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Surgical outcomes for patients diagnosed with dementia: a coarsened exact matching study

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Abstract

Background—An increasing number of elderly patients with dementia are undergoing surgical operations. Little is known about the differential impact of dementia on surgical outcomes. We investigated whether demented patients undergoing surgical operations have worse outcomes than their non-demented counterparts.

Methods—We performed a cohort study of all patients undergoing a series of surgical operations who were registered in the New York Statewide Planning and Research Cooperative System (SPARCS) database from 2009-2013. We examined the association of dementia with inpatient case-fatality, discharge to a facility, and length of stay (LOS). Coarsened exact matching was used to balance comorbidities among the comparison groups, and mixed effect methods were used to control for clustering at the hospital level.

Results—During the study period, 342,075 patients underwent surgical operations that met the inclusion criteria. Multivariable logistic regression models, after coarsened exact matching, demonstrated that demented patients were not associated with higher case-fatality (OR, 0.43; 95% CI, 0.13 to 1.36), but were associated with higher rates of discharge to a facility (OR, 1.71; 95% CI, 1.26 to 2.31) and longer LOS (Adjusted difference, 31%; 95% CI, 26% to 36%). These persisted in pre-specified subgroups stratified on particular operations.

Conclusions—Using a comprehensive all-payer cohort of surgical patients in New York State we identified an association of dementia with increased rate of discharge to rehabilitation and longer LOS. No difference was identified in the case fatality of the two groups. Policy makers,

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payers, and physicians should take these findings into account when designing new policies, and when counseling patients.

Keywords

surgery; dementia; postoperative outcomes; coarsened exact matching; SPARCS

INTRODUCTION

As the US population is aging,(1) and safer surgical and anesthetic techniques are developed, older and more debilitated patients are now undergoing surgery.(2, 3) In this setting, patients with dementia are increasingly undergoing surgery for a wide variety of conditions.(3, 4) Although some studies suggested that individuals with dementia are healthier than age-matched controls,(5) more recent evidence reveals greater comorbidity in demented patients.(1, 4, 6) Management of comorbid conditions is more challenging in the presence of dementia due to the often-limited ability of the patient to communicate, or adhere to treatment recommendations.(7) Clinicians therefore need to coordinate medical care through surrogates. Additionally, presence of dementia may affect health professionals' care decisions, especially about surgical indications.(6) In this context, concerns have been raised about the surgical outcomes of this population in comparison to their non-demented counterparts.(3)

The impacts of dementia on surgery are complex. Most previous studies focused on specific procedures, such as hip surgery, or minor procedures, such as cataracts or hernia repair, and had limited general applicability because of the single center retrospective study design.(8, 9) Other multi-center investigations lack appropriate control for confounding factors – most specifically, matching comparison groups based on their comorbidities so that similar patients (outside of dementia status) are compared.(3) There has been no previous study addressing this question in a comprehensive, all-payer, appropriately matched cohort of surgical patients.

We used the New York Statewide Planning and Research Cooperative System (SPARCS) (10) to study the association of dementia with case-fatality, discharge to a facility, and length of stay (LOS) for patients undergoing surgery. Following coarsened exact matching, a multivariable analysis was used to control for confounders and minimize differences between the comparison groups.

METHODS

New York Statewide Planning and Research Cooperative System (SPARCS)

This study was approved by our institutional Committee for Protection of Human Subjects. This study is based on de-identified data and therefore the consent process was waived by the committee. All patients who were hospitalized for a series of surgical operations and registered in the SPARCS (New York State Department of Health, Albany, NY)(10) database between 2009 and 2013 were included in the analysis. For these years, SPARCS contains patient-level details for every hospital discharge, ambulatory surgery, and emergency

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department admission in New York State as coded from admission and billing records. More information about SPARCS is available at https://www.health.ny.gov/statistics/sparcs/.

Cohort Definition

To establish the cohort of patients, we used *International Classification of Disease-9-Clinical Modification* (ICD-9-CM) codes to identify adult (18 years and older) patients in the database, who were hospitalized after abdominal aortic aneurysm (AAA) repair, carotid endarterectomy (CEA), coronary artery bypass graft (CABG), cardiac valve replacement, cystectomy, esophagectomy, lung resection, pancreatic resection, craniotomy, and spine surgery (Table S2) between 2009 and 2013.

Outcome variables

The primary outcome variable was case-fatality during the initial hospitalization after the surgical operations above. Secondary outcomes were length of stay (LOS) during the initial hospitalization, and discharge to a facility. The latter included all locations of disposition other than the patient's home.

Exposure variables

The primary exposure variable was whether the patient was diagnosed with dementia. This was defined as *International Classification of Disease-9-Current Modification* (ICD-9-CM) codes 290.xx, 331.0-331.2 at the time of admission to the hospital for the operation.

Covariates (Table S1) used for risk-adjustment were age, gender, race (African-American, Hispanic, Asian, Caucasian, other), insurance (private, Medicare, Medicaid, uninsured, other), and the specific type procedure performed.

The comorbidities used for risk adjustment were diabetes mellitus (DM), smoking, chronic lung disease, hypertension, hypercholesterolemia, peripheral vascular disease (PVD), congestive heart failure (CHF), coronary artery disease (CAD), history of ischemic stroke, history of transient ischemic attack (TIA), alcohol abuse, obesity, chronic renal failure (CRF), and coagulopathy. Only variables that were defined as "present on admission" were considered part of the patient's comorbidity profile.

Statistical analysis

The association of dementia with our outcome measures was examined in a multivariable setting.

A logistic regression was used for the categorical outcomes (case-fatality, discharge to a facility), and a linear regression for the linear outcomes (LOS). The values of LOS were positively skewed and therefore were log transformed for the purpose of the analysis. The covariates used for risk adjustment in these models were: age, gender, race, insurance, the specific type of surgery performed and all the comorbidities mentioned previously. Fixed effects were used for surgery type.

In an alternative way to control for confounding in differences between the two groups (demented, non-demented) we utilized coarsened exact matching methods.(11, 12) Matched

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patient cohorts were created after balancing the covariates to reduce the risk of confounding by indication. The *MatchIt* package(13) in the 64-bit version of R.3.1.0 was used. Our data set was matched across the following variables: age, gender, race, insurance status, and specific procedure performed. Cohorts were matched using coarsened exact matching using the *MatchIt* package.(13) Balance among the covariates after coarsened exact matching was assessed with numerical diagnostics, quantile-quantile plots, histograms, and jitter plots. The dataset underwent matching, the matched cohort was imported into the Zeilig package and used in a logistic regression (logit) model with the same variables as our prior logistic regression.

In order to demonstrate the robustness of our data in a sensitivity analysis, we used standard techniques to account for measured confounding, while accounting for clustering at the hospital level. For categorical outcomes we used a logistic regression model with hospital ID as a random effects variable, while controlling for all the covariates mentioned previously. For continuous outcomes, we performed similar analyses using linear models. Finally, we repeated the above analyses in pre-specified subgroups, specific to the procedure performed. The direction of the observed associations did not change and therefore these results are not reported further.

Regression diagnostics were performed for all models. All results are based on two sided tests, and the level of statistical significance was set at 0.05. This study, based on 342,075 patients, has sufficient power (80%) at a 5% type I error rate to detect differences in case-fatality as small as 7.8%.

RESULTS

Patient characteristics

In the selected study period there were 342,075 patients hospitalized after surgery who were registered in SPARCS. The mean age was 60.8 years, with 44.3% females. 1,313 were diagnosed with dementia preoperatively, and 340,762 were not. The characteristics of the two cohorts at baseline can be seen in Table 1.

Inpatient case-fatality

Overall, 54 (4.11%) inpatient deaths were recorded among patients with preoperative diagnosis of dementia and 6623 (1.94%) among those without. Dementia was not associated with higher case-fatality (OR, 1.13; 95% CI, 0.86 to 1.50) in unadjusted analysis. Likewise, using a logistic regression model after coarsened exact matching, we identified that patients with dementia were not associated with higher case-fatality (OR, 0.43; 95% CI, 0.13 to 1.36) in comparison to non-demented individuals (Table 2). This persisted in a mixed effects logistic regression model (OR, 0.96; 95% CI, 0.72 to 1.27).

Length-of-stay

The median LOS was 8.0 days (IQR 4.0-15.0) for surgical patients with a preoperative diagnosis of dementia, and 4.0 days (IQR 2.0-8.0) for those without. Dementia was associated with longer LOS (Percentage change, 35%; 95% CI, 31% to 40%) in the

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unadjusted analysis. Likewise, using a multivariable linear regression after coarsened exact matching, we identified that patients with dementia were associated with 31% longer LOS (95% CI, 26% to 36%) in comparison to non-demented individuals (Table 2). This persisted in a mixed effects multivariable linear regression model (Adjusted difference, 31%; 95% CI, 26% to 37%).

Discharge to a facility

Overall, 880 (70.17%) patients with preoperative diagnosis of dementia were discharged to a facility, and 159,057 (47.7%) non-demented patients had the same disposition. Dementia was associated with higher rates of discharge to rehabilitation in (OR, 1.81; 95% CI, 1.59 to 2.07) in unadjusted analysis. Likewise, using a logistic regression after coarsened exact matching, we identified that patients with dementia were more likely to be discharged to a facility (OR, 1.71; 95% CI, 1.26-2.31) in comparison to non-demented individuals (Table 2). This persisted in a mixed effects logistic regression model (OR, 1.71; 95% CI, 1.60 to 2.08).

DISCUSSION

Using a comprehensive all-payer cohort of patients undergoing surgical operations in New York State, we identified an association of preoperative diagnosis of dementia with increased rate of discharge to a facility, and LOS. No difference in case-fatality between the two groups was identified. These results were consistent across techniques to control for confounders. As the prevalence of dementia is increasing, these patients are undergoing a rising number of operations. However, there is conflicting evidence about the surgical outcomes of this population.

Prior retrospective investigations demonstrated conflicting results regarding the association of dementia with patient outcomes. Several researchers focused on specific procedures, such as hip surgery, or minor procedures, such as cataracts or hernia repair, and had limited generalization given their single center retrospective design.(8, 9) In a multi-center study of a national database in Taiwan, Hu et al(3) demonstrated that demented patients undergoing surgical procedures were associated with higher overall postoperative complication rate, with higher medical resources use, and in-hospital expenditures. Most specifically, these patients were found to have increased risk of acute renal failure, pneumonia, septicemia, stroke, and urinary tract infections. All these prior investigations have significant methodologic drawbacks. Those mainly stem from a lack appropriate control for confounding factors. Most specifically, they authors fail to match comparison groups based on their comorbidities so that similar patients outside of dementia status are compared. The lack of accounting for this selection bias significantly restricts the interpretation of these findings.

Our study purposefully addresses many of these methodologic limitations. First, we created a comprehensive statewide cohort, in order to accurately represent practice in the community. Second, we used advanced observational techniques to control for confounding. Coarsened exact matching was employed to balance comparison groups. This way all comparisons were performed among patients of similar age and comorbidities. This analysis is expected to control for selection bias and report results for patients of similar functional

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status. Previous studies have used this technique to balance covariates among comparison groups, especially in settings where a randomized trial would not be feasible.(14) The possibility of clustering was accounted for by using mixed effects methods. Our results were robust across techniques, supporting the validity of the observed associations.

However, this investigation demonstrates the association between dementia and increased healthcare usage, in terms of higher rates of discharge to a facility and longer length of stay. These findings are aligned with recent economic literature linking dementia to higher healthcare expenditure,(1, 6) and have significant implications for clinicians, policy makers, payers, and researchers. When patients have multiple chronic illnesses, clinicians need guidance regarding identification of high-risk groups. When caring for patients with dementia, clinicians need to maintain ongoing communication with caregivers, other medical providers, and agencies.(7) Such efforts need support and investment from policymakers and payers to improve coordination of care. Further research, particularly prospective studies, is needed to understand the risk profile of a patient with dementia. Information from these studies could ultimately help target interventions and innovative models of care delivery that take into account the interaction between chronic illness and dementia, and ultimately prevent morbidity and optimize healthcare resources.

Our study has several limitations. Residual confounding could account for some of the observed associations. However, this is minimized by coarsened exact matching.(14) In addition, coding inaccuracies will undoubtedly occur and can affect our estimates. Identification of dementia cases in population-based research is challenging for several reasons.(1) Clinically, the syndrome has an insidious onset, and there is no universal confirmatory diagnostic test. There is the potential for under-reporting of dementia in claims data because, before the spring of 2002, there was a financial disincentive to code dementia. (1, 15) To address these methodological issues, an inclusive definition was used that captured most types of dementia and required only one claim during admission, rather than two during a year, as used in other outcomes studies. Although SPARCS includes all hospitals from the entire New York State, the generalization of this analysis to the entire US population is uncertain. SPARCS does not provide any clinical information on the severity of dementia.

Additionally, we were lacking post-hospitalization and long-term data on our patients. Quality metrics are also not available through SPARCS, and therefore we cannot compare the two groups on these outcomes. The definitive comparison of the two groups on functional outcomes can only be done through prospective registries. In this direction, several specialty societies are creating prospective registries, with results expected in the near future.(16) Finally, causality cannot be definitively established based on observational data, despite the use of advanced techniques.

Conclusions

An increasing number of elderly patients with dementia are undergoing surgical operations. Little is known about the differential impact of this pathology on surgical outcomes. We investigated whether demented patients undergoing surgical operations have worse outcomes than their non-demented counterparts. Using a comprehensive all-payer cohort of surgical

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patients in New York State we identified an association of dementia with increased rate of discharge to rehabilitation and longer LOS. No difference was identified in the case fatality of the two groups. Policy makers, payers, and physicians should take these findings into account when designing new policies, and when counseling patients.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

Acknowledgments

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Table 1

Patient characteristics

		All Patients		Non-Demented Patients		Demented Patients		P-Value
Sample size		**342,075**		**340,762**		**1,313**		
		Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	
Age		60.81	15.17	60.74	15.15	78.32	8.06	<0.0001
			%		%		%	
Sex	F	151539	44.30	150,952	44.30	587	44.71	0.787
	M	190533	55.70	189,807	55.70	726	55.29	0.787
Insurance status	Medicare	133330	39.04	132292	38.89	1038	79.06	<0.0001
	Medicaid	15344	4.49	15309	4.50	35	2.67	0.001
	Private insurance	156203	45.74	155988	45.85	215	16.37	<0.0001
	Self-pay	8880	2.60	8865	2.61	15	1.14	0.001
	Other	27764	8.13	27754	8.16	10	0.76	<0.0001
Race	Caucasian	247421	72.75	246515	72.76	906	69.53	0.007
	African American	28882	8.49	28743	8.48	139	10.67	0.005
	Hispanic	22963	6.75	22864	6.75	99	7.60	0.230
	Asian	7769	2.28	7741	2.28	28	2.15	0.735
	Other	33061	9.72	32930	9.72	131	10.05	0.701
Comorbidities								
History of TIA		1088	0.32	1078	0.32	10	0.76	0.004
History of ischemic stroke		1746	0.51	1729	0.51	17	1.29	<0.0001
CAD		89522	26.17	89009	26.12	513	39.07	<0.0001
COPD		62524	18.28	62288	18.28	236	17.97	0.775
CHF		31675	9.26	31422	9.22	253	19.27	<0.0001
Diabetes		73097	21.37	72733	21.34	364	27.72	<0.0001
Coagulopathy		7434	2.17	7383	2.17	51	3.88	<0.0001
CRF		23349	6.83	23162	6.80	187	14.24	<0.0001
Hypertension		193444	56.55	192494	56.49	950	72.35	<0.0001
Hypercholesterolemia		138983	40.63	138385	40.61	598	45.54	0.001

	All Patients		Non-Demented Patients		Demented Patients		P-Value
Sample size	**342,075**		**340,762**		**1,313**		
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	
Tobacco use	50112	14.65	50039	14.68	73	5.56	<0.0001
Obesity	34961	10.22	34909	10.24	52	3.96	<0.0001
Alcohol abuse	7667	2.24	7633	2.24	34	2.59	0.447
PVD	33256	9.72	33042	9.70	214	16.30	<0.0001

SD: standard deviation

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Table 2

Association of dementia with outcomes

	Inpatient mortality[⌘]		Length-of-stay (days)[°]		Discharge to rehabilitation[⌘]	
	OR (95% CI)	**P-value**	**Adjusted Difference (95% CI)**	**P-value**	**Adjusted Difference (95% CI)**	**P-value**
Crude	1.13 (0.86-1.50)	0.377	35% (31%-40%)	<0.0001	1.81 (1.59-2.07)	<0.0001
Multivariable logistic regression[*]	0.96 (0.72-1.27)	0.773	31% (27%-36%)	<0.0001	1.82 (1.60-2.08)	<0.0001
Logistic regression after coarsened exact matching	0.43 (0.13-1.36)	0.150	31% (26%-36%)	<0.0001	1.71 (1.26-2.31)	<0.001

OR: Odds Ratio; 95% CI: 95% Confidence Interval

[*] Mixed effects; Includes hospital as a random effect variable

[⌘] Analyses based on logistic regression

[°] Analyses based on linear regression

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