Does detection of carotid plaque affect physician behavior or motivate patients?

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Background Imaging techniques to identify subclinical atherosclerosis are becoming more widespread, but few data exist regarding their influence on patient or physician behavior. We evaluated the impact of ultrasound screening to identify carotid artery plaques on physician treatment plans and patient motivation.

Methods Subjects included asymptomatic patients without known vascular disease who had 2 or more cardiac risk factors. Circumferential scanning of the right and left carotid arteries to identify carotid plaques was performed using a handheld ultrasound device in an office setting. The physician's initial treatment recommendations were assessed before and after the results of the carotid scan were reported. Subjects completed a survey to assess motivation to make lifestyle changes before and after the results of the scan were provided.

Results Fifty subjects were enrolled over 9 months. Their mean (SD) age was 54.0 (10.4) years and their mean Framingham 10-year cardiovascular risk was 7.8% (7.9%). More than half (58%) of the subjects had at least one carotid plaque. When carotid plaque was identified, physicians were more likely to prescribe aspirin (P = .031) and lipid-lowering therapy (P = .004). Although subjects with carotid plaque reported an increase in their perceived likelihood of developing heart disease (P = .013), they did not report increased motivation to make lifestyle changes.

Conclusions Ultrasound screening for carotid plaque in an office setting can alter physician treatment plans. Although the presence of plaque increased patient perception of cardiovascular risk, it did not motivate patients to make lifestyle changes. (Am Heart J 2007;154:1072-7.)

A simple, noninvasive, reliable, and inexpensive tool for screening individuals for cardiovascular (CV) disease before the development of symptoms could be very useful for primary care and specialty physicians to help target treatment strategies for individuals at the highest risk. Although multiple risk factor CV risk prediction models are used widely, their estimates are heavily dependent on age, they do not account for changes in a patient's health status over time, and they only provide a short-term (10-year) estimate of CV risk.[1] Also, treatment options are less clear for patients with multiple risk factors who are not at high CV risk. In these "intermediate-risk" patients, some have proposed the use of additional tests for further risk stratification.[2] The ankle-brachial pressure index is perhaps the simplest office-based tool; however, in 2 large population-based surveys (the Multi-Ethnic Study of Atherosclerosis and the National Health and Nutrition Examination Survey), the prevalence of abnormal ankle-brachial index was low in asymptomatic patients.[3,4] Detection of coronary artery calcification by computed tomography lacks portability, is expensive, and exposes the patient to radiation. Ultrasound measurement of carotid intima-media thickness (CIMT) requires specialized training to perform and interpret the results, both of which can be time-consuming.[2]

Ultrasound-detected carotid plaque is an independent and powerful predictor of future CV events.[5-9] In one study, the presence of carotid plaque increased the area under the receiver operator characteristic curve for the prediction of CV and all-cause mortality, in addition to standard risk factors and therapies.[7] Ultrasound detection of carotid plaque is as safe and portable as CIMT, but is less time-consuming. Advances in technology now allow the use of small, lightweight, handheld ultrasound devices with high-resolution B-mode imaging capabilities, thus making the idea of integrating carotid plaque screening into an office-based setting more attractive. Although one small study suggested that screening for carotid plaque and presenting the patients with pictures of plaques improved smoking cessation rates,[10] there is

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This study was funded in part by the National Center for Research Resources (RR-1617601), Bethesda, MD.
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doi:10.1016/j.ahj.2007.06.046

little evidence that screening for atherosclerosis affects physician management, patient motivation, or long-term health-related outcomes.[11] This study investigated whether carotid plaque screening in an office setting could affect physician treatment plans and patient motivation.

Methods

Study protocol

This study was approved by the institutional review board of the University of Wisconsin School of Medicine and Public Health. Individuals with at least 2 CV risk factors were recruited from a general CV medicine clinic and a preventive cardiology clinic over 9 months. Assessed CV risk factors included current cigarette smoking, hypertension (systolic blood pressure ≥140 mm Hg or taking antihypertensive medication), hyperlipidemia (low-density lipoprotein cholesterol [LDL-C] ≥130 mg/dL or taking lipid-lowering medication), high-density lipoprotein cholesterol (HDL-C) <40 mg/dL, family history of coronary artery disease in a first-degree male relative younger than 55 years or a first-degree female relative younger than 65 years, and age ≥45 years in men or ≥55 years in women. Individuals with known atherosclerotic vascular disease or diabetes mellitus were excluded.

Fasting laboratory tests were performed using standard serum enzymatic assays in a clinical laboratory whose procedures have been validated by the College of Pathology and Pacific Biometrics proficiency testing programs. LDL particle concentrations and average diameters were measured by nuclear magnetic resonance spectroscopy (LipoScience, Inc, Raleigh, NC). The Framingham global CV risk equation was used to determine the 10-year risk of cardiac death or myocardial infarction.[12]

Carotid ultrasound imaging

Imaging was performed using a handheld device (TITAN, SonoSite, Inc, Bothell, WA) with an L38 linear-array transducer. An initial transverse scan starting from the proximal common carotid artery extending cranially through the internal carotid artery was performed, followed by a longitudinal circumferential scan of each segment to identify plaques in the common, bulb, and internal carotid arteries on each side. Carotid plaque was defined as a focal echogenic thickening of the intimal reflection that encroached on the arterial lumen, with a minimal intimal + medial thickness of >1.2 mm that also was at least twice the thickness of the adjacent region.[7,13] This definition previously has been shown to accurately indicate the presence of carotid plaque and to predict future CV events, even after adjustment for CV risk factors.[5,7,13] Electrocardiogram-gated end-diastolic images of the distal 1 cm of the far wall of each common carotid artery were obtained in triplicate from 3 angles and stored digitally. These images were used for offline measurement of CIMT using a semiautomated border-detection program (SonoCalc, SonoSite) after the office visit.[14] CIMT results were not conveyed to the study participants or physicians making treatment decisions. All ultrasound examinations were performed and interpreted by a single reader (R.A. W.). The scanning procedure including plaque screen and CIMT measurement took, on average, 5 minutes to perform.

Assessments of physician treatment plans and patient motivation

After providing informed consent, subjects completed a pretest survey designed using the theory of planned behavior. According to the theory of planned behavior, intention to perform a behavior is determined by the attitude toward the behavior, the subjective norm, and the individual's perception of control they have over their behavior perceived behavioral control.[15] The survey instrument used a 7-point bipolar Likert scale and contained 14 questions that assessed (1) motivation to exercise, (2) motivation to make specific dietary changes (such as reducing saturated and trans fat intake, reducing intake of sugar and simple starches, increasing intake of fiber), (3) motivation to quit smoking (smokers only), (4) likelihood that they would use medications or lifestyle changes to reduce cholesterol and blood pressure, (5) perception of the impact that high cholesterol and blood pressure have on their health, and (6) the likelihood they have or will have CV disease. Response options ranged from strongly disagree (score = 1) to strongly agree (score = 7), unless otherwise noted. After the carotid ultrasound imaging, the subject was shown a picture of the artery and the findings were explained. Subjects were told that previous studies have shown strong associations between carotid artery disease and coronary artery disease. In addition, they were informed that the risk of myocardial infarction, stroke, and death from these causes was increased in individuals with carotid plaque. Subjects were given a posttest survey identical to the initial survey with the exception of an additional question that asked if the test was valuable to them. The CV medicine fellow (R.A.W.) distributed the pre- and posttest surveys but was not present while the participants completed them. The responses to the survey questions were not reviewed with the patient or the physician. The fellow performed the carotid scan, provided the subjects with the results, and counseled the participants regarding the results. The subjects were given an opportunity to ask the fellow or attending physician questions regarding their carotid scans.

After the physician evaluated each patient, an initial management plan was developed. The Framingham Risk Score was calculated and the information was shared with the evaluating physician. Changes in prescription of aspirin, lipid-lowering therapy, antihypertensive therapy, and LDL-C goal were recorded. The physician was then told the results of the plaque screen and changes in medical therapy or LDL-C goal were recorded.

Statistical techniques

Sigma Stat 3.0.1 (SPSS, Inc, Chicago, IL) and SAS 8.0 software (SAS Systems, SAS Institute, Cary, NC) were used for descriptive and comparative statistics. Continuous variables were described by mean (SD) or median (range) values. Student *t* test was used to identify differences in continuous variables among subjects with and without plaque. The χ^2 test was used to identify differences among categorical variables. Fisher exact test was used to assess if a change in medical management resulted from the findings of the plaque screen. Because item distributions were skewed, analysis of variance after rank transformation was used to evaluate changes in the pre- and postsurvey questionnaire responses with plaque presence as a possible differential influence. These models permitted evaluation of the

Table I. Subject characteristics (N = 50)

	Mean	SD	Range
Age (y)	54.3	10.4	34-82
Waist circumference (cm)	40.1	5.1	28-52
Body mass index (kg/m²)	30.3	5.5	21-45
Systolic blood pressure (mm Hg)	129.7	15.3	98-170
Lipids			
Total cholesterol (mg/dL)	221.4	62.7	123-526
Triglycerides (mg/dL)	259.4	542.7	24-3839
HDL-C (mg/dL)	51.3	18.9	19-103
LDL-C (mg/dL)	128.0	40.7	55-217
Total cholesterol–HDL-C ratio	4.98	2.78	1.88-18.79
LDL particles (nmol/L)	1697.8	533.2	793-3162
Lipoprotein(a) (mg/dL)	35.6	31.6	6-97
Homocysteine (μmol/L)	8.5	2.9	4-16.1
Fasting glucose (mg/dL)	95.3	10.6	69-121
Framingham Risk Score (%)	7.8	7.9	<1-30

Table II. Relationship between plaque presence or absence and measured clinical parameters

	Plaque present (mean)	Plaque absent (mean)	*P*
Age (y)	57	50	.029
Waist circumference (cm)	41	38	.197
Body mass index (kg/m²)	31	28	.107
Systolic blood pressure (mm Hg)	133	125	.083
Lipids			
Total cholesterol (mg/dL)	232	206	.159
Triglycerides (mg/dL)	324	170	.326
HDL-C (mg/dL)	51	52	.887
LDL-C (mg/dL)	134	120	.250
Total cholesterol–HDL-C ratio	5.23	4.62	.448
LDL particles (nmol/L)	1766	1616	.430
Lipoprotein(a) (mg/dL)	39.3	32.6	.565
Homocysteine (μmol/L)	8.6	8.4	.920
Fasting glucose (mg/dL)	96	94	.595
Framingham Risk Score (%)	9.7	5.1	.039

The following dichotomous variables were not higher among participants with plagues: male sex (P = .78), use of antihypertensive treatment (P = .07), history of hypertension (P = .14), use of lipid-lowering treatment (P = .78), small LDL particle size (P = .97), history of aspirin use (P = .93), current tobacco use (P = .99), or family history of coronary artery disease (P = .81).

effects of time (repeat survey), plaque presence, and the plaque by time interaction.

Results

Subject characteristics

Subjects included 50 asymptomatic individuals with 2 or more CV risk factors. All subjects approached for enrollment agreed to participate in the study. Subject characteristics are described in Table I. The mean (SD) age of the entire cohort was 54.3 years (10.4 years) (range 34-82 years), and 31 (62%) of the subjects were men. The mean Framingham CV risk was 7.8% (7.9%). Because of the high prevalence of use of lipid-lowering medications,

Table III. Physician treatment recommendations after initial physician evaluation, then after carotid plaque screening (N = 50)

Treatment recommendation	N	New therapy, n (%)	Titrated therapy, n (%)
Aspirin			
Initially	9	–	–
After screening	10*	10 (100)	–
Antihypertensive therapy			
Initially	7	2 (29)	5 (71)
After screening	3	0	3 (100)
Lipid-lowering therapy			
Initially	25	9 (36)	16 (64)
After screening	13*	3 (23)	10 (77)

*$P < .05$.

this value may underestimate CV risk. All of the subjects had a history of hyperlipidemia, more than half (62%) had a history of hypertension, and few were current smokers (12%). Almost half of subjects had a family history of early coronary artery disease (48%). There was a high prevalence of use of lipid-lowering medication (62%), antihypertensive treatment (60%), and aspirin (54%) at baseline. The mean CIMT was 0.785 mm (0.115 mm).

Carotid plaque was present in 29 individuals (58%). Patients with carotid plaque were older (57.0 vs 50.6 years, P = .029) and had a higher Framingham CV risk (9.7% vs 5.1%, P = .039). Statistically significant differences in other variables, including sex, tobacco use, and family history of early coronary heart disease were not detected (Table II).

Impact of plaque screening results on physician treatment plans

Physician recommendations related to antiplatelet therapy, lipid-lowering therapy, and antihypertensive therapy after performing a history and physical examination and reviewing laboratory data, but before the carotid plaque scan, are described in Table III, along with therapeutic changes that were recommended after being informed of the results of the plaque scan. After plaque was identified, physicians were more likely to prescribe aspirin therapy (P = .031) and lipid-lowering therapy (P = .004), although the use of antihypertensive treatment did not change (P = .254). Patients also were more likely to be given a lower LDL-C goal based on the plaque screen results ($P < .001$).

Impact of plaque screening on patient motivation

As shown in Table IV, there were significant changes in the subjects' responses between the pre- and postsurvey items on the survey questions regarding dietary changes and lifestyle changes ($P < .05$), with trends for changes on items related to lowering cholesterol values (P = .06). However, the only statistically significant effect of the presence of plaque on survey responses was that patients

Table IV. Mean subject survey scores before and after carotid plaque screening of entire cohort (N = 50)

Question	Presurvey	Postsurvey	*P* (Δ time)	*P* (Δ effect of plaque)
I plan to exercise for at least 30 minutes 5 times a week	4.92	5.46	<.001	.131
I will try to eat more high-fiber foods (at least 3 servings of vegetables per day, oatmeal and dried beans or peas several times per week, and whole-grain breads and cereals)	5.77	6.10	.001	.213
I intend to limit saturated and trans fats (butter, cheese, ice cream, fatty meats, deep-fried foods, etc) in my diet	5.90	6.40	<.001	.274
I will try to limit sugars, sweetened drinks, juices, and starches	5.96	6.35	.006	.372
I am confident that I can make health changes to my lifestyle	5.85	7.56	.036	.093
I plan to reduce my cholesterol through diet changes	5.85	6.09	.059	.420
I plan to reduce my cholesterol through medications	5.08	5.32	.062	.993
I plan to reduce my blood pressure through diet changes	5.53	5.73	.173	.062
I plan to reduce my blood pressure through medications	4.76	5.07	.247	.664
Lowering cholesterol is harmful (1) or beneficial (7)	6.94	6.85	.057	.441
Lowering blood pressure is harmful (1) or beneficial (7)	6.96	6.88	.125	.535
Improving my lifestyle (eg, eating healthy, exercising regularly) will decrease my heart disease risk	6.67	6.58	.355	.448
The likelihood I have heart disease is extremely high (1) or extremely low (7)	4.58	4.44	.340	.092
The likelihood I will develop heart disease is extremely high (1) or extremely low (7)	4.28	3.85	.667	.013

Response options on a 1 to 7 scale are strongly disagree (1) or strongly agree (7), unless otherwise indicated.

with plaque perceived they were at higher risk of developing heart disease, with a mean score increase from 4.28 to 3.85 (P = .013). Trends toward an effect of plaque on plans to make healthy lifestyle changes (P = .093), reducing blood pressure through dietary changes (P = .062), and on perceived likelihood of having heart disease (P = .092) also were observed. Because there only were 6 smokers in this study, pre- and postscan values for questions related to smoking could not be meaningfully compared.

Discussion

The presence of carotid plaque is strongly associated with CV risk factors and angiographic coronary disease.[6] In studies that collectively evaluated more than 38 000 subjects, it has been demonstrated that the presence of ultrasound-detected carotid plaque independently predicts future CV events.[6-9] With the availability of handheld ultrasound machines, carotid plaque screening can be performed in an office setting. Screening takes only a short amount of time (approximately 5 minutes) and can be performed within the time allocated for a typical clinic visit. Use of a handheld ultrasound device for carotid plaque screening is fairly easy and accurate. In one study, internal medicine residents received only 1 hour of training and demonstrated 70% accuracy for the identification of plaque compared with an experienced vascular technician.[16] More rigorous training leads to accuracy rates of approximately 90%.[17] In both this study and our previous experience with 327 intermediate-risk patients referred for CIMT screening, the prevalence of carotid plaque approached 58%.[18] The high prevalence of carotid plaque and its strong, independent association with CV risk help justify screening in similar patients who otherwise would appear to be at lower risk and not qualify for more aggressive risk-reduction therapies.

Our study demonstrates that detection of carotid plaque in an office setting altered physician treatment patterns. Patients with carotid plaque were more likely to be prescribed aspirin, have their LDL-C target goal lowered, and have lipid-lowering therapy either prescribed or titrated based on the presence of plaque. A study that evaluated the impact of self-referred electron beam computed tomography coronary calcium screening found similar results. Patients with higher calcium scores were more likely to begin aspirin therapy, lipid-lowering medication, or antihypertensive treatment.[19] In the Rancho Bernardo cohort, the 364 individuals who underwent electron beam computed tomography and completed questionnaires regarding follow-up were more likely to be placed on cholesterol-lowering medications ($P < .001$) or aspirin (P = .009) if they were in the high CV risk group than those in the low-risk group.[20] In addition, the high-risk individuals were more likely to have cholesterol screening ($P < .001$).[20] These data suggest that screening for subclinical atherosclerosis affects patient management and leads to increased use of interventions that reduce CV risk.

Evaluation of patient motivation, however, is more complicated. Although the patients who were subjects in this study were more confident they could make lifestyle changes and were more motivated to exercise for 30 minutes 5 times a week, increase fiber intake, and decrease fat and sugar intake, these good intentions did not appear to be influenced by the result of the scan. This finding suggests the screening procedure or the way the scan results were presented to the subjects may have affected their motivations more than the results. Subjects without plaque may have had positive reinforcement, which may have led to better intentions to make healthy lifestyle changes after the scan results. Positive changes among individuals without plaque may account for the absence of an association between plaque presence and motivational changes. Clearly, the interactions between the screening process and how individuals interpret and internalize screening messages and their results needs further study before widespread screening can be recommended.

The only survey outcome significantly affected by the presence of plaque was perception of CV risk. Individuals with carotid plaque were more likely to perceive themselves at higher risk of developing heart disease than those without plaque; however, this recognition did not translate into an increased motivation to make healthy lifestyle changes. Similar results were found in a study that evaluated the effect of communicating the results of electron beam computed tomography coronary calcium screening to a group of army personnel aged 39 to 45 years.[21] One year of follow-up of changes in health-related behaviors were related to case management rather than the results or knowledge of the results of a coronary artery calcium score. In that study, there were no differences in the blood pressure, physical activity, mental health scores, cholesterol and fasting glucose levels, or body mass index in the group who knew the calcium score versus those who did not.[21] In the Rancho Bernardo cohort, only 27% of individuals in the high-risk group correctly classified themselves as high risk.[20] Despite this finding, those in the high-risk group were more likely to reduce dietary fat and cholesterol intake than the low-risk individuals. Taken together, these studies fail to shed light on the impact that screening tests have on motivating patients to make lifestyle changes.

Limitations

This was a small study, but one of the few that investigated the effects of screening for subclinical atherosclerosis on patient and physician behavior. We demonstrated that the use of carotid ultrasound to screen for plaque changed physician's use of evidence-based, risk-reducing therapy, but did not evaluate long-term changes in patient behaviors. Although we have not shown that carotid screening changes CV morbidity or mortality outcomes, the recent METEOR study demonstrated that prescription of statin therapy to patients with a minimal CIMT of 1.2 mm (similar to our definition) led to a significant reduction in progression of carotid atherosclerosis, of a magnitude similar to that seen in trials where a reduction in CV events was observed.[22,23] Although some physicians think it is obvious that early detection will improve outcomes, CV risk reduction requires more than changes in physician behavior. The process of ultrasound screening itself appeared to improve motivation; however, the fact that plaque presence did not affect motivation illustrates the complexity of translating screening into clinical practice. Indeed, the potential for negative outcomes related to labeling and increased perceived risks, or false negatives, have been raised previously.[24]

This pilot study was conducted in a university cardiology clinic with the potential for referral bias and response bias. Indeed, it is likely that patients being screened in a primary care rather than a referral setting would have a different response. We tried to minimize response bias by not being present in the room while the survey was administered or discussing the results of the survey with the patient or physician. Based on the small sample size, some true effects of plaque screening may have been missed; however, some of the associations found that were of borderline significance may be due to chance. Clearly, larger studies with more refined motivation and behavioral assessment tools are needed. This study can help plan future studies of noninvasive imaging and effects on patient and physician behavior.

Conclusions

Ultrasound screening for carotid plaque in an office setting can alter physician treatment plans and increase use of evidence-based, risk-reducing therapies. Although the presence of plaque increased patient perception of CV risk, it did not motivate patients to make healthy lifestyle changes. Larger studies that evaluate CV screening programs are needed to determine if the changes in physician behavior and patient motivation we demonstrated translate into a cost-effective reduction in CV risks, and if screening has any untoward effects.

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