Evidence-Based Approach to Palpitations

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KEYWORDS

• Palpitations • Workup • Diagnose • Ambulatory ECG • Primary care • Heart monitor

KEY POINTS

- All patients presenting with a chief complaint of palpitations should undergo a detailed history, physical examination, and electrocardiogram (ECG).
- A thorough history is key in helping to diagnose the cause of the palpitations and is important in triaging which patients will need additional evaluation.
- Physical examination is low yield for diagnosing the cause of palpitations but should be used to guide further workup.
- A 2-week continuous loop event monitor has the highest diagnostic yield to cost ratio and is the test of choice when pursuing ambulatory ECG monitoring. Holter monitors should play a limited role in the evaluation of palpitations and should only be used when the patient's typical symptoms reliably occur at least every 24 hours.
- Consumer grade wearable devices such as smartwatches have potential for medical use in the future, but current data show their accuracy to be variable and their likelihood of finding clinically irrelevant abnormalities to be high.

INTRODUCTION

Palpitations are a common chief complaint and can be seen in a variety of settings including primary care, urgent care, the emergency department, and cardiology offices. The complaint of palpitations can refer to tachycardia, skipped beats, premature beats, or fluttering in the chest. The prevalence of palpitations in the community is 6% to 11%.[1,2] In a study evaluating the prevalence of chief complaints from multiple outpatient primary care offices, 16% of patients indicated that palpitations were a "major problem" for them.[3] Palpitations are also the second most common reason for referral to cardiology.[4]

A retrospective cohort study compared 109 patients who presented to primary care with palpitations with age- and sex-matched controls who did not report palpitations over a 5-year period and found no difference in the incidence of morbidity

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and mortality between these 2 groups.[5] The overall mortality rate of patients with palpitations in a study by Weber and Kapoor was also low at 1.6%. Although overall morbidity and mortality is low, they found that palpitations resulted in missed work days (12% of patients), self-reported decreased work productivity (19% of patients), and accomplishing less than usual amount of work at home (33% of patients).[6]

It is therefore important to pursue a cost-conscious, evidence-based approach to evaluation and workup of palpitations. This article outlines the evidence behind the history, physical examination, laboratories, electrocardiogram (ECG), and additional testing modalities for patients presenting to primary care with palpitations.

Differential Diagnosis of Palpitations

Any arrhythmia, including sinus tachycardia, atrial fibrillation, premature ventricular contractions, ventricular tachycardia, and myocardial infarction can cause palpitations. There are noncardiac reasons for palpitations as well, including anxiety, thyroid issues, medications etc. Hypertrophic obstructive cardiomyopathy (HOCM) and ventricular tachycardia represent a small proportion of patients presenting with palpitations but are red flag diagnoses that can lead to sudden cardiac death. **Box 1** displays a broader differential diagnosis for palpitations.

In the Weber and Kapoor study described earlier, the cause of palpitations was found to be cardiac in 43% of patients, psychiatric in 31%, other in 10%, and unknown in 16%. Forty percent of the causes could be determined with the history and physical examination, an ECG, and/or laboratory data.[6] **Table 1** displays the prevalence breakdown of the different causes of palpitations in this study.

PATIENT HISTORY

Importance of History

Palpitations are a nonspecific symptom; the differential diagnosis of their origin is broad. A detailed patient history can help narrow the scope of further testing.

History of Present Illness

When did the palpitations start? Did the palpitations start suddenly or gradually? One study showed that the longer the palpitation lasts, the more likely it is to be related to an arrhythmia rather than a noncardiac cause.[7] On the other hand, palpitations that last for only a moment are more likely to represent premature ventricular contractions (PVCs) or premature atrial contractions. Sustained palpitations, lasting for minutes (or longer), are more consistent with supraventricular arrhythmias, ventricular arrhythmias, or anxiety.[8]

Where was the patient when the palpitations began and what were they doing? Sitting at rest could be a sign of vagal nerve-mediated cause (eg, ventricular premature contraction), whereas occurring with exercise or exertion that could lead to dehydration suggests worsening of mitral valve prolapse cardiomyopathy or exertional syncope.[9] One study showed that palpitations that occurred at work or palpitations that awoke one from sleep were significantly more likely to have a cardiac cause.[7] Onset while speaking in front of a large group of people could suggest a more benign origin such as anxiety or supraventricular tachycardia. Posture and postural changes are also important to note. For instance, atrioventricular nodal reentrant tachycardias have been described as being triggered by standing up after bending over. Supraventricular tachycardia and ventricular premature contractions have often been noted while the patient is lying in bed.[10]

Box 1
Differential diagnosis of palpitations

Cardiac—Arrhythmia
- Atrial fibrillation/flutter
- Bradycardia caused by arteriovenous block or sinus node dysfunction
- Brugada syndrome
- Multifocal atrial tachycardia
- Premature supraventricular or ventricular contractions
- Sinus tachycardia or arrhythmia
- Supraventricular tachycardia
- Ventricular tachycardia
- Wolf-Parkinson-White syndrome/long QT syndrome
- Pacemaker-mediated tachycardia

Cardiac—Structure
- Atrial or ventricular septal defect
- Atrial myxoma
- Cardiomyopathy
- Congenital heart disease
- Congestive heart failure
- Valvular disease (mitral valve prolapse, aortic insufficiency, aortic stenosis)

Drugs, Medications, Toxins
- Alcohol
- Tobacco/nicotine
- Caffeine
- Street drugs (cocaine, amphetamines, anabolic steroids, marijuana, ecstasy, heroin)
- Prescription medications (beta agonists, theophylline, digitalis, phenothiazine, steroids, methylphenidate, midodrine, epinephrine, anticholinergics)
- Over-the-counter medications (pseudoephedrine, omega-3-polyunsaturated fatty acids, coenzyme Q10, carnitine)
- Withdrawal of medications (beta-blockers)

Physiologic
- Exercise
- Fever
- Hypovolemia/dehydration
- Pregnancy

Endocrinologic
- Hyperthyroidism
- Hypoglycemia
- Paget disease of the bone
- Pheochromocytoma

Hematologic
- Anemia
- Mastocytosis

Psychological
- Anxiety, stress
- Panic attacks

Neurologic
- Autonomic dysfunction
- Vasovagal syndrome
- Postural Orthostatic Tachycardia Syndrome

Other
- Electrolyte Imbalance
- Pulmonary Disease

Courtesy of A. Abbott, M.D., Los Angeles, California.

Table 1
Prevalence of causes of palpitations in Weber and Kapoor study

Causes of Palpitations	No.	Percent
Cardiac	82	43.2
Atrial fibrillation	19	10
Supraventricular tachycardia	18	9.5
Premature ventricular beats	15	7.9
Atrial flutter	11	5.8
Premature atrial beats	6	3.2
Ventricular tachycardia	4	2.1
Mitral valve prolapse	2	1.1
Sick sinus syndrome	2	1.1
Pacemaker failure	2	1.1
Aortic insufficiency	2	1.1
Atrial myxoma	1	0.5
Psychiatric	58	30.5
Panic attack or disorder plus anxiety	20	10.5
Panic attack alone	17	8.9
Panic disorder alone	14	7.4
Anxiety alone	6	3.2
Panic plus anxiety plus somatization	1	0.5
Miscellaneous	19	10
Medication	5	2.6
Thyrotoxicosis	5	2.6
Caffeine	3	1.6
Cocaine	2	1.1
Anemia	2	1.1
Amphetamine	1	0.5
Macrocytosis	1	0.5
Unknown	31	16.3

From Weber BE, Kapoor WN. Evaluation and outcomes of patients with palpitations. The American Journal of Medicine. 1996;14(6):138-148; with permission.

Ask your patient to carefully describe the quality of the palpitation. A feeling of rapid fluttering in the chest is typically seen in sustained ventricular or supraventricular arrhythmias, including sinus tachycardia. The regularity or irregularity of the palpitation may indicate what is causing the arrhythmia. As described by Zimetbaum and Josephson, a sensation of "flip-flopping" in the chest, the experience of a pounding, or very strong heart beat followed by the heart briefly "stopping" may be caused by premature supraventricular or ventricular beats.[8] An irregular, pounding feeling in the neck along with palpitations has been reported by patients with PVCs, complete heart block, pacemaker syndrome, or ventricular tachycardia.[11] Patients frequently describe a feeling of an "unpleasant awareness" with aortic regurgitation.[12] **Table 2** summarizes some typical palpitation descriptions and the diagnosis with which they are classically associated. Patients with palpitations on a regular basis were more than twice as likely to have a significant cardiac arrhythmia as a cause for their palpitations versus those who did not describe any regularity to their palpitations.[7]

Table 2
Key clinical findings with palpitations and suggested diagnoses

Finding	Suggested Diagnosis
Single skipped beats	Benign ectopy
Feeling of being unable to catch one's breath	Ventricular premature contractions
Single pounding sensations	Ventricular premature contractions
Rapid regular pounding in neck	Supraventricular arrhythmias
Palpitations since childhood	Supraventricular tachycardia
Palpitations terminated by vagal maneuvers	Supraventricular tachycardia
Palpitations that are worse at night	Benign ectopy or atrial fibrillation
Rapid irregular rhythm	Atrial fibrillation, tachycardia with variable block
Palpitations associated with emotional distress	Psychiatric cause or catecholamine-sensitive arrhythmia
General anxiety	Panic attacks
Palpitations associated with activity	Coronary heart disease
Rapid palpitations with exercise	Supraventricular arrhythmia, palpitations associated with exercise
Medication or recreational drug use	Drug-induced palpitations
Positional palpitations	Atrioventricular nodal tachycardia, pericarditis
Friction rub	Pericarditis
Heat intolerance, tremor, thyromegaly	Hyperthyroidism
Heart murmur	Heart valve disease
Midsystolic click	Mitral valve prolapse

The information in this table is based on clinical experience and not data from clinical trials. *Courtesy of* A. Abbott, M.D., Los Angeles, California.

Symptoms associated with the noncardiac causes outlined in **Box 1** are important to investigate to help build a differential. For instance, palpitations associated with heat intolerance could be associated with hyperthyroidism, whereas fever may indicate infection. Shortness of breath or choking sensation, nausea, dizziness, chest pain/discomfort, and paresthesias may help guide the diagnosis toward anxiety or panic attack.

Past Medical History

Past medical history is equally important as anxiety is the most common noncardiac cause of palpitations.[11] One study showed that a patient's palpitations are more likely to be of psychiatric nature if the patient is young, has a disability, has shown hypochondria-like behavior, or has been previously diagnosed with a somatization disorder.[13] The prevalence of an underlying panic disorder in patients with palpitations is 15% to 31%.[6] If it is thought that anxiety is playing a role, a clinician could use the Generalized Anxiety Disorder 7 item scale (GAD-7), a validated assessment tool to further assess the severity of symptoms. Other associated symptoms, including impending doom, diaphoresis, perioral numbness, and peripheral numbness, can help point to a diagnosis of anxiety or panic attack. It is important to remember that a person experiencing anxiety may have an underlying structural or additional medical reason for the palpitations. One study showed that 13% of patients diagnosed with a

psychiatric disorder had a nonpsychiatric cause of their palpitations,[13] so anxiety as the sole cause should remain a diagnosis of exclusion until after proper testing has been completed.

Medications

Many medications, whether prescription, over the counter, or herbal supplements, can trigger palpitations, so a complete medication reconciliation is paramount. Antidepressants and benzodiazepines have been shown to be associated with a decreased risk of cardiac arrhythmia, whereas the use of beta-blockers, diuretics, angiotensin-converting enzyme inhibitors, and other antihypertensives correlated with an increased risk of cardiac arrhythmia.[7] Changes in dose or withdrawal can also be a source of palpitations, so ask for recent changes in dosage or frequency of use. Over-the-counter medications such as nasal decongestants with pseudoephedrine, omega-3-polyunsaturated fatty acids, coenzyme Q10, and carnitine have all been shown to cause palpitations.[14]

Social History

Caffeine is a common culprit for palpitations and is integral in many patient's routines. Cigarettes and other nicotine products also can trigger palpitations. Although cocaine and methamphetamines are commonly associated with palpitations and a combination of both accounts for 1.6% of patients presenting with palpitations,[6] marijuana has additionally been shown to cause arrhythmias.[15] Athletes and weight lifters may have tried performance-enhancing drugs such as anabolic steroids.[15]

Family History

A family history of diseases such as those described in **Box 1** can also help direct workup for palpitations. Prolonged QT syndrome and cardiomyopathies can run in families, as well as anxiety and thyroid disease. Ask your patient specifically if anyone in their family passed away from or had a heart attack before the age of 55 years for men and 65 years for women.[16]

PHYSICAL EXAMINATION

The physical examination, although a wonderful tool, can have low yield for patients with palpitations. This is likely due to the intermittent nature of palpitations, resulting in lack of symptoms at the time of presentation to the office. However, it can be helpful in ruling out many causes and help to refine the differential diagnosis.

The general appearance of the patient is important for many cardiac causes, particularly that of a myocardial infarction. Apparent distress due to pain or shortness of breath will alter the urgency of the workup.

Reviewing vital signs, even if within the normal range, can be an important clue in the workup for palpitations, particularly a change from the individual's baseline. For instance, an increase in the heart rate and a decrease in weight may indicate an excess of thyroid hormone. Although lung causes are less commonly associated with palpitations, an increased heart rate or respiratory rate and low pulse oximetry may indicate a pulmonary-induced cause such as multifocal atrial tachycardia or a pulmonary embolus. A lower blood pressure or orthostatic hypotension may indicate volume depletion. Orthostatic vital signs can also diagnose postural orthostatic tachycardia syndrome (POTS), which usually presents with complaints of intermittent palpitations and lightheadedness or syncope. POTS is characterized as orthostatic tachycardia, with an increase in heart rate by greater than 30 bpm (or an increase to

≥120 bpm) when moving from lying down to standing position, in the absence of orthostatic hypotension.[17] If there is clinical suspicion of POTS, a set of orthostatic blood pressures with pulse can make the diagnosis.

If a patient is actively having palpitations, a simple pulse check can begin to narrow the differential greatly, especially for arrhythmia-induced palpitations. An irregular pulse would lead a practitioner to think of atrial fibrillation or premature ventricular contractions. A retrospective study by Zeldis and colleagues reviewed charts of 477 patients presenting with cardiovascular complaints including palpitations, dyspnea, chest pain, dizziness, or syncope who underwent one or more 24-hour ECG monitor recordings. Of those with an irregular pulse on examination, 91% had a significant arrhythmia on 24-hour ECG (positive predictive value of 91%) and of those with a regular pulse on examination, 28% had a significant arrhythmia on their 24-hour ECG.[18] The sensitivity of an irregular pulse for significant arrhythmia on ECG in this study was only 7%. Thus, you would not have an irregular pulse on examination in most patients with significant arrhythmia on 24-hour ECG, but if you do detect an irregular pulse on examination then there is a very high chance of also detecting a significant arrhythmia on ambulatory ECG monitoring. No other single history or physical examination finding in this study could reliably predict detecting a significant arrhythmia on ambulatory ECG monitoring.

Point of maximal impulse (PMI), which is determined by careful palpation of the chest wall to determine the location of the apex, can be useful in assessing cardiomegaly, particularly if it is displaced laterally and inferiorly. Noting the strength of the PMI is also useful as stronger or weaker than anticipated may indicate a cardiac cause of palpitations.

Heart auscultation is useful with structural heart causes. Mitral valve prolapse has the classic sound of a mid- to late systolic click, and can be seen in isolation, or in conjunction with hyperthyroidism, particularly in young white women.[19] Some other murmurs that are commonly associated with the symptom of palpitations include aortic regurgitation and diastolic tumor plop. Aortic regurgitation is described as a soft high-pitched early diastolic decrescendo murmur. Links to audio clips of these murmurs can be found in **Box 2**.

Examination findings that could point to a thyroid cause include exophthalmos and/or lid lag, thyromegaly and/or thyroid nodules, diaphoresis, hand tremor, hyperreflexia, widened pulse pressure, and irregular or elevated heart beat.

Although not as common of a presentation, anemia can also present with palpitations, therefore looking for evidence of anemia on examination is reasonable. Individuals with anemia may have diastolic flow murmur, pallor of the conjunctiva, nail beds, and/or oral mucosa, or splenomegaly. In a 2017 study, researchers looked at signs/symptoms of severe anemia (hemoglobin less than or equal to 7%) in 94 patients.

Box 2
Murmur sound clips

Mitral valve prolapse—Heart Sounds. Medzcool https://www.youtube.com/watch?v=sH_KmHIHR70. Accessed March 30, 2020.

Aortic Regurgitation—Heart Sounds.; 2019. https://www.youtube.com/watch?v=uZysrKXHJMM. Accessed March 30, 2020.

From Medzcool. Mitral Valve Prolapse - Heart Sounds. Youtube. Available at: https://www.youtube.com/watch?v=sH_KmHIHR70. Accessed March 30, 2020; and Medzcool. Aortic Regurgitation - Heart Sounds. Available at: https://www.youtube.com/watch?v=uZysrKXHJMM.

They found that 54 patients out of the 94 had a cardiac murmur and when followed-up, most of these patients' murmur resolved after treatment of their anemia. The same study showed that 39 out of the 94 (41%) reported palpitations at presentation, which improved or resolved after treating their anemia.[20]

In addition, abnormal pupil size may indicate medication or drug effect or withdrawal. Oral examination should note moist or dry mucous membranes.

Although anxiety is a diagnosis of exclusion and is difficult to diagnose with physical examination alone, patients can often present with a hyperdynamic pulse along with diaphoresis, and abnormal speech patterns.

TESTING (EVALUATION)

Following a thorough history and physical examination, an ECG is warranted, as it has been shown to reveal the cause of palpitations in 27% of patients.[6] Even if the patient is asymptomatic in the office, an ECG may identify many arrhythmias, including, Wolff-Parkinson-White (WPW) syndrome, long QT syndrome, atrioventricular (AV) blocks, atrial fibrillation, premature atrial complexes, and premature ventricular complexes. It can also show evidence of structural heart disease such as atrial enlargement, right ventricular hypertrophy, left ventricular hypertrophy, and prior myocardial infarction.

If the history, physical and/or ECG suggests the possibility of structural heart disease or congestive heart failure, then an echocardiogram should be ordered. This includes anyone with palpitations associated with syncope or presyncope, a family history of HOCM, a murmur or signs of hypervolemia on examination (increased jugular venous pressure, crackles, bilateral lower extremity edema), ECG showing q waves, left bundle branch block, left ventricular hypertrophy, atrial enlargement, AV block, short PR interval and delta waves (WPW syndrome), or prolonged QT interval.[11]

There is no strong evidence to direct laboratory testing in patients presenting with palpitations. Although some articles recommend that all patients presenting with palpitations should have a thyroid stimulating hormone, complete blood count, and basic metabolic panel checked,[9,21] a position paper by the European Heart Rhythm Association states that targeted laboratory testing should be done only when history and physical examination suggest a cause such as hyperthyroidism, anemia, drug use, or pheochromocytoma.[22] Abnormal renal function and derangements of potassium and sodium can cause cardiac arrhythmias. Illicit substances can cause palpitations, making urine toxicology important if there is history or clinical suspicion of drug use.[9,21,22] Based on the relative cost of bloodwork compared with other diagnostic modalities (see **Box 4**), this remains a relatively cost-efficient starting point for the workup of palpitations.[23]

Palpitations lacking a clear diagnosis after performing a history, physical examination, and ECG are classified as "unexplained palpitations." According to the 2017 expert consensus statement by the International Society for Holter and Noninvasive Electrocardiology and the Heart Rhythm Society (ISHNE-HRS), ambulatory ECG monitoring is indicated for patients with unexplained palpitations who meet any of the following criteria displayed in **Box 3** (Class I Recommendation with level of evidence B-R). The American College of Cardiology/American Heart Association guidelines from 1999 recommend ambulatory ECG monitoring to evaluate patients with unexplained recurrent palpitations.[24] There are multiple types of ambulatory ECG monitors including 24- to 48-hour Holter monitors and continuous loop event monitors. The ISHNE-HRS consensus statement gives a Class I recommendation with level of evidence B-NR for doing a 24- to 48-hour Holter monitor when frequent symptomatic events reliably occur within the recording window (daily or more often).[25] In

Box 3
Indications for ambulatory electrocardiogram monitoring based on the 2017 consensus statement from the International Society for Holter and Non-invasive Electrocardiology-Heart Rhythm Society in patients with unexplained palpitations

1. When history, physical examination, and 12-lead ECG suggest a possibility of arrhythmia
2. In the setting of diagnosed structural heart disease, family history of sudden cardiac death, or inherited channelopathy with known risk of arrhythmia
3. When patients need reassurance and specific explanation of their symptoms
4. When symptoms warrant therapy and specifics of treatment depend on a formal arrhythmic diagnosis (eg, ablation, antiarrhythmic therapy)

Data from Steinberg JS, Varma N, Cygankiewicz I, et. al. 2017 ISHNE-HRS expert consensus statement on ambulatory ECG and external cardiac monitoring/telemetry.Heart Rhythm. 2017 Jul;14(7):e55-e96.

addition, the consensus statement gives a Class I recommendation with level of evidence B-R for doing 15- to 30-day ambulatory ECG monitoring for patients with undefined symptom frequency or symptoms that do not reliably occur every day.

Holter monitors, when worn, record heart rhythms continuously for 24 to 48 hours and are recommended to evaluate unexplained palpitations that occur at least daily. Patients keep a diary of their symptoms during the recording period in order to correlate the time of the symptoms with a particular portion of ECG recording. One study showed 53% of the patients did not experience their presenting symptoms during the 24-hour Holter monitor period, 13% of patients had an arrhythmia correlating with their symptoms, and 34% of patients had their typical presenting symptoms associated with a recording of normal sinus rhythm.[18] The diagnostic yield of a 24-hour Holter monitor for evaluation of palpitations ranges between 5% and 39%.[6,8,26–28] Forty-eight hour Holter monitor did not have a significantly higher diagnostic yield than 24-hour Holter monitoring for detection of maximal ventricular ectopy in patients with coronary artery disease,[29] and it is rarely valuable.

Holter monitors can inadvertently show asymptomatic arrhythmias. One retrospective study reviewing 518 consecutive Holter monitor recordings found that, of those who did not experience their presenting symptoms during the Holter recording period, 56% were found to have an asymptomatic arrhythmia. Furthermore, of the patients who did experience their typical presenting symptoms but had no correlating arrhythmia, 33% were found to have an arrhythmia during their asymptomatic time periods.[18]

Transtelephonic event monitors such as a continuous loop event monitor are worn continuously for 7 to 30 days and will continuously record the heart rhythm. Durable recordings will only be saved and sent to a central station for the few minutes before and after the patient manually activates it. Many of these devices now have an auto-trigger mode that will automatically save data when the heart rate goes greater or less than a certain threshold. Continuous loop event monitors can miss asymptomatic arrhythmias or arrhythmias associated with syncope, as the patient may not activate the recorder during those events. There is another type of transtelephonic event monitor that is not worn continuously but is carried with the patient and placed on the chest when palpitations occur. This often misses the rhythm at the onset of the palpitations.

The diagnostic yield of transtelephonic event monitors for palpitations is 66% to 83%,[8] which is considerably higher than the diagnostic yield of Holter monitors. A study of 147 patients being worked up for cardiac arrhythmia directly compared the

diagnostic yield of 24-hour Holter monitor with 2-week continuous event monitor by having the patients wear both simultaneously and then remove the Holter after 24 hours but continue the event monitor for 2 weeks. During the first 24 hours of simultaneous use of both devices 60 arrhythmic events were noted in both devices and 1 arrhythmic event was detected in the Holter but not the event monitor. However, after the first 24 hours once Holter was removed, the continuous event monitor continued and subsequently detected an additional 36 arrhythmic events. There was a total of 61 events identified by Holter and 96 total events identified by 2 week monitor ($P < .001$).[30]

Zimetbaum and colleagues conducted a prospective cohort study of 105 patients with palpitations referred for continuous event monitor to assess the diagnostic yield and cost of continuous event monitors for each week over a 4-week time period. **Table 3** shows the cost, cost per new diagnosis made, and number of new diagnoses made per patient in each week by continuous loop event monitors in the United States in 1997. The probability of finding a diagnosis over the 4-week time period took the shape of a logarithmic curve that plateaued around week 2 with marginal additional diagnostic yield in weeks 3 and 4.[8] One hundred percent of the "serious diagnoses" made during this study (supraventricular tachycardia, atrial fibrillation/atrial flutter, nonsustained ventricular tachycardia, high-degree heart block) were made within the first 2 weeks of wearing continuous loop event monitors.[8] Thus 2 weeks is considered the optimal duration of continuous loop event monitors for a highest value balance between diagnostic yield and cost. If the 2-week continuous event monitor does not reveal the cause of palpitations in either a high-risk patient or a patient with significant impact on quality of life, then a referral to cardiology is warranted.

A study evaluating syncope workup in Ontario, Canada in 2005 reported the cost (including material, tech/labor, service, overhead, and professional) from Ontario-based fee codes converted to US dollars of various diagnostic testing strategies that are frequently used in the workup of palpitations. The *relative* costs may be applicable to workup of palpitations in the United States and are displayed in **Box 4** rounded to the nearest dollar amount.[23]

The cost per diagnosis is important because once a definitive diagnosis is established, that halts further testing (associated with further diagnostic expenditures) and shifts the focus to appropriate management. Overall, the Holter monitor is

Table 3
Cost, cost per new diagnosis made, and number of new diagnoses made per patient by continuous loop event monitors in the United States in 1997

Length of Time Event Monitor Worn	Cost of Event Monitor in 1997 US Dollars	Cost per New Diagnosis Made in the Additional Time	Number of New Diagnoses Made per Patient during Each Additional Week
Week 1	$102	$98	1.04
Week 2	$96 (+$102 = $198)	$576	0.17
Week 3	$81 (+$198 = $279)	$5832	0.01
Week 4	$81 (+$279 = $360)	No new diagnoses made	0.00

Data from Steinberg JS, Varma N, Cygankiewicz I, et. al. 2017 ISHNE-HRS expert consensus statement on ambulatory ECG and external cardiac monitoring/telemetry.Heart Rhythm. 2017 Jul;14(7):e55-e96.

Box 4
Cost of various testing in Ontario, Canada in 2005 in US dollars

Primary care doctor initial assessment: $49

Primary care doctor follow-up: $25

Emergency room visit: $64

ECG: $21

Bloodwork: $10

24-h Holter: $103

48-h Holter: $178

External loop (1 mo): $534

Echocardiogram: $228

Cardiology consult: $103

Electrophysiologic study: $937

Standard treadmill stress test: $142

Stress: MIBI $616

Cardiac catheterization: $462

Adapted from Rockx MA, Hoch JS, Klein GJ, et al. Is ambulatory monitoring for "communityacquired" syncope economically attractive? A cost-effectiveness analysis of a randomized trial of external loop recorders versus Holter monitoring. American Heart Journal. 2005;150(5):1065; with permission.

cheaper but of much lower diagnostic yield, making the event monitor more cost-effective and the ambulatory ECG the test of choice unless palpitations are consistently experienced at least every 24 hours.

Many patients currently use smartwatches or other "wearables," which are consumer grade devices that record heart rate (usually not heart rhythm) by photoplethysmography. Although some of these devices have achieved or are seeking Food and Drug Administration (FDA) "clearance" (considered safe), none of these devices currently have FDA "approval" (endorses evidence of accuracy for medical use). According to the 2017 ISHNE-HRS expert consensus statement on ambulatory ECG and external cardiac monitoring/telemetry, consumer grade devices currently have no medical oversight and should not replace any medically indicated workup at this time.[25] One 2019 study of patients undergoing cardiac rehabilitation showed insufficient concordance of heart rate measurement between various wearable devices and the gold standard of ambulatory ECG monitors.[31] Other studies show some (but not all) models of wearables with high concordance with ambulatory ECGs for heart rate during certain controlled activities (eg, sitting, walking, running, etc.) and overall. However, there is no standard for what level of concordance is considered acceptable for medical use. Of the devices with a high overall concordance with ambulatory ECGs, there was still significant variability in concordance during different types of activities including low concordance during some activities of daily living (chores, brushing teeth) or certain types of exercise (eg, elliptical, cycling). Different devices had different activities during which their measurements were less accurate.[32–36] This is a rapidly evolving field of study with vast potential, given the rapid improvement in device performance during a broad range of activities over the last few years. There are several ongoing studies evaluating the ability of wearables to

detect heart rhythm (not just heart rate) abnormalities such as atrial fibrillation and supraventricular arrhythmias.[37,38]

Although these devices have high potential for helping diagnose medically relevant arrhythmias, they may also lead to increased testing and overdiagnosis of asymptomatic benign arrhythmias. Given that Holter monitors have shown a high prevalence of asymptomatic arrhythmias,[18] it is likely that consumer grade wearables will as well. As the technology of commercially available products is exploding, patients may begin to present to their doctors with data from consumer grade devices rather than symptoms. For the time being, clinicians should remain focused on symptom driven evaluation with evidence-based workup dictated by history, physical examination, and ECG, but in the future, wearables may represent an easily accessible and cost-effective way to evaluate palpitations.

Many patients with palpitations can be diagnosed and managed in the outpatient setting without a cardiology referral. If the palpitations are caused by premature atrial or ventricular contractions in the absence of structural heart disease, patients should be reassured about this benign condition, and symptoms can be managed with a beta-blocker, if needed. A longitudinal study demonstrated no increased mortality in patients with frequent premature ventricular contractions without structural heart disease compared with the healthy general population.[29] Red flags that warrant further evaluation (sometimes urgently in the emergency room) include palpitations associated with syncope or presyncope, known or suspected family history of hypertrophic obstructive cardiomyopathy, suspicion of active cardiac ischemia and/or abnormal stress test, and abnormal echocardiogram showing structural heart disease. Practitioners should consider cardiology referral for management of certain arrhythmias diagnosed by primary care provider workup including supraventricular tachycardias, ventricular arrhythmias, or second- or third-degree AV heart blocks. Cardiology referral is also recommended for patients with a negative workup by primary care who are poorly tolerating their symptoms.

SUMMARY

Palpitations are a common chief complaint of patients in the primary care setting, urgent care, emergency department, and cardiology offices. A thorough history is central in helping to narrow down the cause of the palpitations. All components of the patient's history should be addressed, including their personal social and medical history along with their family history. A comprehensive history will help determine who will need further testing and monitoring. Although the physical examination may provide limited additional information, it should be used to guide further workup. There are many options available for additional investigation of the cause of palpitations. Of the available tests, a 2-week continuous loop event monitor has been shown to have the highest diagnostic yield to cost ratio when pursuing ambulatory ECG monitoring.[8] If a patient's symptoms are reportedly occurring at least every 24 hours, a Holter monitor can be used. Currently, there are multiple consumer grade wearable heart monitor devices available to our patients such as smartwatches. Their use and efficacy are still being investigated. At this point their accuracy seems to be variable, and they are likely to provide a lot of clinically irrelevant data. Nevertheless, they do have an exciting potential for medical use in the future and may have the ability to reduce the overall cost of a palpitations workup.

DISCLOSURE

The authors have no conflicts of interest to disclose.

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