ORIGINAL RESEARCH

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Validation of Carotid Artery Revascularization Coding in Ontario Health Administrative Databases

Abstract

Purpose: The positive predictive value (PPV) of carotid endarterectomy (CEA) and carotid artery stenting (CAS) procedure and post-operative complication coding were assessed in Ontario health administrative databases.

Methods: Between 1 April 2002 and 31 March 2014, a random sample of 428 patients were identified using Canadian Classification of Health Intervention (CCI) procedure codes and Ontario Health Insurance Plan (OHIP) billing codes from administrative data. A blinded chart review was conducted at two high-volume vascular centers to assess the level of agreement between the administrative records and the corresponding patients' hospital charts. PPV was calculated with 95% confidence intervals (CIs) to estimate the validity of CEA and CAS coding, utilizing hospital charts as the gold standard. Sensitivity of CEA and CAS coding were also assessed by linking two independent databases of 540 CEA-treated patients (Ontario Stroke Registry) and 140 CAS-treated patients (single-center CAS database) to administrative records.

Results: PPV for CEA ranged from 99% to 100% and sensitivity ranged from 81.5% to 89.6% using CCI and OHIP codes. A CCI code with a PPV of 87% (95% CI, 78.8-92.9) and sensitivity of 92.9% (95% CI, 87.4-96.1) in identifying CAS was also identified. PPV for post-admission complication diagnosis coding was 71.4% (95% CI, 53.7-85.4) for stroke/transient ischemic attack, and 82.4% (95% CI, 56.6-96.2) for myocardial infarction.

Conclusions: Our analysis demonstrated that the codes used in administrative databases accurately identify CEA and CAS-treated patients. Researchers can confidently use administrative data to conduct population-based studies of CEA and CAS.

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Ontario health administrative databases have been successfully used in the conduct of several population-based research studies [1–4]; however, reabstraction studies have showed that diagnostic and procedure codes in these databases can vary in completeness and accuracy [5]. Prior to utilizing these codes for large epidemiological studies, validation is often necessary to ensure accuracy of the collected data [6–9].

Carotid endarterectomy (CEA) and carotid artery stenting (CAS) are two revascularization procedures commonly used to treat patients with carotid artery stenosis [10]. Several epidemiological studies in the United States have researched the trends and outcomes of carotid revascularization using health administrative data [11–14]; however, the accuracy of the specific codes used to identify CEA and CAS-treated patients in these studies has been called into question [15].

CEA and CAS procedure coding in Ontario healthcare administrative data has not been validated, and the accuracy of these codes is unknown. The primary objective of our study was to determine the positive predictive value (PPV) of CEA and CAS coding in Ontario administrative databases. As a secondary objective, we sought to assess the PPV of coding for major post-admission complications of carotid revascularization.

Methods

Study Design

A retrospective validation study using linked health administrative databases was conducted in the province of Ontario, Canada over a 12-year period – from 1 April 2002 to 31 March 2014. Since April 2002, the diagnostic codes in Ontario administrative databases have been based on the enhanced Canadian version of the 10th revision of the *International Statistical Classification of Diseases and Related Health Problems* (ICD-10-CA), and treatment codes are based on the Canadian Classification of Health Interventions (CCI). The study period began in April 2002 to coincide with the implementation of ICD-10-CA and CCI coding.

The following databases were used to conduct this study: the Canadian Institute for Health Information Discharge Abstract Database (CIHI-DAD), which is a national database containing clinical and patient demographic data for all hospital discharges from acute inpatient hospitals; the Ontario Health Insurance Plan (OHIP) database, which records all claims submitted by healthcare providers and paid by the Ontario Ministry of Health and Long-Term Care

(MOHLTC) for insured services provided to the residents of Ontario; and, the Registered Persons Database, which is a registry managed by MOHLTC that contains demographic and vital statistics data of all people in Ontario who are, or were, entitled to publicly-funded healthcare services covered under OHIP. Each database mentioned above was linked using an encrypted identifier unique to each patient. Residents of Ontario have access to universal healthcare services funded by the MOHLTC, which allows for all patient interactions with healthcare to be captured using these linked administrative databases.

Two distinct methodologies were used to conduct this multi-center validation study: 1) chart abstraction method; and, 2) database linking method.

Chart Abstraction Method

A list of carotid surgery and stenting-related CCI and OHIP codes was first compiled through literature search (16), discussions with clinicians who routinely perform CEA and CAS in Ontario, and manual search of the CCI and OHIP code books. All CCI procedure codes that potentially coded CEA (1JE57Lx –extraction, carotid artery open approach; 1JE57Vx –extraction, carotid artery using open approach with placement/implant of stent) and CAS (1JE57Gx –extraction, carotid artery percutaneous transluminal approach; 1JE50x –dilation, carotid artery using percutaneous transluminal approach) as well as OHIP fee codes for CEA (N220 [1992 to 2009]; R792 [2009 to current]) were selected. No OHIP fee codes were selected for CAS as we found there was a wide range of fee code combinations used by Ontario clinicians for this relatively new procedure, rendering validation impractical.

Between 1 April 2002 and 31 March 2014, a random sample of 428 patients that underwent CEA or CAS at one of two high volume vascular centers in Toronto, Ontario (St. Michael's Hospital [SMH] and Sunnybrook Health Sciences Centre [SHSC]) were identified using the aforementioned CCI and OHIP codes from CIHI-DAD and OHIP database independently of each other. A pre-defined maximum sample size of 100 records was set for each procedure/fee code for convenience, balancing sample size considerations *versus* resources required for chart abstraction. If the number of administrative records available for a code was fewer than 100, all records were selected for abstraction; for example, only 28 records were identified using the CCI code 1JE57Gx and, thus, all of these records were selected for abstraction. If the number of administrative records available for a code exceeded our maximum threshold of 100, 100 records were randomly selected for abstraction using PROC SURVEYSELECT

(METHOD=SRS) in SAS, version 9.4 (SAS Institute, Cary, North Carolina). In addition, we also determined if these patients had a Type 2 (post-admission) diagnosis of acute myocardial infarction (MI) (ICD-10-CA: I21 or I22) or ischemic stroke/transient ischemic attack (TIA) (ICD-10-CA: I63, I64, G45 or H34.1) to assess for the coding accuracy of these major procedural complications post-carotid revascularization. Patients with multiple carotid revascularization procedures recorded during the same hospital admission were excluded.

An independent, blinded retrospective chart review was then conducted at SMH and SHSC to assess the level of agreement for CEA and CAS procedure and complication coding between the administrative data records and the corresponding patients' hospital charts. Hospital charts were identified using the following variables captured in administrative data: hospital; patient chart number; and, admission date. A clinically-trained reviewer (M.A.H.) blinded to the coding in administrative data reviewed discharge summaries, operative notes and radiological reports to determine the carotid revascularization procedures and complications recorded in hospital charts. This was then used as the gold standard to calculate the PPVs of procedure and complication codes.

Database Linkage Method

To determine the sensitivity of carotid revascularization procedure coding, two additional databases were accessed: the Ontario Stroke Registry; and, the SMH CAS database. The Ontario Stroke Registry (formerly known as the Registry of the Canadian Stroke Network) contains data on all patients seen in the emergency department or admitted to the 11 Ontario regional stroke centers with a stroke or TIA from 1 July 2003 onward [17,18]. Data on patient demographics, comorbidities, stroke characteristics, investigations, treatments (including CEA) and complications is collected by trained neurology research nurses and entered into the registry. Furthermore, data validation is performed on an annual basis with duplicate chart abstraction to ensure accuracy of the data entered into the registry [18]. All patients treated with CEA in the Ontario Stroke Registry between 1 July 2003 and 31 March 2013 were identified, and their records linked with administrative databases (CIHI-DAD and OHIP database) to determine the sensitivity of CEA coding, utilizing the Ontario Stroke Registry as the gold standard. Linking was done on the basis of procedure date and an encrypted identifier that is unique to each patient, and common to administrative databases and the Ontario Stroke Registry.

To calculate the sensitivity of CAS coding, a single-center database of consecutive CAS-treated patients at SMH between 7 December 2010 and 31 March 2014 was accessed and linked to the administrative databases. Records were linked deterministically on the basis of patient date of birth, gender, OHIP number and date of CAS procedure. Patients that underwent only diagnostic carotid angiography, had failed/aborted CAS, or had multiple neurointerventional procedures on the same admission were excluded.

Statistical Analysis

The PPV and sensitivity (where possible) with 95% confidence intervals (CIs) of carotid revascularization procedure and complication coding were calculated. PPV was defined as the proportion of CEA and CAS procedure and complication codes that matched the corresponding documentation in patient charts. Sensitivity was defined as the proportion of positive CEA or CAS records identified in CIHI-DAD or OHIP database using the database linkage method. All statistical analyses were conducted using SAS, version 9.4 (SAS Institute, Cary, North Carolina, USA).

We obtained ethical approval by the institutional review boards of SMH and SHSC prior to executing our study protocol.

Results

A total of 428 records (219 from SMH and 209 from SHSC) were identified for validation through chart abstraction. Maximum numbers of records ($n = 100$) were identified for each of the following CCI procedure and OHIP fee codes: 1JE50x; 1JE57Lx; N220; and, R792. Only 28 records were identified using the CAS code 1JE57Gx, while no records were identified using the CEA code 1JE57Vx. Overall, all 428 administrative database records were matched with hospital charts at SMH and SHSC for procedure and complication coding validation (Figure 1). Using chart review as the gold standard, the PPV of CCI and OHIP coding for CEA ranged from 99% to 100% (Table 1). With respect to CAS coding, the PPV of the CCI code 1JE50x was 87% (95% CI, 78.8-92.9), whereas the PPV of 1JE57Gx was only 7.1% (95% CI, 0.9-23.5) (Table 1). The PPV of Type 2 diagnosis coding was 71.4% for ischemic stroke/TIA, 82.4% for acute MI and 98.3% for neither (Table 2).

With respect to the database linking method, the Ontario Stroke Registry consisted of 540 unique CEA records that were linked to administrative data. The sensitive of CEA coding was 89.6% (95% CI, 86.7-92.1) in CIHI-DAD for CCI

FIGURE 1. Flow diagram of records in chart abstraction method (left) and dataset linkage method (right).

Figure Legend. *Reasons for exclusion: diagnostic procedure, failed/aborted CAS and multiple procedures in same admission. CEA = carotid endarterectomy; CAS = carotid artery stenting; HSC = Health Sciences Centre; CCI = Canadian Classification of Health Interventions; OHIP = Ontario Health Insurance Plan.

TABLE 1. Positive predictive values of carotid revascularization codes using chart abstraction method

Procedure/Fee Code	n	PPV	
		%	95% CI
Carotid endarterectomy			
1JE57Lx (CCI)	100	99.0	94.6—100
N220 (OHIP)	100	99.0	94.6—100
R792 (OHIP)	100	100	96.4—100
Carotid artery stenting			
1JE50x (CCI)	100	87.0	78.8—92.9
1JE57Gx (CCI)	28	7.1	0.9—23.5

PPV = positive predictive value; CI = confidence interval; CCI = Canadian Classification of Health Interventions; OHIP = Ontario Health Insurance Plan.

TABLE 2. Positive predictive value of Type 2 (post-admission) complication coding using chart abstraction method

Complication*	n	PPV	
		%	95% CI
Acute myocardial infarction	17	82.4	56.6—96.2
Ischemic stroke or TIA†	35	71.4	53.7—85.4
Neither	350	98.3	96.3—99.4

PPV = positive predictive value; CI = confidence interval; TIA = transient ischemic attack.

*Patients that had both acute myocardial infarction and ischemic stroke/TIA complications on the same admission (n = 3) were excluded from the analysis because the sample size did not meet a pre-defined minimum cut-off (n ≥ 5) for reporting. Complications were not examined in patients who did not undergo either carotid surgery or stenting as determined by chart review (n = 23).

†None of the records were coded as ICD-10-CA: I63.6 (cerebral infarction due to cerebral venous thrombosis, nonpyogenic) or G45.4 (transient global amnesia).

code 1JE57Lx, and 81.5% (95% CI, 77.9-84.7) in the OHIP database for fee codes N220 and R792. The SMH CAS database consisted of a total of 154 CAS records, of which 140 were selected for linkage with administrative data after applying exclusions (Figure 1). The sensitivity of CAS coding was 92.9% (95% CI, 87.4-96.1) for CCI code 1JE50x and 0.7% (95% CI, 0.1-3.9) for CCI code 1JE57Gx.

Discussions

Validation of coding in health administrative databases has been identified as high priority for health services and population health research by an international consortium [19]. To that end, we conducted a multi-center validation study using chart abstraction and database linkage methods to assess the accuracy of carotid revascularization procedure and complication coding in Ontario administrative data.

Our findings show 99% to 100% PPV with 81.5% to 89.6% sensitivity of CEA coding in CIHI-DAD and OHIP databases, and 87% PPV with 92.9% sensitivity for CAS coding in CIHI-DAD. These results are comparable to the coding accuracy of common cardiac procedures, such as percutaneous coronary intervention, coronary artery bypass surgery, valve surgery and cardiac catheterization, in Ontario administrative databases (PPV range, 94% to 96%) (5). We also identified CCI codes that performed poorly in identifying

CAS (1JE57Gx) and CEA (1JE57Vx). These codes should not be used in algorithms to identify CAS and CEA when conducting population-based health research on carotid revascularization.

In addition, our findings suggest that post-procedure complications of CAS and CEA are coded with reasonable accuracy as Type 2 diagnoses in CIHI-DAD: ischemic stroke/TIA (PPV, 71.4%); and, acute MI (PPV, 82.4%). This observation is consistent with data from a previous reabstraction study, which reported 76.7% coding accuracy for a Type 2 ischemic stroke diagnosis and 90% coding accuracy for a Type 2 acute MI diagnosis in CIHI-DAD [5]; however, unlike our study, this study did not focus on complications of CEA and CAS-treated patients. A summary of the most accurate procedural and post-admission complication codes for carotid revascularization based on our analysis is presented in Table 3.

Strengths and Limitations

This study was conducted across two vascular centers in Toronto, Ontario, which may limit the generalizability of our results. Furthermore, the CAS database used for linkage with administrative data to calculate CAS coding sensitivity only captured procedures at a single center, which may further limit broad applicability of our results. A larger validation study across a variety of hospitals in Ontario is needed to confirm that the results of our study are generalizable. In addition, a paucity of validation studies in other settings precludes comparison of our results to other studies; however, this highlights the novelty of our study, and the need for other researchers to conduct similar studies to validate carotid revascularization coding in their administrative databases.

Conclusion

Our study demonstrates that patients treated with carotid surgery and stenting can be identified from Ontario health administrative databases with high accuracy. Major post-admission complications of carotid revascularization can also be identified with good accuracy. Researchers can confidently use these codes to conduct population-based studies in Ontario.

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TABLE 3. Recommended Ontario administrative data procedure and Type 2 (post-admission) complication diagnosis codes for carotid revascularization studies

	Recommended Codes
Procedure	
Carotid endarterectomy	1JE57Lx (CCI) or N220 and R792 (OHIP)
Carotid artery stenting	1JE50x (CCI)
Type 2 (post-admission) complication diagnosis	
Acute myocardial infarction	I21 and I22 (ICD-10-CA)
Ischemic stroke/TIA	I63, I64, G45 and H34.1 (ICD-10-CA) (excluding I63.6 and G45.4)

CCI = Canadian Classification of Health Interventions; OHIP = Ontario Health Insurance Plan; ICD-10-CA = Canadian version of the 10th revision of the International Statistical Classification of Diseases and Related Health Problems; TIA = transient ischemic attack.

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