)	153 (143 to 163)	44 (24 to 62)	<.001	178 (165 to 190)	156 (153 to 158)	22 (7 to 36)	.003
CABG surgery (n = 6539)	278 (260 to 295)	294 (275 to 313)	-16 (-33 to 0.8)	.06	304 (299 to 309)	290 (289 to 290)	14 (9 to 20)	<.001
Craniotomy (n = 15 832)	269 (242 to 295)	216 (195 to 237)	53 (28 to 77)	<.001	254 (245 to 262)	220 (217 to 222)	34 (23 to 45)	<.001
Predicted mortality or complication risk^c								
Low risk (n = 45 573)	223 (204 to 243)	149 (137 to 162)	74 (54 to 94)	<.001	183 (176 to 190)	155 (154 to 156)	28 (20 to 35)	<.001
High risk (n = 20 857)	261 (244 to 279)	213 (198 to 227)	48 (31 to 67)	<.001	247 (241 to 253)	215 (214 to 216)	32 (25 to 39)	<.001

Conclusions

- Overlapping surgery is generally safe
- However caution and further study warranted for some high-risk groups
- Is associated with longer cases (~30 minutes)
 - Potential cost considerations (\$30-\$60/min)

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