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Original Investigation

Common Reasons That Asymptomatic Patients Who Are 65 Years and Older Receive Carotid Imaging

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IMPORTANCE National guidelines do not agree on the role of carotid screening in asymptomatic patients (ie, patients who have not had a stroke or transient ischemic attack). Recently, several physician organizations participating in the Choosing Wisely campaign have identified carotid imaging in selected asymptomatic populations as being of low value. However, the majority of patients who are evaluated for carotid stenosis and subsequently revascularized are asymptomatic.

OBJECTIVE To better understand why asymptomatic patients who undergo revascularization receive initial carotid imaging.

DESIGN, SETTING, AND PARTICIPANTS Retrospective cohort study of 4127 Veterans Health Administration patients 65 years and older undergoing carotid revascularization for asymptomatic carotid stenosis between 2005 and 2009.

MAIN OUTCOMES AND MEASURES Indications for carotid ultrasounds were extracted using trained abstractors. Frequency of indications and appropriateness of initial carotid ultrasound imaging for patients within each rating category after the intervention were reported.

RESULTS The mean (SD) age of this cohort of 4127 patients was 73.6 (5.9) years; 4014 (98.8%) were male. Overall, there were 5226 indications for 4063 carotid ultrasounds. The most common indications listed were carotid bruit (1578 [30.2% of indications]) and follow-up for carotid disease (stenosis/history of carotid disease) in patients who had previously documented carotid stenosis (1087 [20.8% of indications]). Multiple vascular risk factors were the next most common indication listed. Rates of appropriate, uncertain, and inappropriate imaging were 5.4% (227 indications), 83.4% (3387 indications), and 11.3% (458 indications), respectively. Among the most common inappropriate indications were dizziness/vertigo and syncope. Among the 4063 patients, 3373 (83.0%) received a carotid endarterectomy. Overall, 663 procedures were performed in patients 80 years and older.

CONCLUSIONS AND RELEVANCE Carotid bruit and follow-up for carotid disease accounted for approximately half of all indications provided by physicians for carotid testing. Strong consideration should be given to improving the evidence base around carotid testing, especially around monitoring stenosis over long periods and evaluating carotid bruits. Targeting carotid ultrasound ordering with decision support tools may also be an important step in reducing use of low-value imaging.

Invited Commentary

Author Audio Interview at jamainternalmedicine.com

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Stroke is the fifth most common cause of death and is a major cause of disability among US adults.[1] Approximately 10% to 15% of ischemic strokes are attributable to atherosclerosis of the carotid arteries.[2] Secondary stroke prevention guidelines support the use of carotid imaging to evaluate patients with a recent cerebrovascular event to assess them for carotid plaque.[3] However, national guidelines conflict on the role of carotid screening in asymptomatic populations (patients without a history of stroke or transient ischemic attack [TIA]).[4] For example, the US Preventive Services Task Force (USPSTF) has recommended against carotid screening in adult patients without a history of stroke or TIA in both its 2007 and updated 2014 guidance.[5] Other national guidelines favor imaging for some limited indications in patients with asymptomatic carotid disease (eg, those with established stenosis, carotid bruit, or multiple vascular risk factors) although these recommendations are based on expert opinion rather than robust evidence.[4,6]

More recently, carotid imaging in asymptomatic populations has been identified by different physician specialty organizations as a low-value test and has appeared on several top 5 lists in the national "Choosing Wisely" campaign.[7] The American Academy of Family Physicians,[8] for example, has stated, "don't screen for carotid artery stenosis in asymptomatic adults." The American Academy of Neurology[9] has stated, "don't perform imaging of the carotid arteries for simple syncope without other neurologic symptoms," and the Society of Thoracic Surgeons[10] has stated, "don't initiate routine evaluation of carotid artery disease prior to cardiac surgery in the absence of symptoms or other high-risk criteria."

Once imaging occurs in an asymptomatic patient, revascularization can be offered to patients with carotid stenosis based on current guidelines for primary prevention of stroke.[3] Embedded in these recommendations is an understanding derived from randomized clinical trials that patients undergoing revascularization are expected to live for at least 5 years so that the short-term risks such as stroke, myocardial infarction, and death posed by the procedure are offset by the long-term benefits of stroke risk reduction.[3,11] Although the evidence in support of efficacy of carotid revascularization to reduce recurrent cerebrovascular events among patients with symptomatic carotid disease is strong, the majority of revascularization procedures are performed in patients with asymptomatic carotid artery disease, in whom the evidence for clinical benefit is more modest and long-term outcomes are of paramount importance.[3,12,13] Therefore, ensuring that patients selected for revascularization will live long enough to benefit is critical, and improving patient selection for carotid imaging will ultimately improve the selection of revascularization recipients.

The long-term health consequences of low-value imaging have not been commonly studied, and the risks and benefits of diagnostic imaging are not always clear to patients and clinicians.[14] To better understand why asymptomatic patients receive carotid artery imaging, we examined the indications provided by physicians for carotid ultrasounds in a national cohort of patients who received carotid intervention for asymptomatic stenosis in the Veterans Health Administration (VHA). Because guidelines recommend that patients who receive revascularization have a 5-year life expectancy, we also examined long-term survival of these patients after the intervention.

Key Points

Question Why do asymptomatic patients who undergo revascularization receive initial carotid imaging?

Findings In this study of 4127 patients 65 years and older who received carotid revascularization, the most common indications provided by physicians for the initial carotid ultrasound were carotid bruit and follow-up for carotid disease.

Meaning Consideration should be given to improving the evidence base around carotid imaging.

Methods

Sample and Data Sources

This study was approved by the University of California, San Francisco, Committee on Human Research. Informed consent was waived because this was a retrospective cohort study with no human subject contact and minimal privacy risks. Using national VHA data, we identified (N = 4127) patients 65 years and older undergoing carotid endarterectomy (CEA) and carotid stenting (CAS) for asymptomatic carotid stenosis between 2005 and 2009. We defined asymptomatic patients as patients who did not have evidence of any type of stroke or TIA in the 6 months prior to receipt of first carotid imaging. To identify asymptomatic patients, we used a previously developed high-sensitivity algorithm based on *International Classification of Diseases, Ninth Revision,* codes to exclude patients with stroke (including retinal artery occlusion) and TIA using administrative data.[15] We then reviewed each patient's medical record and further excluded any patient with any history of stroke and TIA documented in the medical record. We examined the indication for the first carotid image each patient received in this period before revascularization. We intentionally looked for the first image in this period to reduce the number of nonspecific indications provided such as "follow-up." We limited the sample to carotid ultrasounds rather than all imaging because other imaging modalities (eg, computed tomographic angiogram or magnetic resonance angiogram) may also be ordered to evaluate other vascular disease and carotid findings may be incidental, whereas carotid ultrasound is used primarily to identify carotid stenosis. We used national Veterans Affairs (VA) Corporate Data Warehouse and VA Medical SAS administrative databases to obtain data on age, sex, comorbidities, and CEA or CAS procedures.[16] Medical record abstraction was used to confirm that CEA or CAS was performed after the first carotid image was obtained and to obtain additional data on comorbidities and indications listed by physicians for carotid imaging. Long-term survival of the cohort of patients who underwent CEA and CAS was extracted from the VA vital status file.[16]

Table 1. Current National Guideline Recommendations on Carotid Imaging in Patients Without a History of Stroke or Transient Ischemic Attack (TIA)

Guideline	USPSTF[5]	ASA/AHA[4]	AIUM[6]
Screening for asymptomatic carotid artery stenosis in asymptomatic adult (ie, someone without a history of TIA or stroke)	Not recommended	...	...
Routine screening of patients who have no clinical manifestations of or risk factors for atherosclerosis	Not recommended	No benefit	...
Asymptomatic carotid bruit	Not recommended	Recommendation in favor of procedure being useful based on diverging expert opinion, case studies, or standard of care	Indicated
Follow-up of established carotid stenosis >50%	...	Recommendation in favor of procedure being useful based on diverging expert opinion, case studies, or standard of care	...
May be considered in asymptomatic patients with symptomatic peripheral arterial disease, coronary artery disease, or atherosclerotic aortic aneurysm	...	Recommendation's usefulness/efficacy less well established based on diverging expert opinion, case studies, or standard of care	...
Might be considered to detect carotid stenosis in asymptomatic patients without clinical evidence of atherosclerosis who have 2 or more of the following risk factors: hypertension, hyperlipidemia, tobacco smoking, family history in a first-degree relative of atherosclerosis manifested before age 60 y, or a family history of ischemic stroke	...	Recommendation's usefulness/efficacy less well established based on diverging expert opinion, case studies, or standard of care	...
Not recommended for routine evaluation of patients with neurological or psychiatric disorders unrelated to focal cerebral ischemia, such as brain tumors, familial or degenerative cerebral or motor neuron disorders, infectious and inflammatory conditions affecting the brain, psychiatric disorders, or epilepsy	...	No benefit	...
Noninvasive imaging of the extracranial carotid arteries is reasonable 1 mo, 6 mo, and annually after revascularization to assess patency and exclude the development of new or contralateral lesions. Once stability has been established over an extended period, surveillance at longer intervals may be appropriate. Termination of surveillance is reasonable when the patient is no longer a candidate for intervention	...	Recommendation in favor of procedure being useful based on diverging expert opinion, case studies, or standard of care	Indicated
Carotid duplex ultrasound screening is reasonable before elective coronary artery bypass graft surgery in patients older than 65 y and in those with left main coronary stenosis, peripheral arterial disease, a history of cigarette smoking, a history of stroke or TIA, or carotid bruit	...	Recommendation in favor of procedure being useful based on diverging expert opinion, case studies, or standard of care	Indicated
Annual noninvasive imaging of the carotid arteries is reasonable initially for patients with fibromuscular dysplasia to detect changes in the extent or severity of disease, although the effect on outcomes is unclear	...	Recommendation in favor of procedure being useful based on diverging expert opinion, case studies, or standard of care	...

Abbreviations: AHA, American Heart Association; AIUM, American Institute of Ultrasound Medicine; ASA, American Stroke Association; ellipses, no recommendation; USPSTF, US Preventative Services Task Force.

Identification of Indication for Imaging

All indications for the initial carotid ultrasound were identified by 4 trained abstractors (A.W., A.A., R.A., S.S.). The abstractors were trained to review both the carotid report for indications listed by providers and the referring providers' note. Each carotid ultrasound could have multiple indications. If the abstractors could not identify an indication based on these 2 sources of information or were unsure of the indication, 1 of 3 clinicians (S.K. [internist], E.M.C. [neurologist], A.N. [ophthalmologist]) reviewed the medical record and assigned an indication. If no indication was identified, then it was classified as unknown and the patient was excluded from the sample. If the indication was deemed to be unrelated to the carotid artery (eg, evaluation of a neck mass), the image was excluded from the sample. The κ for agreement in indications from the medical record for 2 reviewers for 2 separate samples of 20 carotid images was very good and ranged from 0.71 to 0.88.

Expert Panel Review of Indications

Expert review of indication was necessary because guideline recommendations on screening in asymptomatic populations are limited and conflicting. **Table 1** lists all the indications for which at least 1 national guideline has issued recommendations. For example, some but not all guidelines recommend screening for patients with carotid bruits.[4] Given the limited guidance available, we convened a multidisciplinary panel of practicing clinicians and stroke researchers including 3 internists (S.K., E.A.H., D.M.B.), 2 vascular neurologists (E.M.C., L.S.W.), 1 vascular surgeon (J. J.), and 2 ophthalmologists (S.R., A.N.) to review and rate the indications through a consensus process. Prior to the first meeting, each panel member received a list of indications to be rated. Panel members were instructed to rate each indication as appropriate, uncertain, or inappropriate based on a balance of risk and benefit of imaging. The ratings were compiled and discussed among panel participants through 2 conference calls with 1 caveat: the ocular indications were discussed and rated separately by the ophthalmologists because many of the indications were based on eye examination findings not commonly encountered by other clinicians. Each indication was then discussed by the group and a final rating was assigned on the basis of consensus. The indication was rated as uncertain if all raters deemed it uncertain or if consensus on appropriateness was not reached. We considered panel members as having agreement on ratings if all panel members agreed and disagreement if 1 or more panel members disagreed. Overall, there

Table 2. Characteristics of Patients Who Received a Carotid Ultrasound Between 2005 and 2009

Characteristic	No. (%) (N = 4063)
Age, y	
65 to 74	2467 (60.7)
75 to 84	1472 (36.2)
≥85	124 (3.1)
Male sex	4014 (98.8)
Comorbidity	
Hypertension	3583 (88.2)
Hyperlipidemia	3167 (77.9)
Diabetes mellitus	1607 (39.6)
Atrial fibrillation	442 (10.9)
Coronary artery disease	2019 (49.7)
Peripheral vascular disease	1107 (27.2)
Congestive heart failure	288 (7.1)
Chronic obstructive pulmonary disease	798 (19.6)
Procedure[a]	
Carotid endarterectomy	3373 (83.0)
Carotid artery stenting	684 (16.8)

[a] Medical record review revealed that 6 patients did not receive subsequent intervention.

was unanimity on 86.0% of the indications and disagreement on 14.0% of the indications. Among the uncertain indications, 50.0% were uncertain based on consensus and 50.0% were rated uncertain because of disagreement among the panel members.

Analysis

First, we compared the indications abstracted from the medical record to currently available national guidelines to determine how well guidelines cover current practice. Second, we compared the indications abstracted from the medical records to the quality assessments made by the expert panel. For this analysis, the sample was restricted to the 4063 patients whose carotid ultrasound had at least 1 indication listed. If the ultrasound had multiple indications, the rating of the test was assigned on the basis of the most appropriate indication(s). We calculated percentages of carotid ultrasounds rated appropriate, uncertain, or inappropriate. Finally, we also compared 5-year overall survival in patients receiving carotid imaging and subsequent medical record–confirmed revascularization among the 3 appropriateness categories using a log-rank test. Analyses were conducted using SAS, version 9.4 (SAS Institute), and Stata, version 12.1.

Results

Patient Characteristics

A total of 4127 patients were in the cohort; 64 patients had no indications provided by clinicians, leaving a final sample of 4063 patients (**Table 2**). The mean (SD) age of this cohort was 73.6 (5.9) years; 4014 (98.8%) were male. Comorbidities were common and included hypertension (3583 [88.2%]), diabetes mellitus (1607 [39.6%]), and atrial fibrillation (442 [10.9%]). The majority of patients received CEA (3373 [83.0%]), while 684 (16.8%) received CAS, and 6 patients (0.1%) did not have a medical record–confirmed revascularization within 5 years after first carotid image.

Frequency and Type of Indications

Overall, there were 5226 indications for 4063 carotid ultrasounds in 4063 patients. Approximately 3062 (75.4%) carotid ultrasounds had a single indication while the remaining (n = 1001) had multiple indications. Fifty-seven unique indications were identified. Among these 57 indications, 32 (56%) were listed 10 or more times and 11 (19%) were listed only once. **Table 3** provides the entire list of indications grouped by clinical themes identified. Overall, there were 6 main clinical themes for ordering carotid images in asymptomatic populations that emerged: (1) vascular indications, (2) near-syncope/syncope indications, (3) neuropsychiatric indications, (4) ear-related indications, (5) ocular indications, and (6) imaging as part of a preoperative evaluation. There were also some isolated indications presented in the "other" category that were uncommon (<1% of all indications) and could not be clinically grouped. The most common indication listed was carotid bruit, which accounted for approximately one-third of all indications (1578 [30.2%] of 5226 indications). Follow-up for carotid disease (stenosis/history of carotid disease) in a patient who had previously documented carotid stenosis was the second most common indication (1087 [20.8%] of 5226 indications). Carotid bruit and follow-up for carotid disease accounted for half (2677 [51.2%] of 5226 indications) of all indications. Multiple vascular risk factors were the next most common indication listed. Overall, currently available national guidelines shown in Table 1 covered 3593 (68.7%) of the indications extracted from this national cohort. The most common areas not covered by guidelines included syncope, dizziness/vertigo, remote history of stroke or TIA, and preoperative evaluation.

Appropriateness of Carotid Imaging

Each indication was rated using the expert panel's assessment. The majority of images (3421 [84.2%]) had a single indication, while the remaining images had between 2 and 4 indications. A total of 398 (9.8%) images had multiple indications with different levels of appropriateness. We assigned each image the most appropriate quality assessment. Some carotid ultrasounds had multiple indications with the same quality assessments (eg, 2 indications that were both appropriate). Rates of appropriate, uncertain, and inappropriate imaging were 5.4% (227 indications), 83.4% (3387 indications), and 11.3% (458 indications), respectively (**Table 4**). Whereas most of the appropriate indications assigned to images were related to ocular disease (164 [72.2%] of 227), the most common appropriate indication listed was follow-up within 2 years of carotid intervention. Carotid bruit and follow-up for established carotid disease were the most prevalent uncertain indications. Among the inappropriate indications, dizziness/vertigo, syncope, and blurred/change in vision were the most common (Table 3).

Table 3. The 57 Unique Indications Grouped by Clinical Theme (N = 5226)

All Indications, No. (%)						
Vascular	Near-Syncope/ Syncope	Eye Related	Preoperative Evaluation	Neurological/ Psychological	Other	Ear Related
3881 (74.2)	568 (10.8)	351 (6.7)	239 (4.5)	117 (2.2)	50 (0.94)	21 (0.40)
Carotid bruit, n = 1578 Stenosis/history of carotid disease, n = 1099 Hypertension with another vascular risk factor, n = 505 History of stroke/TIA >6 mo, n = 199 Follow-up after CEA/CAS >2 y, n = 175 Old stroke/silent stroke found on neuroimaging, n = 95 Carotid calcification/finding on x-ray or other image, n = 80 Follow-up after CEA/CAS <2 y, n = 63 Suspected carotid disease, n = 44 Smoking history with another vascular risk factor, n = 35 Decreased carotid pulse, n = 5 No palpable carotid pulse, n = 2 Family history of cerebrovascular accident, n = 1	Dizziness/ vertigo, n = 388 Syncope, n = 147 Lighthead-edness, n = 22 Orthostatic hypotension, n = 11	Blurred vision/change in vision, n = 124 Multiple unilateral peripheral retinal hemorrhage, n = 36 Single unilateral peripheral retinal hemorrhage, n = 28 Hollenhorst plaque/eye plaque, n = 59 Ocular ischemic syndrome, n = 38 Asymmetrical intraocular pressure, n = 1 Asymmetrical retinopathy, n = 30 Branch retinal vein occlusion, n = 13 Optic nerve ischemia, n = 9 Diplopia, n = 5 Anterior ischemic optic neuropathy, n = 3 Sequential disk swelling, n = 1 Cotton wool spot, n = 1 Occasional dark spot in visual field, n = 1 Optic nerve changes, n = 1 Cystoid macular edema, n = 1	Other surgical procedures, n = 146 CABG, n = 93	Memory loss or dementia, n = 32 Fall (without focal weakness), n = 26 Tilting/change in gait (without focal weakness), n = 11 Balance problems (without focal weakness), n = 10 Seizure, n = 8 Tingling sensation of body part without other neurologic deficit, n = 7 Nonfocal peripheral neuropathy, n = 7 Tremor, n = 6 Mental status change, n = 5 Staggering (without focal weakness), n = 4 Tingling sensation with elevation of head, n = 1	Headache, n = 17 Generalized weakness, n = 16 Neck pain, n = 10 Chest pain, n = 2 Cardiac murmur radiating to neck, n = 2 Jaw pain, n = 2 Dyspnea, n = 1	Pulsation in ears, n = 14 Tinnitus, n = 5 Ringing above ear, n = 1 Ear tingling, n = 1

Abbreviations: CABG, coronary artery bypass graft; CAS, carotid stenting; CEA, carotid endarterectomy; TIA, transient ischemic attack.

Table 4. Expert Panel Rating and Frequency of Indications Per Ultrasound (4774 Indications for 4063 Images)

Patients, No. (%)		
Appropriate Indications[a] (n = 227)	Uncertain Indications[a] (n = 4028)	Inappropriate Indications[a] (n = 519)
218 (5.4)	3387 (83.4)	458 (11.3)
Follow-up after CEA/CAS <2 y, n = 63 Hollenhorst plaque, plaque in eye, n = 59 Ocular ischemic syndrome, n = 38 Multiple unilateral peripheral retinal hemorrhages, n = 36 Eye findings suggestive of ocular ischemic syndrome (eg, asymmetrical intraocular pressure), n = 1 Asymmetrical retinopathy, n = 30	Carotid bruit, n = 1572 Follow-up for stenosis/history carotid disease, n = 1073 Hypertension with 1 other vascular risk factor, n = 500 History of stroke/transient ischemic attack >6 mo, n = 194 Follow-up after CEA/CAS (>2 y), n = 172 Preoperative evaluation, n = 145 Old stroke/silent stroke found on neuroimaging, n = 93 CABG workup, n = 92 Carotid calcification or finding on x-ray or other image, n = 79 Suspected carotid disease/rule out carotid disease, n = 41 Smoking history with other risk factor, n = 35 Pulsation in ears, n = 14 Neck pain, n = 9 Decreased carotid pulse, n = 5 Cardiac murmur radiating to neck, n = 2 No palpable carotid pulse, n = 2	Dizziness/vertigo, n = 209 Syncope, n = 100 Blurred vision/change in vision, n = 70 Single peripheral retinal hemorrhage, n = 19 Memory loss or dementia, n = 13 Lightheadedness, n = 12 Fall without focal weakness, n = 9 Headache, n = 9 Optic nerve ischemia, n = 8 Branch retinal vein occlusion, n = 7 Generalized weakness, n = 7 Orthostatic hypotension, n = 7 Tilting/change in gait (without focal weakness), n = 7 Tingling of limb without focal weakness, n = 6 Balance problems without focal weakness, n = 5 Seizures, n = 5 Tremor, n = 4 Anterior ischemic optic neuropathy, n = 3 Diplopia, n = 3 Mental status change, n = 2 Nonfocal peripheral neuropathy, n = 2 Tinnitus, n = 2 Cotton wool spot, n = 1 Cystoid macular edema, n = 1 Dyspnea, n = 1 Family history of cerebrovascular accident, n = 1 Jaw pain, n = 1 Occasional dark spot in visual field, n = 1 Optic nerve changes, n = 1 Sequential disk swelling, n = 1 Staggering (without focal weakness), n = 1 Tingling with elevation of head, n = 1

Abbreviations: CABG, coronary artery bypass graft; CAS, carotid stenting; CEA, carotid endarterectomy.

[a] If an image had multiple indications, the indication that was most appropriate was listed in Table 3; therefore, there are fewer indications than were listed in Table 2. Patients could have multiple appropriate indications, multiple uncertain indications, and multiple inappropriate indications.

Long-term Survival

Among the 4063 patients in the final sample, 3373 (83.0%) received a CEA. Overall, 663 procedures were performed in patients 80 years and older. Postintervention overall survival in this cohort was 71.4% at 5 years. Rates of survival by age group 65 to 74, 75 to 84, and 85 years and older were 75.3% (1857 patients), 66.5% (979 patients), and 58.9% (73 patients), respectively ($P < .001$). Rates of survival among patients who received carotid imaging on the basis of appropriate, uncertain, and inappropriate indications were not significantly different ($P = .07$) and were 66.4%, 72.1%, and 68.8%, respectively.

Discussion

Most carotid imaging tests that resulted in patients with asymptomatic carotid disease undergoing revascularization were performed for indications in which the benefits of imaging are uncertain, and 1 in 9 tests were performed for inappropriate indications. We found that approximately one-third of indications listed by clinicians are not addressed by current national guidelines. We also found that many patients do not live long enough to benefit from revascularization.

There is a tension between appropriate screening and appropriate revascularization that necessitates further comment. It is possible that a patient would be screened on the basis of an indication that would appear clinically inappropriate for imaging but lead to an otherwise appropriate revascularization procedure if severe stenosis was identified. This clinical dilemma is the result of the chosen point of reference. From an individual perspective, it may be beneficial to have screening that is not guideline based if that screening demonstrates a true positive abnormality that is amenable to an effective evidence-based intervention. From a societal perspective, screening all patients (including a patient who benefited) may not be beneficial (and thus not recommended) if the false-positive rate of the screening test is high or the evidence for intervention is weak. This tension between the individual perspective (which often does not include consideration of the harms of false-positive test results) and the societal perspective is at the root of many of the current national debates on screening.

In the case of carotid disease, the tension between the individual and population perspective is further exacerbated by the fact that different societies have different recommendations based on how they define an "asymptomatic" individual.[4,5] A patient with vascular disease may have asymptomatic carotid disease (ie, no history of stroke or TIA), but by virtue of the presence of systemic atherosclerosis, the American Heart Association considers it reasonable to screen such patients, whereas the USPSTF does not.

Other areas in which national recommendations differ include further assessment of a carotid bruit. In our study, greater than half of all imaging was performed to evaluate for carotid bruit and monitor the progression of carotid stenosis, indications that our panel rated as of uncertain value because of a lack of evidence in the area. For example, a patient with a carotid bruit who is of advanced age and has multiple comorbidities may have little clinical benefit from imaging. Such a patient may not live long enough to benefit from intervention. Another area in which improved guidance is necessary relates to the duration of follow-up imaging for patients with established carotid stenosis. The USPSTF has an overall recommendation against any screening in asymptomatic carotid populations, whereas the guidelines issued by the American Heart Association in conjunction with other specialty societies recommend screening and follow-up for carotid disease in patients with carotid bruit and also patients with greater than 50% stenosis.[4] Revisiting the evidence base and clarifying, expanding, and harmonizing the guidelines for imaging in asymptomatic populations may be warranted to reduce potentially unnecessary testing.

The 2 most recent major randomized clinical trials of intervention in asymptomatic patients showed that given the procedural risks inherent in CEA and CAS procedures, patients must live 5 years to realize a net benefit from revascularization.[3,17,18] Roughly one-quarter of the patients in our cohort who received intervention did not survive 5 years. This was more than double the death rate observed in the most recent trial.[17,19] The fact that long-term survival was similar for patients who received imaging for indications deemed appropriate or uncertain vs inappropriate imaging deserves some comment. Revascularization once carotid stenosis is identified may occur without full consideration of a patient's life expectancy. Although patient reassurance, clinician uncertainty, and other reasons might underlie test ordering regardless of patient eligibility, these findings could suggest that guideline development and decision support for carotid imaging ordering in an asymptomatic patient should more fully address eligibility for intervention at the time of initial test ordering.

Our results also suggest that reducing inappropriate carotid imaging may stem a "pipeline" of low-value care because many patients who were subsequently revascularized received initial imaging for reasons considered inappropriate by our expert panel. Reducing low-value carotid imaging can also reduce low-value carotid intervention in patients who will not live long enough to benefit. Given that carotid imaging is a fairly commonly ordered test, targeting carotid imaging using decision support tools to reduce inappropriate use may be a good approach to improve the value of health care without compromising quality. Currently there is no guidance on ordering carotid ultrasound in the VHA or in most clinical settings. Our study demonstrates that developing such decision support is needed.

The sample chosen for this study has both strengths and limitations. On the one hand, this cohort focuses on asymptomatic patients who underwent revascularization and does not represent all patients who receive carotid imaging. The distribution of indications may be different in a population that did not receive intervention. On the other hand, our cohort is an important sample to examine because it provides an assessment of the primary reason for screening for carotid stenosis among patients who ultimately received intervention. The long-term consequence of this pipeline of low-value care is more apparent. Another important limitation to consider is the generalizability of the sample. The indications extracted were for carotid ultrasounds ordered by physicians practic-

ing in the VHA, a national setting with an electronic health record and electronic ordering system. Our results may not represent the scope of indications for which physicians order carotid imaging in different settings. However, most VHA hospitals have academic affiliations and many clinicians practice in multiple settings; therefore, it is likely that our results are representative of academic settings with electronic imaging ordering. Another limitation is that our cohort was almost entirely male; however, there is no reason to believe that indications listed by physicians for imaging would vary by sex. In addition, appropriateness assessment by the expert panel was by full consensus and any disagreement resulted in a quality assessment of "uncertain." Our conservative approach with a requirement of 100% agreement among panel members on indications resulted in more quality assessments being assigned an "uncertain" rating than an "inappropriate" rating. However, a slight shift in the quality assessments from uncertain to inappropriate would not materially affect our conclusions. Finally, the indications extracted were for the period of 2005 to 2009; it is possible that reasons for ordering carotid images have evolved. However, national guidelines currently still conflict.[4,5]

Conclusions

The majority of patients who undergo carotid revascularization for asymptomatic carotid disease received a diagnosis on the basis of results of tests ordered for uncertain or inappropriate reasons. Consideration should be given to improving the evidence base around carotid testing, especially around monitoring stenosis over long periods and evaluating carotid bruits. The ongoing National Institutes of Health–sponsored Carotid Revascularization and Medical Management for Asymptomatic Carotid Stenosis Trial (CREST-2) should clarify the value of revascularization in asymptomatic populations.[20] Finally, clarifying and harmonizing current guidelines and the development of evidence-based decision support tools to support appropriate patient selection for carotid imaging in practice can reduce the use of low-value imaging and improve long-term patient outcomes.

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Study concept and design: Keyhani, Williams, Hebert.
Acquisition, analysis, or interpretation of data: Keyhani, Cheng, Naseri, Halm, Johanning, Madden, Rofagha, Woodbridge, Abraham, Ahn, Saba, Eilkhani, Bravata.
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