A 84-year-old woman with a medical history significant for hypertension and hyperlipidemia presented with aphasia and was found to have a left parietal subacute infarct with hemorrhagic conversion and a remote right parietal lobe infarct, not previously recognized on computed tomography of the head. Workup included a transthoracic echocardiogram that showed normal left ventricular size, an ejection fraction >65%, and abnormal left ventricular diastolic filling. The left atrium was mild to moderately dilated. There was mild mitral regurgitation, mild pulmonary hypertension, and no evidence of patent foramen ovale with agitated saline. She complained of intermittent palpitations (every few weeks) and was placed on telemetry during her inpatient stay, with no significant arrhythmia detected. After her inpatient admission, she was treated with aspirin and had a 30-day event monitor that showed no episodes of atrial fibrillation.

One year later, she presented at the office of her primary care physician with complaints of palpitations and shortness of breath. She was found to be in atrial fibrillation and was subsequently treated with warfarin.

Atrial fibrillation is a common cause of ischemic stroke; overall, one sixth of cerebral infarcts are attributed to atrial fibrillation. As patients age, that proportion increases. Between 50 and 59 years of age, 1.5% of strokes are attributed to atrial fibrillation, but between 80 and 89 years of age the proportion increases to 23.5%. In patients with rheumatic heart disease, the incidence is even higher, 17× that of patients without atrial fibrillation. Atrial fibrillation can be persistent (lasted >7 days) or paroxysmal (spontaneously terminating in <7 days). Diagnosing paroxysmal atrial fibrillation can be a challenge but an important endeavor in patients suspected of cardioembolic stroke. All patients with prior stroke, transient ischemic attack, or thromboembolism receive anticoagulation, leading to deterioration of mechanical function. The ventricular response depends on the electrophysiological properties of the atrioventricular node and conduction system. Atrial fibrillation is often associated with structural heart disease. Factors correlated with the development of atrial fibrillation include left atrial size, valvular disease (especially mitral valve), coronary artery disease, dilated cardiomyopathy, congenital heart disease (especially atrial septal defect), cardiac tumors, and constrictive pericarditis. Mitral valve prolapse, calcification of the mitral annulus, cor pulmonale, and idiopathic dilatation of the right atrium have also been associated with higher rates of atrial fibrillation.

Clues to the propensity to develop atrial fibrillation can be found on surface ECG and echocardiography. ECG predictors include left atrial enlargement, prolonged or variable PR interval, left ventricular hypertrophy, and frequent atrial premature beats. Transthoracic or surface echocardiography is a widely available, portable, noninvasive, and low-cost modality for evaluation of cardiac anatomy. Transesophageal echocardiography is an invasive, but highly sensitive and specific, technique for evaluation of aortic and cardiac pathology that may be the source of embolization, including thrombi caused by atrial fibrillation. Predictors of atrial fibrillation include cardiac chamber dimensions, chamber mass, and systolic/diastolic chamber function. Several studies have shown a strong correlation between left atrial dimensions, left atrial volume and left atrial volume indexed for body surface area, and risk of new atrial fibrillation, ischemic stroke, congestive heart failure, and cardiovascular and all-cause mortality. Once left ventricular hypertrophy, left ventricular mass, and diastolic function are controlled for, the net effect is attenuated but remains significant. For every 5-mm increase in left atrial diameter, patients in the Framingham study demonstrated a 39% increase in the development of atrial fibrillation. In the Cardiovascular Health Study, a similar 5-mm increase was associated with >4-fold increase in the development of new atrial fibrillation. In patients without atrial fibrillation at baseline, a left atrial volume index of >32 mL/m² predicted first ischemic stroke, independent of other parameters.
The patient in our case is at risk for atrial fibrillation because of her age and hypertension. Furthermore, she has a history of palpitations and multiple embolic infarcts. These infarcts are in 2 vascular territories and of different ages (Figure), strongly suggesting cardioembolic origin. Furthermore, left atrial enlargement is evident on the echocardiogram. Based on these findings, paroxysmal atrial fibrillation is suspected and the patient should undergo cardiac monitoring. Although one would not anticoagulate her initially because of her hemorrhagic infarction, she would be a candidate for anticoagulation once her hemorrhage has resolved. The patient does not have any recorded atrial fibrillation episodes during short-term telemetry monitoring in the hospital. What are the options for further monitoring and what is most likely to detect paroxysmal atrial fibrillation?

There are multiple monitoring techniques available for diagnosis of arrhythmias, including ambulatory Holter monitors, event monitors, continuous ambulatory telemetry monitoring, and loop recorders. The yield for diagnosing atrial fibrillation by extended monitoring (>72 hours) is significantly increased compared with short-term monitoring with inpatient telemetry and Holter monitors. Asymptomatic episodes of atrial fibrillation occur more commonly than symptomatic episodes and can be missed with event recorders.

**Ambulatory Holter Monitors**

These are available for continuous durations from 24 to 72 hours. Patients are given a diary to record symptoms to correlate with arrhythmias. They are typically used when symptoms occur on a daily basis and can evaluate both symptomatic and asymptomatic atrial fibrillation.

**Event Monitors**

These are recordings of extended duration, typically between 7 and 30 days. Patients indicate when they have symptoms and trigger recordings. They are useful for symptoms occurring at least once a week or a few times a month. Because recordings occur only during events, asymptomatic atrial fibrillation can be missed. Patient’s understanding of device activation is needed, and elderly or disabled patients may experience difficulty in correct activation in response to symptoms.

**Continuous Ambulatory Telemetry Monitoring**

When patients have infrequent or transient symptoms and the detection of both symptomatic and asymptomatic episodes is desired, continuous ambulatory telemetry monitoring is the modality of choice. A pager-sized device sends continuous ECG information to a portable monitor or cell phone carried by the patient. The data are transferred wirelessly to a data monitoring center where technicians analyze the tracings and inform the physician. Current available services include CARDIONET, ECAT, and LIFEWATCH. Patients can undergo hookup in an office or hospital. Because all data are available for analysis in this technique, patient activation becomes less crucial.

**Loop Recorders**

When continuous extended monitoring beyond 4 weeks is sought, particularly when symptoms are infrequent, an implantable loop recorder has the greatest diagnostic yield. Loop recorders are MRI safe, leadless devices that can be implanted subcutaneously above the left precordium. They record for ≤3 years and store ≤50 minutes of data, with a combination of patient-activated and programmable automated recording options. Auto-detection algorithms are available to classify brady- and tachyarrhythmias. An exclusive atrial fibrillation detection algorithm can detect both symptomatic and asymptomatic episodes of atrial fibrillation, and the number and duration of atrial fibrillation episodes can be assessed.

Patients with implantable devices as pacemaker and defibrillators store data similar to a loop recorder and can be interrogated to evaluate whether stored electrogram tracings represent episodes of atrial fibrillation.

The patient in our case had infrequent palpitations. Furthermore, she is elderly and has aphasia. She may have had difficulty understanding how to mark events, allowing events to be missed. In her case, continuous ambulatory telemetry monitoring would have been a more appropriate monitoring choice than the event monitor because it would have also detected asymptomatic atrial fibrillation and would not have required her to trigger the recordings. There is still indecision on the optimal duration of monitoring paroxysmal atrial fibrillation and balancing the increased yield of longer duration monitoring versus the cost. The Cryogenic Stroke and Underlying Atrial Fibrillation Study (CRYSTAL AF) study should help provide answers. This randomized prospective study examines standard arrhythmia monitoring as defined by hospital practice versus implantation of a loop recorder (Reveal XT). The study was completed in May 2013, but results are not yet available.
TAKE-HOME POINTS

- Chronic and paroxysmal atrial fibrillation are common causes of stroke, and anticoagulation is the treatment of choice for patients with atrial fibrillation and stroke to prevent recurrent embolization.
- The ECG and echocardiogram provide important information that indicates the propensity to develop paroxysmal atrial fibrillation.
- It is important to understand the different types of cardiac monitoring to choose the most appropriate device to detect paroxysmal atrial fibrillation.

Disclosures
Dr Sundararajan owns stock in Medtronic. The other authors report no conflicts.

References

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