The impact of the present on admission indicator on the accuracy of administrative data for carotid endarterectomy and stenting

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Background: **Administrative data are often hampered by coding errors, absent data, and the difficulty of distinguishing pre-existing conditions from perioperative complications. We evaluated whether the introduction of the present on admission (POA) indicator improved outcome analysis of carotid endarterectomy (CEA) and carotid angioplasty and stenting (CAS) using administrative data.**
Methods: **State inpatient databases from California (2005-2008), New York (2008), and New Jersey (2008) were used to identify patients undergoing CAS and CEA. We first analyzed morbidity data without the POA indicator, using International Classification of Diseases, Ninth Revision complication codes (eg, 997.02, iatrogenic cerebrovascular infarction or hemorrhage, postoperative stroke) and diagnosis codes (eg, 433.11, occlusion and stenosis of the carotid artery with cerebral infarction). Then, we applied the POA indicator to both diagnosis and complication codes and calculated the proportion of events that were labeled POA. Symptom status and perioperative stroke rate were compared using these coding approaches.**
Results: **We identified 21,639 patients who underwent CEA and 3688 patients who underwent CAS. Without the POA indicator, the complication code for stroke indicated a postoperative stroke rate of 1.4% for CEA and 2.4% for CAS. After applying the POA indicator, 54% (CEA) and 62% (CAS) of these strokes were labeled POA. These POA strokes were either preoperative or intraoperative events. Proportion of symptomatic patients ranged from 7% to 16% for CEA and from 5% to 22% for CAS. Perioperative stroke rate was the lowest in the POA method (1.1% CEA, 1.8% CAS) compared with two other methods without POA information (1.4% and 9.5% CEA and 2.4% and 16.4% CAS). Kappa indicated a poor (0.2) to fair (0.7) agreement between these approaches.**
Conclusions: **Administrative data has known limitations for assignment of symptom status and nonfatal perioperative outcomes. Given the uncertain timing of POA events as preoperative vs intraoperative and its apparent underestimation of the perioperative stroke rate, the use of administrative data even with the POA indicator for symptom status and nonfatal outcomes after CEA and CAS is hazardous. (J Vasc Surg 2014;59:32-8.)**

The use of administrative data to analyze population-based outcomes after carotid revascularization has recently been called into question.[1,2] Despite the benefit of large patient samples, administrative data are often hampered by coding errors, absent data, and the difficulty of distinguishing pre-existing conditions from postoperative complications. More specifically, stroke may be either the indication for revascularization of a symptomatic carotid stenosis, or an adverse event after carotid angioplasty and stenting (CAS) or carotid endarterectomy (CEA). Such misclassification may lead to under- or overestimating both the proportion of symptomatic patients and the number of perioperative complications. Previous comparisons of CAS and CEA utilizing administrative data have been further limited by a lack of standardized outcome definitions. While some reports considered only complication codes (eg, 997.02 iatrogenic cerebral infarction or hemorrhage - postoperative stroke) to identify postoperative strokes, others included diagnosis codes (eg, 434.11 cerebral embolism with cerebral infarction) as well.[3-5] A present on admission (POA) indicator has been developed to improve coding accuracy beyond the standard International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) diagnosis and complication codes. When the Centers for Medicare and Medicaid Services implemented a new pay-for-performance policy

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in 2008, they mandated that all pre-existing diagnoses or conditions be identified as POA in patient discharge abstracts. Whereas hospitals would not be penalized for pre-existing conditions designated as POA, management of 10 prespecified hospital-acquired conditions (stroke not included), those without a POA identifier, would be nonreimbursable and ineligible for contribution to higher reimbursement diagnosis-related groups.[6] The refinement of administrative claims data through the addition of a POA indicator has been shown to improve the validity of surgical outcome measures, as investigated by prior studies.[7-10] However, the impact of the new POA methodology has not yet been evaluated for carotid interventions. Therefore, we utilized the State Inpatient Databases (SID), which consist of inpatient hospital discharge abstracts in participating states (about 90% of all U.S. hospital discharges) translated into a uniform format containing a core set of clinical and nonclinical information on all patients, regardless of payer. Our aim was to investigate the impact of the POA indicator on administrative data in order to evaluate outcomes of CAS and CEA.

METHODS

Database. The SID from three states (California 2005-2008, New York 2008, and New Jersey 2008) were used to identify patients undergoing CEA and CAS. Database selection was made based upon data availability and sample size. Our inclusion criteria generated a study population >25,000 patients, which is comparable to other population based studies in the field.[11,12] The SID is a component of the Healthcare Cost and Utilization Project produced by the Agency for Healthcare Research and Quality and captures all hospitalizations that occur in community and academic hospitals in the participating states.[13] Quality and comparison reports of the data are available online (http://www.hcup-us.ahrq.gov). Effective October 1, 2007, the Hospital Uniform Bill was enacted, which set forth specific data requirements for hospital claims including a POA indicator for each diagnosis field. However, pioneering the practice in the 1990s, New York and California were early adopters of the POA indicator and required to report POA information in all in hospital discharge data as of that time. Thus, the POA indicator was a requirement for all included states during the study period. For the purposes of the POA indicator, hospitals code (using a uniform format across all states) any conditions the patient has at the time of inpatient admission as POA. Medical record documentation from any provider involved in the care and treatment of the patient may be used to support the determination of whether a condition was POA. Hospitals and other facilities are required to use a standardized set of requirements and definitions to report the POA indicator as delineated in the *Official UB-04 Data Specifications Manual and the ICD-9-CM Official Guidelines for Coding and Reporting.*

Data retrieval. The SID was queried for patient selection using both ICD-9-CM procedure and diagnosis codes. Patients undergoing CEA (38.12) and CAS (00.61, 00.63) were identified. Patients undergoing cardiac procedures during the same hospital stay were excluded (coronary artery bypass, cardiac valve repair, percutaneous coronary artery intervention, or a diagnostic cardiac catheterization). To ensure accurate coding on POA information, patients were selected with at least one diagnosis listed as POA. ICD-9 diagnosis codes include a separate set of codes for "complications of surgical and medical care, not elsewhere classified." For the purpose of this manuscript we will refer to these codes as "complication codes," as others have done previously.[1] We used all diagnosis and complication codes (in each diagnosis field) that potentially represent comorbidities or outcome following carotid revascularization, as specified in the Supplementary Table I, online only. Codes were obtained by a thorough review of the coding literature and include all codes that were previously used for carotid interventions.

POA defined. POA is defined as any condition present at the time the inpatient admission order is placed. For carotid revascularization procedures, POA codes can refer to different events depending on the specific order of events for a particular patient. If the patient is admitted to the hospital prior to carotid revascularization, a POA event refers to a preoperative, prehospital condition (eg, a complication stroke coded as POA will refer to a symptomatic patient). However, when the inpatient order is written after the procedure (eg, same day admission patients scheduled for elective procedures), a POA event most likely refers to an intraoperative event. In the latter scenario, it is unclear which event or condition was present before the operation and which events were complications during procedures.

Data analyses. For all patients undergoing CAS or CEA, frequencies and event rates for potential preadmission comorbidities and perioperative outcomes were calculated using diagnosis and complication codes without the application of the POA information. We then analyzed these rates in the presence of the POA information, which was applied on those same diagnosis and complication codes. The proportion of events that were POA and revised rates for each event were calculated, distinguishing the rate of "POA event rate" from "non-POA event rate." Subsequently, the proportion of symptomatic patients and postoperative stroke rate in symptomatic and asymptomatic patients was evaluated using three different previously described methodologies.[3-5,14] While the first method (A) uses the complication code for stroke to identify perioperative stroke, the second method (B) uses diagnosis codes for stroke together with the complication code for stroke to identify perioperative stroke (Table I). In administrative data that contains POA information, a third methodology (POA) was used.[11] Under the assumption that a complication code of stroke with a POA label refers to a preprocedural condition, preoperative symptom status could be identified using both diagnosis and complication codes for neurologic symptoms (stroke, transient ischemic infarction, amaurosis fugax)[5] with the POA flag (Supplementary Table II, online only). Patients

Table I. Different methodologies to identify symptom status and perioperative stroke rate using administrative data

	Symptom status	*Perioperative stroke*
Method A	Diagnosis codes for stroke, TIA, and amaurosis fugax	Complication code for stroke
Method B	Diagnosis codes for TIA and amaurosis fugax	Diagnosis codes and the complication code for stroke
Method POA	Diagnosis codes for stroke, TIA, and amaurosis fugax and the complication code for stroke with POA label	Diagnosis codes and complication code without POA label

POA, Present on admission; *TIA,* transient ischemic infarction.

without any diagnosis codes for neurologic symptoms are considered asymptomatic. Perioperative outcomes include both diagnosis codes and the complication code for stroke in the absence of POA flags. We calculated Cohen's Kappa (K) to measure agreement of method A and B with the POA method to identify symptom status and perioperative stroke rate. Kappa values of >0.75 indicate excellent agreement between methodologies, 0.4-0.75 indicate fair to good agreement, and values <0.4 indicate poor agreement. In addition, mortality rates and stroke-to-death ratios were investigated.

Queries of the SID data were performed with SAS v 9.2. (SAS Institute, Cary, NC). IBM SPSS v 19.0 (IBM Corporation, Armonk, NY) was used for all statistical analyses.

RESULTS

A total of 41,684 patients were identified who underwent CEA (n = 36,002; 86.4%) or CAS (n = 5682; 13.6%); 60.7% of those patients had at least one diagnosis listed as POA, resulting in a final study sample of 25,327 patients including 21,639 (85.4%) undergoing CEA and 3688 (14.6%) undergoing CAS.

The proportions of comorbidities and adverse events that were POA. Without POA information, diagnosis codes for stroke were found in 9.1% (n = 1960) of those undergoing CEA and 15.6% (n = 574) of those undergoing CAS. After applying the POA information, 90.3% (CEA) and 91.3% (CAS) of these strokes were labeled POA (Tables II and III). The complication code for stroke was present in 1.4% (n = 296) of patients undergoing CEA and 2.4% (n = 87) of patients who underwent CAS. In 54% of CEA and in 62% of CAS patients, these strokes were labeled as POA. The vast majority of diagnosis codes for other neurologic or acute cardiac diagnoses such as transient ischemic infarction, amaurosis fugax, and acute myocardial infarction were POA. The cardiac complication code was designated POA in 58% of CEA and 62% of CAS. Conditions that are infrequently encountered after carotid interventions, but are more likely to represent a postoperative complication than a pre-existing condition, were most impacted by the POA indicator: between 40% and 61% of peripheral vascular complications, respiratory complications, pneumonia and acute renal failure diagnosis were labeled POA for both CEA and CAS. Conditions that are regularly pre-existing conditions were correctly designated as being POA in more than 88% of diagnoses.

Defining preoperative symptom status using administrative data. Of the CEA patients, 15.9% (n = 3436) were considered symptomatic using method A (no POA information) and 7.1% (n = 1540) using method B (no POA information). In method POA, 15.4% (n = 3324) of CEA patients were considered symptomatic (Table IV). Kappa indicated an excellent agreement between method A compared with method POA (0.96), while a fair agreement (0.57) was seen between method B and method POA.

Among CAS patients, 21.7% (n = 801) of patients were symptomatic using method A, 4.6% (n = 243) using method B, and 21.0% (n = 776) using method POA. Similar to CEA, kappa indicated an excellent agreement between method A and method POA (0.95) and a fair agreement (0.40) between method B and method POA.

Defining perioperative stroke and mortality using administrative data. Following CEA, the perioperative stroke rate was 1.4% (5.9% symptomatic and 0.5% asymptomatic) using method A. Using method B, the perioperative stroke rate was 9.5% (4.8% symptomatic and 9.9% asymptomatic). Using method POA, the perioperative stroke rate was 1.1% (2.5% symptomatic and 0.9% asymptomatic) (Table V). Between method A and method POA, kappa indicated a fair agreement in the identification of postoperative strokes (kappa 0.7). Although the stroke rate in method A (1.4%; n = 296) and method POA (1.1%; n = 247) was fairly similar, 23.9% (n = 59) of strokes that were designated as perioperative events with the POA method were not picked up as perioperative strokes with method A. Similarly, method A designated 36.5% (n = 108) of strokes as perioperative events, while these strokes were pre-existing with the POA methodology. Method B clearly identifies all strokes that were found using method POA, but 88% (n = 1817) of these strokes were designated as being POA with the POA method. A kappa of 0.2 showed poor agreement between method B and method POA. Mortality for all patients was 0.5% and varied between symptomatic and asymptomatic patients according to the different methodologies that were applied (Table V). Using the POA method, death rate was 1.3% and stroke-to-death ratio was 1.9:1 for symptomatic patients, while death rate in asymptomatic patients was 0.4% and stroke-to-death ratio 2.5:1.

Following CAS, the perioperative stroke rate was 2.4% (7.5% symptomatic and 0.9% asymptomatic) using method A. Using method B, the perioperative stroke rate was 16.4% (8.4% symptomatic patients and 11.4% asymptomatic). Using method POA, the perioperative stroke rate was 1.8% (3.4% symptomatic and 1.6% asymptomatic patients) (Table V). Similar inaccuracies and agreements between the three methodologies were identified as after

Table II. Frequencies of diagnosis and complication codes used in the State Inpatient Databases of California, New York, and New Jersey in 21,639 patients undergoing carotid endarterectomy (CEA) and the impact of the present on admission (*POA*) indicator on preoperative conditions and perioperative outcome

	Rates identified without POA indicator		*Proportion POA*[a]		*Revised rates with POA indicator*	
	%	*No.*	*%*	*No.*	*POA rate,*[b] *%*	*Non-POA rate,*[c] *%*
Major neurologic or acute cardiac diagnoses that may represent either pre-existing conditions or complications after intervention						
Stroke						
Diagnosis code	9.1	1960	90.3	1770	8.2	0.9
Complication code	1.4	296	53.7	159	0.7	0.6
Transient ischemic attack	3.1	665	94.9	631	2.9	0.2
Amaurosis fugax	4.2	905	98.0	887	4.1	0.1
Cardiac complication	2.8	609	58.3	355	1.6	1.2
Acute myocardial infarction	2.4	509	70.3	358	1.7	0.7
Conditions that are infrequently encountered after intervention						
Peripheral vascular complication	0.1	18	61.1	11	0.1	0.0
Respiratory complication	0.7	151	45.0	68	0.3	0.4
Pneumonia	1.6	337	54.6	184	0.9	0.7
Acute renal failure	2.4	527	60.0	316	1.5	1.0
Conditions that are regularly pre-existing comorbidities						
Coronary artery disease	29.4	6369	97.3	6195	28.6	0.8
Angina	1.4	313	88.2	276	1.3	0.2
Congestive heart failure	11.2	2414	91.3	2203	10.2	1.0
Chronic obstructive pulmonary disease	27.3	5918	96.6	5719	26.4	3.4
Chronic kidney disease	11.5	2495	96.7	2412	11.1	0.4
Diabetes	49.9	10,801	97.5	10,526	48.6	1.3

[a]Of the rates that were identified without the use of the POA indicator.
[b]Condition flagged POA.
[c]Condition not flagged POA.

CEA, illustrated by kappa values of 0.6 (method A and method POA) and 0.2 (method B and method POA).

DISCUSSION

In this study, we examined the impact of the POA indicator on the accuracy of administrative data to evaluate outcome after CAS and CEA. While the majority of diagnosis codes represented conditions that were POA, we found that nearly one-half of complication codes were coded as POA. Our evaluation of the POA indicator identified several flaws with the use of this method as well as the others, indicating that the use of administrative data for carotid outcome analysis is limited.

A major limitation of the POA indicator is its variable designation of intraoperative strokes as either pre-existing or perioperative complications depending on the timing of admission order placement. Most elective carotid procedures will be scheduled as same-day admissions with admission order placed only after the procedure. Following the coding guidelines, an intraoperative stroke during carotid intervention should then be coded as a complication code of stroke with a POA label. While the goal of the Centers for Medicare and Medicaid Services pay-for-performance policy was to differentiate pre-admission conditions (unrelated to hospital stay) from conditions or complications that develop during the hospital stay (and can be, thus, attributed to medical or surgical management), this interpretation is not applicable to a large proportion of carotid procedures. Therefore, the coding of such intraoperative strokes is confusing and potentially subject to error. This is reflected by an inconsistency in the proportion of strokes that would have occurred intraoperative in the SID (54% of all CEA strokes and 62% of all CAS strokes) compared with the proportion of intraoperative stroke identified in the Society for Vascular Surgery vascular registry (16% of all CEA and 33% of all CAS strokes)[12] and in a large institutional review (15% of all CEA strokes).[15]

While it is unclear what proportion of patients are admitted before or after their procedure, many will interpret POA events as preoperative comorbidities and conditions without a POA label as periprocedural events.[11] Although the POA indicator was never validated by physician chart review, this POA methodology has the potential to improve outcome analyses based on administrative data compared with traditional methodologies. However, in all methodologies that were examined in this study, we identified serious shortcomings. The most important limitation of the POA method is that the POA indicator eliminates the ability to detect a second (perioperative) stroke in those patients who have a stroke complication code labeled POA. Under the assumption that this stroke represents a symptomatic patient, all perioperative events in this exceptionally high-risk group of patients would be missed. This also translates to a reduced apparent perioperative stroke rate for the method POA even in comparison to methods A and B, of which method A is known to underestimate perioperative strokes.[3-5,14]

Table III. Frequencies of diagnosis and complication codes used in the State Inpatient Databases of California, New York, and New Jersey in 3688 patients undergoing carotid endarterectomy (CEA) and the impact of the present on admission (*POA*) indicator on preoperative conditions and perioperative outcome

	Rates identified without POA indicator		*Proportion POA*[a]		*Revised rates with POA indicator*	
	%	*No.*	*%*	*No.*	*POA rate,*[b] *%*	*Non-POA rate,*[c] *%*
Major neurologic or acute cardiac diagnoses that may represent either pre-existing conditions or complications after intervention						
Stroke						
Diagnosis code	15.6	574	91.3	524	14.2	1.4
Complication code	2.4	87	62.1	54	1.5	0.9
Transient ischemic attack	3.4	125	93.6	117	3.2	0.2
Amaurosis fugax	3.4	126	95.2	120	3.3	0.2
Cardiac complication	3.4	125	61.6	77	2.1	1.3
Acute myocardial infarction	2.8	103	73.8	76	2.1	0.7
Conditions that are infrequently encountered after intervention						
Peripheral vascular complication	0.3	12	58.3	≤10	0.2	0.1
Respiratory complication	0.4	15	40.0	≤10	0.2	0.2
Pneumonia	1.8	67	58.2	39	1.1	0.8
Acute renal failure	2.9	108	56.5	61	1.7	1.3
Conditions that are regularly pre-existing comorbidities						
Coronary artery disease	33.4	1230	96.3	1185	32.1	1.2
Angina	2.2	81	91.6	76	2.1	0.1
Congestive heart failure	15.6	575	93.9	540	14.6	0.9
Chronic obstructive pulmonary disease	23.1	853	96.2	821	22.3	0.9
Chronic kidney disease	12.0	441	97.3	429	11.6	0.3
Diabetes	47.9	1766	98.2	1735	47.0	0.8

[a]Of the rates that were identified without the use of the POA indicator.
[b]Condition flagged POA.
[c]Condition not flagged POA.

Table IV. Symptom status of patients undergoing carotid endarterectomy (*CEA*) or carotid angioplasty and stenting (*CAS*) using different methodologies (A, present on admission [*POA*], and B)

	Method A		*Method POA*		*Method B*	
	No.	*%*	*No.*	*%*	*No.*	*%*
CEA						
Symptomatic	3436	15.9	3324	15.4	1540	7.1
Asymptomatic	18,203	84.1	18,315	84.6	20,099	92.9
CAS						
Symptomatic	801	21.7	776	21.0	243	4.6
Asymptomatic	2887	78.3	2912	79.0	3445	95.4

The low stroke rate in combination with an unexpectedly high proportion of asymptomatic patients in the Nationwide Inpatient Sample (NIS) was recently criticized.[1,2] The reported periprocedural stroke rate in these studies was lower than in major randomized controlled trials (RCTs) such as the Carotid Revascularization Endarterectomy vs Stenting Trial (CREST).[16] This is unexpected because these RCTs were executed in ideal circumstances with highly selected patients, surgeons, and interventionalists. Using administrative data, mortality rate following CEA was higher in nontrial hospitals compared with death rates in a trial setting.[17] We found that the ratio of stroke to death after CEA and CAS in SID was one-half that or less compared with the combined stroke-to-death ratios of three major RCTs among symptomatic patients (CEA 1.9:1 in SID vs 3.8:1 in RCTs; CAS 0.6:1 in SID vs 4.3:1 in RCTs).[18] However, the NIS and SID capture only in-hospital outcome while the RCTs were based on 30-day outcome. A recent report from our group found that over 30% of strokes happen after discharge but within 30 days of surgery.[19] These findings indicate that the nonfatal outcome of stroke is under-reported in administrative databases particularly in comparison to mortality, which is a more readily definable endpoint.

Similarly, symptom status is unreliable in administrative data.[3,20] Using the POA method, we calculated that 15% of CEAs and 21% of CAS procedures were performed in symptomatic patients. In other large vascular registries such as the Vascular Study Group of New England, one-third of patients were reported as being symptomatic.[21] The Society for Vascular Surgery vascular registry reported even higher rates between 40% and 50%.[12,16] The low rates found with the POA methodology thus do not ameliorate concerns regarding the use of administrative data to assign symptom status to patients undergoing carotid revascularization. Although it is highly unlikely that the NIS data represents the true proportion of symptomatic patients undergoing carotid revascularization in the United States, certain societal guidelines still draw heavily on data derived from these administrative studies.[22] Though the inclusion of administrative data to determine societal guidelines is well intentioned, it may be relying on inaccurate data.[23]

Table V. Stroke and death rate in patients undergoing carotid endarterectomy (*CEA*) or carotid angioplasty and stenting (*CAS*) using different methodologies (A, present on admission [*POA*], and B)

	Method A			*Method POA*			*Method B*		
	Stroke, %	*Death, %*	*Stroke:death*	*Stroke, %*	*Death, %*	*Stroke:death*	*Stroke, %*	*Death, %*	*Stroke:death*
CEA									
All patients	1.4	0.5	2.8:1	1.1	0.5	2.2:1	9.5	0.5	19:1
Symptomatic	5.9	1.4	4.2:1	2.5	1.3	1.9:1	4.8	0.5	9.6:1
Asymptomatic	0.5	0.4	1.3:1	0.9	0.4	2.3:1	9.9	0.5	19.8:1
CAS									
All patients	2.4	1.5	1.6:1	1.8	1.5	1.2:1	16.4	1.5	9.4:1
Symptomatic	7.5	5.6	1.3:1	3.4	5.3	0.6:1	7.4	0.8	10.5:1
Asymptomatic	0.9	0.4	2.3:1	1.4	0.5	2.8:1	17.0	1.6	9.5:1

We hope that future studies and the improvement of administrative data accuracy may confirm the generalizability of RCTs to a broad spectrum of healthcare centers.

In our opinion, the only way to improve the reliability of administrative data for carotid interventions is to use diagnosis codes strictly for pre-existing conditions and complication codes strictly for postoperative outcome. In the ICD, Tenth Revision coding system (goal implementation by October 2014), the current ICD-9 "complication" code for stroke will be converted to a new code that will further define whether a complication of stroke occurred intraoperatively or postoperatively, with the addition of stroke laterality. Under this system, if the diagnosis codes for stroke were used for preoperative symptoms, the POA indicator would not be needed for carotid interventions. This methodology will also take away the possibility of miscoding an intraoperative event as a preoperative condition. Until the ICD, Tenth Revision is implemented, the NIS and SID are inappropriate for analysis of stroke risk outcomes. However, the POA indicator is still of general interest for hospital and/or surgeon quality improvement programs and for pay-for-performance initiatives, as this assists in appropriately categorizing reimbursement diagnosis-related groups and calculating hospital reimbursements.

This study must be interpreted in the context of its design, including the inherent limitations of administrative data as discussed in this manuscript. The POA indicator is subject to coding error with improved accuracy for chronic conditions as compared to acute conditions.[24] Although no evidence was found of systematic undercoding of POA, we limited our analyses to those patients with at least one diagnosis listed as POA to minimize coding errors on POA information. Finally, administrative data do not capture anatomic risk factors such as severity of carotid stenosis nor do they provide detailed information regarding preoperative symptoms such as laterality, frequency, or severity. However, it is unlikely that these limitations of administrative data had a significant effect on our overall findings.

In conclusion, we found that the vast majority of diagnosis codes and nearly one-half of complication codes for stroke were coded POA. Whether with the POA indicator or previously described methods for assignment of symptom status or perioperative strokes, administrative data appear to significantly underestimate the proportion of symptomatic patients undergoing carotid revascularization and the proportion of patients suffering perioperative strokes in comparison to RCTs and other clinical registries of vascular surgery. This demonstrates a persistent concern about the validity of administrative data in defining symptom status and perioperative outcome after CEA and CAS. The primary benefit of this analysis is that it provides further evidence that administrative data have limited usefulness for nonfatal outcome analysis after CEA and CAS.

AUTHOR CONTRIBUTIONS

Conception and design: MF, RH, RB, ML
Analysis and interpretation: MF, RH, TC, RB, ML
Data collection: MF, RH, RB
Writing the article: MF, TC
Critical revision of the article: MF, RH, TC, RB, AH, MW, FM, ML
Final approval of the article: MF, RH, TC, RB, AH, MW, FM, ML
Statistical analysis: MF, RH, TC
Obtained funding: MS
Overall responsibility: MS

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Supplementary Table I (online only). International Classification of Diseases, Ninth Revision (*ICD-9*) codes used throughout the manuscript to evaluate comorbidities with and without present on admission (POA) information

Symptom	*ICD-9 code*
Angina	4111
Acute myocardial infarction	410, 41000, 41001, 41010, 41011, 41020, 41021, 41030, 41031, 41040, 41041, 41050, 41051, 41060, 41061, 41070, 41071, 41080, 41081, 41090, 41091
Coronary artery disease	4110, 4111, 4118, 41181, 4119, 4130, 4131, 4139, V4581, V4582
Congestive heart failure	4280, 4281, 42820, 42821, 42822, 42823, 42830, 42831, 42832, 42833, 42840, 42841, 42842, 42843, 4289, 40201, 40211, 40291, 40401, 40403, 40411, 40413, 40491, 40493
COPD	490, 4910, 4911, 49120, 49121, 49122, 4918, 4919, 4920, 4928, 4930, 4931, 49320, 49321, 49322, 4940, 4941, 4950, 4951, 4952, 4953, 4954, 4955, 4956, 4957, 4958, 4959, 496
Pneumonia	4801, 4803, 4808, 4809, 481, 4820, 4821, 4822, 48230, 48231, 48232, 48239, 48240, 48241, 48242, 48249, 4828, 48281, 48282, 48283, 48284,48289, 4829, 4830, 4831, 4838, 484, 4841, 4843, 4845, 4846, 4847, 4848,485,486, 4870, 4871,4878,488
Chronic kidney disease	5853, 5854, 5855, 5856, 5859, 586, V420, V451, V4511, V4512,V560,V561, V562, V563m V5631, V5632
Acute renal failure	584, 5845, 5846, 5847, 5848, 5849
Diabetes	25000, 25001, 25002, 25010, 25011, 25012, 25013, 25020, 25021, 25022, 25023, 25030, 25031, 25032, 25033, 25040, 25041, 25042, 25043, 25050, 25051, 25052, 25053, 25060, 25061, 25062, 25063, 25070, 25071, 25072, 25073, 25080, 25081, 25082, 25083, 25090, 25091, 25092, 25093

COPD, Chronic obstructive pulmonary disease.

Supplementary Table II (online only). International Classification of Diseases, Ninth Revision (*ICD-9*) codes used throughout the manuscript to evaluate symptom status and perioperative complications with and without present on admission (POA) information

Symptom	*ICD-9 code*	*Description*
Stroke	99702[a]	Iatrogenic cerebrovascular infarction or hemorrhage
	43301	Occlusion and stenosis of basilar artery with cerebral infarction
	43311	Occlusion and stenosis of carotid artery with cerebral infarction
	43321	Occlusion and stenosis of vertebral artery with cerebral infarction
	43331	Occlusion and stenosis of multiple and bilateral precerebral arteries with cerebral infarction
	43381	Occlusion and stenosis of other specified precerebral artery with cerebral infarction
	43391	Occlusion and stenosis of unspecified precerebral artery with cerebral infarction
	43401	Cerebral thrombosis with infarction
	43411	Cerebral embolism with infarction
	43491	Cerebral artery occlusion, unspecified with infarction
	431	Intracerebral hemorrhage
	3429	Hemiplegia, unspecified, affecting unspecified side
	36231	Central retinal artery occlusion
	36232	Retinal arterial branch occlusion
	4371	Other generalized ischemic cerebrovascular disease
Transient ischemic attack	4350	Basilar artery syndrome
	4351	Vertebral artery syndrome
	4352	Subclavian steal syndrome
	4353	Vertebrobasilar artery syndrome
	4358	Other specified transient cerebral ischemias
	4359	Unspecified transient cerebral ischemia
	7814	Transient paralysis of limb
Amaurosis fugax	36234	Transient retinal arterial occlusion
	36812	Transient visual loss
	36284	Retinal ischemia

[a]The "complication code" for stroke.