

SUPPLEMENTAL MATERIAL

Misdiagnosis of Cervicocephalic Artery Dissection in the Emergency Department

Ava L. Liberman, MD; Babak B. Navi, MD MS; Charles C. Esenwa, MD MS; Cenai Zhang, MS; Justin Song, BS; Natalie Cheng, MD; Daniel L. Labovitz, MD; Hooman Kamel, MD; Alexander E. Merkler, MD

Table of Contents

Supplemental Methods	Page 1
Supplemental Tables	Page 2, 3
Supplemental References	Page 4

Supplemental Methods

Design

We used publicly available, statewide administrative claims data provide to the Agency for Healthcare Research and Quality for its Healthcare Cost and Utilization Project (HCUP) by the Florida Agency for Health Care Administration and the New York Statewide Planning and Research Cooperative System.¹ We included available data from all ED visits and hospitalizations to nonfederal medical centers in Florida from 2005-2015 and New York from 2006-2015. Each patient included in the HCUP database is assigned a personal linkage number that allows for anonymous tracking through ED and hospital encounters.²

Subjects

To identify our study cohort, we identified hospitalized patients with *ICD-9-CM* codes 443.21 or 443.24 in any diagnosis code position. These *ICD-9-CM* codes for dissection have been shown to have a positive predictive value of 82.1% compared to detailed medical review.³ Patients with any history of cerebrovascular disease prior to index hospitalization, broadly defined using *ICD-9-CM* codes 430-438, were excluded from our study cohort to improve both our measurement of probable misdiagnosis and our ability to identify adverse clinical outcomes at index hospitalization.

Measurements

We used the Symptom-Disease Pair Analysis of Diagnostic Error (SPADE) look-back method to measure probable ED misdiagnosis at index presentation in our cohort of dissection patients.⁴ We included ED treat-and-release visits for headache, facial pain, neck pain, and cranial nerve abnormalities as well as for typical and atypical symptoms of transient ischemic attack and minor stroke⁵⁻⁷ We chose to look at the 14 day window prior to hospitalization for dissection based on a recent crossover-cohort study which found that the highest-risk period for incident ischemic stroke among patients with cervicocephalic artery dissection was in the first two weeks after diagnosis.⁸

In addition to evaluating whether demographics and concomitant head or neck trauma was associated with probable ED misdiagnosis, we included the following stroke risk factors identified through their *ICD-9-CM* codes: atrial fibrillation, congestive heart failure, hypertension, diabetes, peripheral vascular disease, coronary artery disease, chronic obstructive pulmonary disease, tobacco use, and alcohol abuse.⁹

In accordance with a validated algorithm, ischemic stroke was defined as *ICD-9-CM* codes 433.x1, 434.x1, or 436 in any hospital discharge diagnosis code position without a concurrent primary discharge code for rehabilitation (V57) or any codes for trauma (800-804 or 850-854), SAH (430) or ICH (431). ICH was defined as *ICD-9-CM* discharge code 431 without concomitant codes for rehabilitation, trauma, or SAH. Finally, SAH was defined as *ICD-9-CM* discharge code 430 without concomitant codes for rehabilitation or trauma.¹⁰

Supplemental Tables

Supplemental Table I.

Cervicocephalic Artery Dissection Symptoms and Signs as Defined by <i>International Classification of Diseases, Ninth Revision, Clinician Modification (ICD-9-CM) Codes</i>	
Symptom Description	Diagnosis Code (s)
Headache	307.81, 339.xx, 346.0-346.9, 627.2, 784.0x
Facial pain	350.1, 350.2, 351.8
Neck pain	723.1
Horner's syndrome	337.9
Disturbances of taste and smell	781.1
Dysphagia	787.2
Throat pain	784.1
Voice disturbance	784.40, 784.41, 784.49
Lower cranial nerve abnormalities	352.9, 781.94, 951.3-951.8
Objective and subjective visual disturbances	368.8, 368.10-368.16
Diplopia	368.2
Visual field defects	368.46, 368.47
Dysarthria	784.50
Dizziness	780.4
Tinnitus	388.30-388.32
Abnormal skin sensation	782.0
Weakness	728.87
Paralysis, unspecified	344.9
Aphasia	784.3

Supplemental Table II

Multivariable Logistic Regression Model Evaluating the Relationship Between Patient Characteristics and Probable Emergency Department Misdiagnosis of Cervicocephalic Artery Dissection

Demographics	OR (95% CI)	P value
Age	0.97 (0.96-0.98)	<0.001
Female Sex	1.78 (1.34-2.37)	<0.001
Black Race	0.86 (0.54-1.37)	0.53
Clinical Features		
Atrial Fibrillation	1.0 (0.43-2.38)	0.98
Congestive Heart Failure	0.55 (0.13-2.28)	0.41
Diabetes	0.24 (0.11-0.53)	<0.001
Hypertension	1.28 (0.94-1.75)	0.12
Peripheral vascular disease	0.05 (0.01-0.17)	<0.001
Coronary artery disease	0.44 (0.19-1.03)	0.06
Chronic obstructive pulmonary disease	0.65 (0.24-1.82)	0.42
Tobacco Use	1.14 (0.68-1.91)	0.62
Alcohol Abuse	0.71 (0.48-1.05)	0.09
Head and Neck Trauma	3.19 (0.94-10.85)	0.06

Supplemental References

1. Agency for Healthcare Research Quality. Healthcare cost and utilization project. Available at: <http://http://hcupnet.ahrq.gov>. Accessed May 6, 2016.
2. Barrett M SC, Andrews R, Kassed C, Nagamine M. Methodological issues when studying readmissions and revisits using hospital administrative data. *HCUP Methods Series Report #2011-01*. 2011;2016
3. Qureshi AI, Chaudhry SA, Hassan AE, Zacharatos H, Rodriguez GJ, Suri MF, et al. Thrombolytic treatment of patients with acute ischemic stroke related to underlying arterial dissection in the united states. *Arch Neurol*. 2011;68:1536-1542
4. Liberman AL, Newman-Toker DE. Symptom-disease pair analysis of diagnostic error (spade): A conceptual framework and methodological approach for unearthing misdiagnosis-related harms using big data. *BMJ Qual Saf*. 2018;27:557-566
5. investigators Ct, Markus HS, Hayter E, Levi C, Feldman A, Venables G, et al. Antiplatelet treatment compared with anticoagulation treatment for cervical artery dissection (cadiss): A randomised trial. *Lancet Neurol*. 2015;14:361-367
6. Silbert PL, Mokri B, Schievink WI. Headache and neck pain in spontaneous internal carotid and vertebral artery dissections. *Neurology*. 1995;45:1517-1522
7. Biller J, Sacco RL, Albuquerque FC, Demaerschalk BM, Fayad P, Long PH, et al. Cervical arterial dissections and association with cervical manipulative therapy: A statement for healthcare professionals from the american heart association/american stroke association. *Stroke*. 2014;45:3155-3174
8. Morris NA, Merkler AE, Gialdini G, Kamel H. Timing of incident stroke risk after cervical artery dissection presenting without ischemia. *Stroke*. 2017;48:551-555
9. Boehme AK, Esenwa C, Elkind MS. Stroke risk factors, genetics, and prevention. *Circ Res*. 2017;120:472-495
10. Tirschwell DL, Longstreth WT, Jr. Validating administrative data in stroke research. *Stroke*. 2002;33:2465-2470