Original Research

An Assessment of the Diagnostic Value in Syncope Workup: A Retrospective Study

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Abstract

Background
Patients with syncope often undergo costly testing, despite current guidelines and data supporting the contrary.

Objective
To determine the diagnostic value through positivity rate of electrocardiogram (EKG), computed tomography (CT) of the brain, magnetic resonance imaging (MRI) of the brain, transthoracic echocardiogram, nuclear and pharmacologic cardiac stress test, tilt table test and carotid ultrasound in patients diagnosed with syncope.

Methods
This is a retrospective study of 10,036 adults presenting to the emergency department or hospitalized with a primary diagnosis of syncope at 8 acute care facilities in the southwest United States from January 1, 2019, to December 31, 2019. A chi-square analysis was performed for each testing modality to evaluate for a statistically significant difference. The cost of each test was estimated based on published national averages per Medicare.

Results
Of our sample, 903 patients (9%) received a test that yielded any positive finding. The results in the order of highest percent positivity rate to lowest were EKG (5.7%), carotid ultrasound (4.84%), transthoracic echocardiogram (2.56%), tilt table test (1%), MRI brain (0.99%), CT brain (0.82%) and cardiac stress test (0.09%). The total sum spent on testing was estimated at $43,347,332. Only $489,170 of this total was spent on a positive test. If this data is expanded to the 6,146 hospitals across the United States, a yearly $33 billion are wasted on syncope workups.

Conclusion
Costly testing continues to be performed on syncope patients despite guidelines discouraging testing. The necessity of these tests should be carefully evaluated for each patient based on diagnostic value.

Keywords
syncope; syncope workup; cost-conscious evaluation; high-value care; cost and cost analysis; health care costs; financial stress; neuroimaging; brain CT; brain MRI; stress test; EKG; electrocardiography; tilt-table test; diagnostic techniques and procedures

Introduction

Syncope is a common chief complaint among emergency department (ED) visits in the United States (US), accounting for 1 to 3% of all ED visits per year, with an estimated prevalence of 40% in adults.[1-3] Syncope is defined as a transient loss of consciousness caused by inadequate blood supply to the central nervous system with rapid recovery. It is distinct from other causes of a total loss of consciousness, such as seizures, concussions and intoxication. The etiology of syncope is classically grouped into four groups: idiopathic, vasovagal, cardiac

Table 1. Study Demographics

Participants	10,036
Sex	
Female	5,570 (55.5%)
Male	4,466 (44.5%)
Race	
White	5,743 (57.2%)
Other	3,084 (30.7%)
Black	1,209 (12.0%)

and orthostatic hypotension, with idiopathic being the most common.[4,5]

In 2017 the American Heart Association (AHA), American College of Cardiology (ACC) and Heart Rhythm Society (HRS) jointly published guidelines for managing syncope.[6] They recommend an initial evaluation with a thorough history, physical exam and electrocardiogram (EKG). An inpatient hospital stay is only recommended for patients with a severe medical condition that may have precipitated the syncope event (Class I-B-NR). However, guidelines are non-specific when referencing specific workup algorithms, noting "insufficient data to advocate the use of specific decision support algorithms for making disposition decisions." The guidelines specifically discourage the use of neuroimaging and carotid artery imaging during the workup of syncope unless there are "focal neurological findings or head injury that supports further evaluation" (Level III recommendation).[6]

Many patients diagnosed with syncope are asymptomatic and do not display neurologic deficit or head injury symptoms, yet they often undergo testing during their hospital workup. According to one study, 32% of ED visits for syncope resulted in an admission to the hospital. However, up to 33% of these patients are discharged after a full workup with an unexplained etiology.[7] Other studies have shown similar admission rates for syncope.[8,9] Hospitalization presents a significant emotional, physical and financial burden on the patient and a substantial financial burden on the healthcare system, with billions of dollars being spent on costly workups each year.[2,10,11] The abundance of diagnostic workups performed on these patients prolongs the length of stay and seldom yields a significant syncope etiology.[12-15] A patient's quality of life can be negatively affected, especially in cases of recurrent syncope, as they may undergo unnecessary testing multiple times. Syncope also carries the risk of fall and all the associated ramifications, such as brain hemorrhage, hip fracture and the need for assistance while ambulating, which can lead to a cascade of issues that negatively impact quality of life.

In this study, an extensive data set of patients with a chief complaint of syncope was analyzed. Each patient's chart was evaluated to identify tests and imaging ordered. It was then determined how many of these tests resulted in a positive finding. Cost savings were then estimated with a judicial and minimalistic approach.

Methods

Study Population and Design

Our study included a patient population of 10,036 adults over 18 years of age who presented to 8 acute care facilities in the southwest United States from January 1, 2019, to December 31, 2019. (**Table 1**) These were evaluated either in an ED or medical floor for the primary diagnosis of syncope as confirmed by ICD-10 code "R55". Institutional Review Board approval was obtained for the study before data collection. Exclusion criteria included patients who had an existing diagnosis of recurrent syncope, patients whose syncopal event occurred while in the hospital or syncope secondary to a current condition requiring inpatient care.

Each patient's chart was reviewed to determine the types of tests ordered during their hospitalization. Diagnostic tests reviewed included EKG, computed tomography (CT) of the brain, transthoracic echocardiogram (TTE),

nuclear and pharmacologic cardiac stress test, tilt table testing, carotid ultrasound and magnetic resonance imaging (MRI) of the brain. Once it was determined that a patient received a particular test, the ICD-10 codes typically associated with diagnostic utility in syncope for each respective test were used to determine each test's positivity rate. (**Table 2**)

Statistical Analysis

Chi-square analysis and logistic regression (**Table 3**) were performed for each testing modality to evaluate statistically significant differences in patients who received testing and those who did not. The workup cost was calculated using the average price of each test in the US published by Medicare.

Results

A total of 10,036 patients were included in the study. The average age was 55.96 years old. 5,570 were females (55.5%) and 4,466 were males (44.5%). Race distribution was 5,743 white (57.22%), 1,209 black (12.05%) and 3,084 other (30.73%). A total of 903 (9%) patients from our sample received a test that yielded any positive findings and 9,133 (91%) had no positive findings on any of the identified tests. The most common test ordered for evaluating syncope in patients was an EKG, with 9,004 (90%) patients receiving it and 513 (5.7%) having a positive finding. The second most common test was a stress test, with 7,491 (75%) patients undergoing one and 7 (0.09%) yielding a positive finding. (**Table 2 and 4**) The remaining tests in order of most to least ordered were as follows: 4,268 (42.5%) receiving a CT scan, 2,615 (26%) receiving MRI, 1,941 (19%) receiving carotid ultrasound, 803 (8%) undergoing a tilt table test and 156 (1.5%) receiving TTE. The number of patients with positive findings for each test was as follows: 35 (0.82%) patients for CT scan, 26 (0.99%) patients for MRI, 94 (4.84%) patients for carotid ultrasound, 8 (1.0%) patients for tilt table testing and 4 (2.56%) patients for TTE.

For every one year increase in age, a patient was 1.027 times as likely to have any positive

Table 2. Criteria for Positive Findings Associated with Each Test

Test	Positive Finding and Corresponding ICD-10 Code
EKG	• Sinus bradycardia. R00.1 • Supraventricular tachycardia with rapid ventricular rate. I47.1 • Ventricular tachycardia. I47.2 • Non-sustained polymorphic ventricular tachycardia. I47.2 • 2nd-degree Heart Block Mobitz Type 2. I 44.1 • 3rd-degree heart block or complete heart block. I44.2 • QT prolongation. I45.81
Cardiac stress test (nuclear or pharmacologic)	• Reversible ischemia/ischemic defect. R94.39
CT brain/head without contrast	• Hemorrhage. I61.9 • Mass. R90.0 • Acute Ischemia. I67.82 • Acute infarct. IC63.9
MRI of brain/head without contrast	• Hemorrhage. I61.9 • Mass. R90.0 • Acute Ischemia. I67.82 • Acute infarct. IC63.9
Carotid ultrasound	• Carotid artery stenosis > 70%. I65.2
Tilt table testing	• Positive orthostasis. I95.1
Transthoracic echocardiogram	• Aortic stenosis. I35.0 • Hypertrophic cardiomyopathy. I42.2 • Reduced left ventricular function (ejection fraction) less than or equal to 45%. I50.2, I50.4 • Left ventricular outflow tract obstruction. I42.1

Table 3. Individual Analysis and Chi-Square p-Values for Each Type of Test

		No positive findings	Positive findings	Total
EKG (p = 0.12)	Test not performed	985	47	1,032
	Test performed	8,491	513	9,004
	Total	9,476	560	10,036
MRI (p < 0.001)	Test not performed	7,406	15	7,421
	Test performed	2,589	26	2,615
	Total	9,995	41	10,036
CT Head (p < 0.001)	Test not performed	5762	6	5768
	Test performed	4233	35	4268
	Total	9,995	41	10,036
Carotid Ultrasound (p < 0.001)	Test not performed	8,077	18	8,095
	Test performed	1,847	94	1,941
	Total	9,924	112	10,036
TTE (p = 0.36)	Test not performed	9,704	176	9,880
	Test performed	152	4	156
	Total	9,856	180	10,036
Tilt Table Test (p = 0.65)	Test not performed	9,155	78	9,233
	Test performed	795	8	803
	Total	9,950	86	10,036
Stress Test (p = 0.19)	Test not performed	2,540	5	2,545
	Test performed	7,484	7	7,491
	Total	10,024	12	10,036

finding. The odds of having any positive result were 1.357 times as likely for male patients compared to female patients.

CT scan (odds ratio [OR] =1.41), carotid ultrasound (OR=4.67) and MRI (OR=1.528) all had a statistically significant difference in terms of positivity between patients who received the test and those who did not (p<0.0001). Still, the overall positivity rate was low in all groups. (**Table 4**)

Specific positive findings are as follows: bradycardia in 397 (3.96%) patients, carotid artery stenosis in 112 (1.12%), reduced left ventricular function in 112 (1.12%), orthostatic hypotension in 86 (0.86%), tachycardia in 71 (0.71%), aortic stenosis in 64 (0.64%), ventricular tachycardia in 52 (0.52%), long QT in 43 (0.43%), acute stroke in 34 (0.34%), second degree block in 17 (0.17%), third degree block in 17 (0.17%), abnormal cardiac stress test in 12 (0.12%), hypertrophic cardiomyopathy in 8 (0.08%), brain hemorrhage in 4 (0.04%), acute brain ischemia in 2 (0.02%) and brain mass in 1 (0.01%).

The average hospital charge for different procedures varies considerably and depends on the location, timing, overhead costs, negotiating power and the insurance provider. On average, an EKG costs $367 in a hospital in the US.[16] The charge of an echocardiogram is estimated at $4,361, a nuclear cardiac stress test is $2,182, a CT of the head is $2,621 and a brain MRI is $3,422.[16] A carotid ultrasound is on average $787, and the tilt table test is estimated at $1,687.[17]

Table 4. Comparison of the Number of Patients with Positive Findings That Had a Test Versus the Number of Patients with No Findings That Had the Same Test

Test	Number of Patients Receiving Test (Percentage of total patients) Estimated Cost	Number of Positive Findings Present (Percentage of those who underwent the test) Estimated Cost	Number of Positive Findings Present (Percentage of those who underwent the test) Estimated Cost	p-value
EKG	9,004 (94%) $3,304,468	513 (5.7%) $188,271	8,491 (94.3%) $ 3,116,197	0.1296
Stress Test	7,491(75%) $16,345,362	7 (0.09%) $15,274	7,484 (99.91%) $16,330,088	0.1948
CT brain/head without contrast	4,268 (42.5%) $11,186,428	35 (0.82%) $91,735	4,233 (99.18%) $11,094,693	< 0.0001
MRI of brain/ head without contrast	2,615 (26%) $8,948,530	26 (0.99%) $88,972	2,589 (99.01%) $8,859,558	< 0.0001
Carotid Ultrasound	1,941 (19%) $1,527,567	94 (4.84%) $73,978	1,847 (95.16%) $1,453,589	< 0.0001
Tilt Table Test	803 (8%) $1,354,661	8 (1.0%) $13,496	795 (99%) $1,341,165	0.6551
Transthoracic Echocardiogram	156 (1.5%) $680,316	4 (2.56%) $17,444	152 (97.44%) $662,872	0.3649

Based on these numbers, (**Table 4**) the workups of these syncope cases (only the portion pertaining to these tests and not an ED visit or hospital admission) were estimated to cost $43,347,332. Only $489,170 of this was spent on a positive test. Therefore, $42,858,162 was spent on 10,036 people ($4,270 each) with no yield. If this is expanded to 6,146 hospitals across the United States, a yearly sum of $32,925,782,956 is spent with no syncope workup yield.

Discussion

The findings outlined in this study support the hypothesis that syncope patients receive unnecessary workups. This argument is supported by the low positivity rate of each testing modality. Although CT scan, carotid ultrasound, and MRI had a statistically significant difference in positivity rate, the overall number of syncope patients who received the tests and had positive findings was still low. (**Table 4**) This pattern has been demonstrated in several other studies in which each modality was evaluated individually regarding diagnostic value for syncope. Most of these studies have found that CT or MRI of the brain has a low diagnostic yield in syncope.[3,15,18-20] These findings support the argument that when completing a workup for patients presenting with syncope, physicians must consider whether the patient is symptomatic and closely weigh the benefit of each test versus the cost, logistic burden and morbidity (i.e., radiation exposure) to the patient.

In 2014 the American College of Emergency Physicians published guidelines discouraging cranial CT and MRI to determine syncope's etiology. The American Board of Internal Medicine adopted this as part of their "Choosing Wisely" campaign.[21] Despite this recommendation discouraging cranial imaging, our study results show that CT and MRI are still widely used

during the workup of syncope, yet only 0.82% of CT patients and 0.99% of MRI patients who received imaging had positive findings. (**Table 4**) These incidental findings can have certain implications, such as a false-positive result. MRI may be the preferred modality for imaging of the brain over CT. The prevalence of an asymptomatic cerebral infarction, or silent brain infarction (SBI), in the general population has been demonstrated to range between 10 to 20%.[22] MRI can detect these lesions and detect lacunar infarcts common in the general population that may not be the cause of syncope. With the relatively high prevalence of such lesions, it may be reasoned that the superior imaging capabilities of an MRI are, in fact, a limitation in the pursuit of a genuinely cost-conscious, accurate workup for the syncopal patient.

It is essential to consider possible confounding variables when analyzing physicians' orders during the workup of syncope. It is possible that the physician ordered a carotid ultrasound, not to evaluate the cause of the syncope, but rather to investigate a different complaint such as dizziness. Patients who are classified as "trauma" status after collapse secondary to syncope frequently receive head imaging. In these instances, the Canadian CT Head Rule may be used to assess cranial imaging necessity.[23] It is noteworthy that for any patient over the age of 65, the Canadian CT Head score suggests that imaging may be useful.[24,25] Our study does not distinguish between tests ordered to find the etiology of syncope versus tests ordered to assess trauma. However, the low diagnostic utility has also been demonstrated in the population of trauma patients.[15,26]

Of all the testing modalities, carotid ultrasound had the highest positive findings (4.84% in those receiving the test). Previous studies have demonstrated that the prevalence of asymptomatic carotid artery stenosis in men ranged from 0.2% to 7.5%, a finding which correlated positively with age.[27] As our sample's mean age was 55, serious consideration should be given as to whether the discovery of carotid artery stenosis was genuinely responsible for the syncopal episode. Although the low cost, lack of radiation exposure and efficiency may be appealing, the current guidelines discourage ordering it.[13,28-30] Despite this data, carotid ultrasound remains a commonly requested test.[31]

It is not surprising that the presence of positive test results for some testing modalities was statistically significant. For example, it should be expected that a significantly higher number of patients who received a CT scan will have a diagnosis of hemorrhage, mass, acute ischemia or infarct compared to patients who did not receive a CT. However, as described above, the overall number of patients who had positive findings is still low compared to the number of patients who received testing.

TTE was the least ordered test and had the lowest positivity rate in our study. However, it is important to note symptoms in our study did not stratify patients. Current recommendations suggest risk stratifying patients for cardiogenic syncope through history, physical exam and EKG.[32] TTE has also been shown to be beneficial in patients who have elevated brain natriuretic peptide levels and an abnormal EKG, as it can be used to evaluate for the presence of structural heart disease.[33] Patients with a normal EKG and a non-suspicious history and physical exam do not need a TTE, as it has low diagnostic utility and can increase the cost of admission by more than 20%.[34]

As with TTE, the physician should consider ordering a stress test or tilt table test based on the baseline EKG and initial evaluation. The ACC, AHA and HRS recommend a stress test if cardiogenic syncope is suspected and tilt table testing if reflex syncope is suspected.[6] Neither was shown to have significant diagnostic value in our study. However, they have demonstrated utility in unexplained syncope cases, and the ACC has listed unexplained syncope as an indication for tilt table testing.[35-37]

Two studies have compared the diagnostic yield of less costly measures, such as orthostatic blood pressure measurement, thorough history taking and examination and/or baseline EKG versus the various more extensive diagnostics used in the workup of syncope.[29,38] The highest yielding test in both studies, postural blood pressure measurements, was one of the least expensive. Additionally, these studies found that extensive diagnostic imaging and workups provided minimal effect on diagnosis or management.[29,38]

Although our study discourages costly testing modalities, it is crucial to consider that syncope is not a dismissible, benign event. Syncope of all etiologies is associated with a risk of cardiovascular death.[39] This risk may be the impetus for extensive diagnostic workups. Certain factors such as palpitations before a syncopal episode, stigmata of heart failure or ischemic heart disease and syncope associated with exertion are all associated with poor outcomes.[40] However, it should be noted that risk stratification can be obtained via history taking. Diagnostic accuracy using only the history, physical and an EKG is relatively high amongst physicians.[41]

The financial implications of extensive workup on the patient and the healthcare system also need to be considered, especially when it is not justifiable and of low yield. Many of these tests are done as part of practicing "defensive medicine" to limit liability. The fear of litigation that accompanies a missed case seems to be the culprit of this practice. This impetus could perhaps be mitigated by a unified message from the medical community that a missed case is unfortunate but not a justification to perform an extensive, expensive workup. This should then be reflected in the standard of care to avoid liability issues.

Our study has limitations, and it should be noted that a patient's positive finding does not necessarily support an etiology of syncope. For example, a patient who was found to have a mass on the head CT may not have had syncope secondary to the mass. Instead, the patient may have had a vasovagal event leading to syncope, and the mass was an incidental finding during workup. The positivity rate may also have been falsely overestimated, as in some cases a positive finding may have been unrelated to the cause of syncope. As discussed previously, our patients were not stratified by symptoms, and this does not allow us to determine a test's positivity rate based on the type of syncope. Stratification was not performed as our study was primarily interested in the workup during the initial stages of admission, and the potential for miscategorization of syncope could have been a source of error in the results. Our study also excluded exercise stress testing due to its lower utility in the inpatient setting. Electroencephalogram was also not included in the study, but further studies should include it as it is a somewhat commonly ordered test. Another potential limitation is the fact that our study used average reimbursement rates across multiple states, as Medicare reimbursement rates vary by state.

Conclusion

Patients presenting with syncope often receive unnecessarily robust testing. Our study finds that costly tests continue to be a typical care pattern in syncope patients, despite current guidelines and research showing little diagnostic benefit. The $33 billion wasted on these unnecessary workups could be better spent on many healthcare areas in desperate need of attention. Ultimately, risk stratification can be obtained at a lower cost through history and physical examination. This risk stratification can be used to guide appropriate and cost-effective therapy.

Conflicts of Interest

The authors declare they have no conflicts of interest.

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