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General Pediatrics (T Shope, Section Editor)

Syncope for the General Pediatrician

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Opinion statement

Pediatric syncope is a common complaint in the primary care, emergency department, and specialty care setting and is often unsettling to patients and providers alike as a symptom of conditions causing sudden death. In all cases, syncope should be thought of as a symptom rather than a diagnosis and explored with a thorough history and physical. Thankfully, the majority of syncope in children and adolescents is not cardiac in origin and carries no increased risk or association with sudden cardiac death. The majority of life-threatening or cardiac causes of syncope can be differentiated on the basis of history alone. Most concerning symptoms associated with cardiogenic syncope are identified at the time of presentation without extensive testing or referral to specialists. Physical examination and ancillary testing are usually of limited benefit in the initial diagnosis; however, cases with concerning symptoms or uncertainty require further investigation, typically through referral to cardiologists. The majority of pediatric syncope is caused by benign common fainting, also referred to as reflex, vasovagal, or neurocardiogenic syncope, which can and should be treated with reassurance and mild lifestyle modifications only. A minority of syncope is cardiogenic and occurs from three general mechanisms: outflow obstruction, arrhythmia, and myocardial dysfunction. Cardiac causes of syncope are potentially life-threatening and must be excluded during the evaluation. The goal of the primary care evaluation of syncope should be to discriminate common fainting, which almost never requires specialty care, from cardiogenic syncope.

Introduction

Syncope, is a symptom rather than a discrete diagnosis, typically defined as a transient loss of consciousness and tone due to global cerebral hypoperfusion with short duration and spontaneous and complete recovery [1]. As a symptom, syncope should be evaluated with a thorough history and physical and occasionally targeted laboratory and imaging investigations directed by the findings. In general, investigations are of low yield for

children with common fainting and may lead to false positives that beget additional testing. While there are many causes of syncope, the major cause of pediatric syncope is the benign common faint (also known as neurocardiogenic syncope, vasovagal syncope, or reflex syncope). The main differentiation that must be made in the acute and primary care settings is the distinction between more dangerous cardiogenic and neurologic causes of syncope and common fainting. Additional causes of pediatric syncope include coma, trauma, aborted sudden death, seizure, and psychiatric disorders. These conditions can cause transient loss of consciousness resembling common fainting, at least initially, but will not be further discussed in detail in this report.

Syncope in children and adolescents is common, with a peak incidence in adolescents, and a lower incidence with decreasing age. Children below school age are more likely to have a pathologic cause of syncope and are difficult historians, even in the benign cases. Therefore, they usually require additional evaluation and/or referral. A study of pediatric emergency department visits showed syncope was the chief complaint of 0.9 % of all pediatric emergency presentations, and about 1 in 1000 people will seek medical care for syncope [1–4]. Approximately 15 % of children and adolescents will have at least one episode of syncope before the age of 18. While syncope may be a symptom of conditions that cause sudden cardiac death in children, the high prevalence of syncope should be kept in mind relative to the 1 in 100,000 incidence of sudden cardiac death. Resolving the overlap between a high incidence of symptoms and a low incidence of sudden death remains a clinical challenge.

Common fainting, the most common and benign cause of syncope is discussed first to help differentiate it from the pathologic varieties. Regardless of the term used to describe common fainting (i.e., reflex syncope, neurocardiogenic syncope, or vasovagal syncope), the underlying mechanism is an exaggerated reflex arc resulting in cerebral hypoperfusion. The initiation and propagation of this reflex produces fairly consistent and typical prodromal symptoms. Recognition of typical prodromal symptoms and historical features in the absence of "red flag" signs and symptoms (Table 1) will allow the primary care provider to accurately triage the etiology of syncope as benign or requiring further evaluation. Understanding the pathophysiology of common fainting will assist the primary care provider with providing reassurance and lifestyle modification advice to affected individuals and families. Common fainting is reflex triggered, and although there are a few individuals with malignant forms with exceptional syncope burden, overall the course is benign and does not represent any significant underlying disease process.

Common fainting is the result of an exaggerated response of the Bezold-Jarisch reflex and requires a trigger [1, 5–7]. The most common trigger is orthostatic stress (i.e., prolonged standing). Other triggers are situational, like cough, sneeze, gastrointestinal events, micturition, postexercise, fear, pain, emotional distress, and blood or other phobic stimuli. In any given individual, the triggers for common fainting are usually consistent (e.g., sight of blood always results in a faint) but may be multiple. Regardless of the trigger source, the Bezold-Jarisch reflex is activated when ventricular preload is reduced (usually by venous pooling in the lower extremities). The resulting decreased cardiac output causes catecholamine release and cardiac stimulation that forcefully contracts an empty ventricle. This forceful contraction is detected by mechanoreceptors, ultimately causing an increase in vagal tone and withdrawal of peripheral sympathetic stimulation resulting in hypotension and bradycardia. Thus, there are two major physiologic mechanisms at work, cardioinhibition resulting in bradycardia and vasodilation (vasodepression) resulting in hypotension.

Individuals susceptible to common fainting often have a presyncopal prodrome with additional trigger mechanisms like orthostatic stress (i.e., getting up too quickly). While syncope refers to a complete loss of posture and tone, presyncope is the term used to describe the typical prodrome of reflex-mediated syncope. Presyncope is the prodrome without the faint; it is perhaps best thought of as an aborted or attenuated reflex response.

Common fainting always has prodromal autonomic symptoms before the faint, occurs with upright posture, and never occurs during exercise, although it may occur shortly after stopping exercise. Autonomic prodromal symptoms include tunnel vision, vision dimming, constriction of visual fields, feeling warm, dizziness or lightheadedness, and tinnitus. People who have a common faint typically do not injure themselves because they experience the prodromal warning. When they awaken after a brief loss of consciousness, they usually feel quite poorly and may appear pale; it often takes several minutes for them to feel "back to normal." Bystanders commonly observe the child experience a convulsion during common fainting due to cerebral hypoxia. However, these convulsions are not epileptiform in

Table 1. History features and "red flags" to differentiate common fainting from cardiogenic syncope

Favors common fainting	Favors cardiogenic syncope
Prodromal symptoms (lightheadedness, dizziness, nausea, sweating, vision changes, or tinnitus)	No prodromal symptoms
During prolonged standing, immediately after standing, or following a noxious stimulus	Occurs during exercise or following acute arousal or loud noise
Following rapid temperature change (i.e., getting out of warm shower/bath)	Associated with palpitations
Following micturition, coughing, stretching, hair brushing (scalp manipulation), or straining	Abnormal electrocardiogram
	Abnormal cardiac exam
	Injured as a result of faint or requires resuscitation

origin and can be distinguished from epileptiform seizures by the lack of urinary incontinence and postictal period.

As mentioned previously, common fainting can be primarily vasodepressor (predominantly hypotensive) or cardioinhibitory (bradycardic), but is often mixed. Tilt-table testing was previously used to distinguish the two types and is still often requested by primary care providers. Except in truly extreme cases, identifying the common fainting subgroup has no clinical relevance with regard to management, follow-up, or outcome [1, 4, 5]. In individuals with a large syncope burden and concern for primary cardioinhibitory type, implantable loop recorders (ILR) may be beneficial to identify patients that could benefit from pacemaker therapy (see assistive devices below). Most pediatric cardiology offices no longer maintain the equipment required for tilt-table testing in light of its lack of utility.

In contrast to common fainting, the more rare cardiogenic syncope is potentially life-threatening and requires intensive evaluation, management, and follow-up beyond reassurance and lifestyle modification. Cardiac syncope can be broadly divided among three basic mechanisms: primary arrhythmia, outflow obstruction, and myocardial dysfunction; all of which may result in cerebral hypoperfusion leading to the symptom of syncope.

Unlike benign causes of syncope, cardiogenic syncope is typically abrupt or with only a warning of brief palpitations and often requires an intervention to arouse the patient. Interventions may not always be required, however. Any syncope that occurs during exercise requires further evaluation. Unfortunately, and the cause of much consternation in the athlete screening debate, many individuals with cardiac syncope will have a normal physical examination and electrocardiogram (ECG). Identification of the trigger, circumstances, and prodrome of a syncope episode is most clinically useful in separating cardiogenic syncope from common fainting. A family history of sudden death or an abnormal cardiovascular examination should also elicit concern for cardiac causes of syncope and prompt additional investigation.

Syncope from cardiac arrhythmia is most commonly due to ventricular arrhythmias associated with channelopathies. Typical supraventricular tachycardia almost never causes syncope in otherwise normal individuals. The cardiac channelopathies include long QT syndrome (congenital and acquired), catecholaminergic polymorphic ventricular tachycardia, Brugada syndrome, arrhythmogenic right ventricular cardiomyopathy, and short QT syndrome and represent a group of diseases in which there is an increased risk of spontaneous ventricular arrhythmias. Extremely fast heart rates with little filling time result in decreased cardiac output and eventually cerebral hypoperfusion. During an arrhythmia, these children usually experience syncope without a prodrome that would be experienced by a child with common fainting. If the child requires an intervention (e.g., electrical or chemical cardioversion) to terminate the arrhythmia, the symptom should be called aborted sudden death rather than syncope. Syncope in Wolff-Parkinson-White syndrome is not associated with typical reentry supraventricular tachycardia (ECG: narrow complex and regular); rather, it is due to an uncontrolled atrial tachycardia (i.e., atrial fibrillation) resulting in

ventricular arrhythmia. In the latter case, the ECG will show a wide-complex irregular tachycardia. Bradyarrhythmia may cause syncope from sudden or paroxysmal heart block (as in Lyme carditis).

Cardiac syncope from outflow obstruction (hypertrophic cardiomyopathy, aortic stenosis) and myocardial dysfunction (myocarditis, other cardiomyopathies) present in a similar fashion to syncope from arrhythmia, with abrupt, unheralded syncope. The vital signs, physical examination, and ECG are usually abnormal in this population.

Laboratory studies and investigations have limited utility and cost effectiveness in the management of pediatric syncope. The only study that should be obtained in every patient with syncope is a 12-lead ECG. The ECG should be assessed for evidence of channelopathies (QT interval, Brugada pattern, epsilon wave), ventricular preexcitation (Wolff-Parkinson-White), increased voltages (ventricular hypertrophy), and conduction abnormalities. Not all people with cardiac syncope will have an abnormal ECG, but further investigation is warranted in those that do, even with an otherwise benign sounding history. Blood tests and tilt-table testing usually do no aid in the diagnosis and management of pediatric syncope. Ambulatory ECG monitoring may be helpful in individuals with frequent syncope and symptoms questionable for arrhythmia.

Case 1

Samantha, a 6-year-old girl, presents to clinic in follow-up from an emergency department visit the previous evening for syncope. Her mother tells you that yesterday she was playing her final youth soccer game of the season. After she scored a goal in the closing minutes of the game, she sprinted toward the sideline and collapsed in mid-stride. She was unconscious for about 2 min and was described as being limp and pallid. She suddenly recovered and asked to get ice cream for scoring her goal prior to presentation to the emergency department. This was her first faint. Her vitals, physical examination, and family history are normal. An electrocardiogram obtained in the office shows normal sinus rhythm, normal axes, normal voltages, and a corrected QT interval of 490 ms.

Case 2

Tricia, a 16-year-old girl is brought back to the adolescent clinic for fainting 5 min after leaving a routine clinic appointment. She states that she was feeling fine before the visit, but started to feel nauseous and hear a buzzing sound following sequential administration of a PPD skin test and HPV vaccine. The symptoms intensified when she stood up to leave from the procedure, and she reports being able to "power through them" for the checkout process until she got to the parking lot where she experienced dizziness and tunnel vision and lowered herself nearly to the ground prior to fainting. She awoke quickly according to her mother but still does not feel well. She tells you that she skipped breakfast this morning and has had about 8 oz of fluid today. She often sees spots when first standing from a seated or supine position and has fainted previously, experiencing similar symptoms in a hot, crowded, church pew.

Treatment

Case 1 (continued): Samantha's story is concerning because she fainted playing soccer. Her young age, syncope during exercise, syncope following a strong emotional stimulus, inability to protect herself during the faint (suggesting no prodrome), duration of the episode, and the prolonged QT interval all indicate specialty consultation is required for possible cardiogenic syncope.

Specialty referral often causes additional stress for the patient and family. Primary care providers may be able to mitigate some of this additional stress through managing expectations for the consultation. Testing performed by the consultant will be individualized for the child, with the only certainty an ECG. Explaining to the family that "a number of testing options are available and will be individualized as needed" is usually better than telling them what tests to expect. There is often a great deal of anxiety or mistrust when an alternate test or

particularly when no additional testing is done by the specialist. Depending on the situation, a cardiologist may choose to perform echocardiography, exercise stress testing, ambulatory ECG monitoring, cardiac magnetic resonance or computed tomographic imaging, or lab studies including genetic testing. However, aside from the baseline ECG, not one testing strategy is appropriate in all cases.

Case 2 (continued): Tricia's presentation, fainting after having two painful injections, is a classic case of common fainting. She experienced typical situational triggers, autonomic prodrome warning of impending syncope, brief duration of the event, recovery without intervention, and had a history of similar events with a consistent prodrome. This case would not require specialist consultation and can be managed with lifestyle modification and reassurance.

In contrast to cardiogenic syncope, common fainting can be safely and effectively managed in the primary care office. The following discussion of treatment will focus on common fainting as it relates to primary care with additional mention of expectations for referral and some more specialized and novel therapies for interest and to emphasize the pathophysiology of the condition.

Diet and lifestyle

- Reassurance is often all that is needed for the infrequent fainter and reassurance should be provided in all cases.
- Recognition of an individual's prodrome symptoms and triggers for common fainting are important for avoidance, recognition of oncoming syncope, and to allow for initiation of physical countermeasures to attempt to abort the syncope.
- Increased salt and water ingestion helps to reduce the acute preload deficiency that triggers common fainting.

Reassurance

Once a clear and complete history has been obtained supporting a diagnosis of common fainting, the first and most important intervention is reassurance, particularly that the symptom is not being driven by significant pathology. However, in delivering such reassurance, healthcare providers must be careful to avoid the appearance of being dismissive or flippant about a symptom that is particularly bothersome, scary, and affects the quality of life.

Symptom recognition

Common fainting is universally heralded by a prodrome, though the duration and symptoms differ between patients and may often differ between episodes in the same patient. Patients and families should be counseled to recognize the prodrome and any precipitating factors (i.e.,

pain, temperature change, sight of blood, etc.). Avoidance, or at least recognition and mitigation, of noxious precipitating factors are recommended and usually helpful.

Fluid therapy

Given the decreased cardiac preload triggering the Bezold-Jarisch reflex leading to common fainting, fluid therapy has been a mainstay for the management of common fainting and orthostatic intolerance. No studies are available that clearly define the salt and fluid goals for children and adolescents with frequent syncope. However, one study of children with common fainting started with a minimum of 64 oz of fluid daily (no caffeinated fluids which promote diuresis) [8]. A common clinical goal is to have patients increase their fluid intake until the urine becomes clear. Occasionally, over-exuberant families will take a "more-is-better" approach and return for follow-up reporting liters of daily water intake. While clinically significant hyponatremia is uncommon, when presented with the really motivated family, clinicians should remind these families that more is not necessarily better. It is often helpful to provide a note to the school requesting that the patient be allowed to carry a water bottle and permitted frequent restroom breaks. If there is no medical contraindication, salty snacks or light salting of food can be recommended. There is no clear dose of salt, but 2–3 g is probably sufficient in most children.

Pharmacologic treatment

- Drug therapy for syncope has been designed to counteract the two pathophysiologic mechanisms leading to syncope—the vasodepressor effect (hypotension) and cardioinhibition (bradycardia).
- No medications have an FDA approved indication for the treatment of syncope in children.
- The most commonly used medications are listed in Table 2; however, there is no clear evidence to support the use of any medication for syncope, and care must be taken to avoid polypharmacy which has become an unfortunate trend in some children and adolescents with multiple autonomic symptoms (i.e., in postural orthostatic tachycardia syndrome).

Fludrocortisone

Fludrocortisone is a mineralocorticoid administered with the goal of improving preload via renal salt retention and volume expansion and is perhaps the most commonly used medication for common fainting in children and adults [1]. Fludrocortisone was evaluated for syncope in

Table 2. Commonly used medications

Medication	Dose	Contraindications	Major interactions	Cost
Fludrocortisone [9]	0.1–0.3 mg once daily	Systemic fungal infection, hypersensitivity to fludrocortisone or other corticosteroids	No major interactions with commonly used pediatric medications are known	Approximately $15/month
Midodrine [10, 11]	2.5–15 mg two to three times daily	Cardiac disease, hypertension, renal insufficiency, pheochromocytoma, thyrotoxicosis	Ergot derivates, MAO inhibitors	Approximately $20/month

children in a small double-blind trial and showed no benefit [9]. With long-term use, stress-dose steroids may be required in emergencies and intraocular pressure should be monitored annually. Rare but potentially important adverse events include hypothalamic-pituitary-adrenal suppression (typically at high doses), immunosuppression, osteoporosis, and mood disturbance.

Midodrine

Midodrine is an alpha-receptor antagonist which increases blood pressure and improves symptoms of orthostatic hypotension. One pediatric study of midodrine for common fainting showed a decrease in syncope recurrence [10]. However, a more recent crossover study failed to show a benefit [11].

Other medications

Selective serotonin reuptake inhibitors and beta-blockers are commonly prescribed for recurrent common fainting [1]. Trials are equivocal, and there is insufficient data to support the use of either for fainting in children and adolescents.

Interventional procedures

- Cardioneuroablation is a recently described intervention with the goal of syncope reduction but should still be considered experimental and only performed in a small number of centers. It is included here for interest only.

Cardioneuroablation utilizes the same technologies as radiofrequency ablation of cardiac arrhythmias to ablate the atrial ganglionic plexi and abort the syncope reflex [12, 13]. While the initial reports are encouraging, the benefits

have not been confirmed in larger trials. This procedure should still be considered experimental, and it is only performed in a few centers. No major adverse events were reported related to the ablation procedure.

Assistive devices

- Permanent cardiac pacing has been utilized to counter the bradycardia or asystole in the syncope reflex loop. Though studies have been equivocal or had methodological problems, more recent studies suggest specific pacing modes and algorithms reduce syncope in carefully selected patients.
- Permanent pacing is a reasonable strategy for syncope without clear provocation and a cardioinhibitory response of greater than 3 s (Class IIa, level of evidence C) [14].
- Implantable loop recorders (ILRs) may be helpful in the diagnosis of syncope with unclear prodrome or complicating factors.

Permanent cardiac pacing

The potential utility of pacing in syncope is to attempt to counteract the exaggerated bradycardia (occasionally asystole) known as the cardioinhibitory component in common fainting. Permanent cardiac pacing for common fainting has been explored in a number of trials with varied results both supporting and not supporting its use [15–22]. In general, the initial studies showed a reduction in syncope events in the paced groups but suffered from methodological problems. Additionally, all used a cardioinhibitory response to head-up tilt test as a criterion for enrollment and pacemaker implantation; however, tilt testing has been shown to have a poor correlation to clinical cardioinhibition. The VPSII and SYNPACE trials included implantation in all enrolled subjects, who were then randomized to pacemaker on versus off. In these groups, the recurrence rates for syncope were equivalent [18, 19]. More recent trials compared pacemaker on versus off in patients with syncope and asystole following adenosine or documented asystole during a clinical event by ILR. These studies showed a significant reduction in syncope burden, suggesting these are better selectors for clinical response prediction than tilt testing [21, 22]. Specialized closed loop circuits and rate smoothing algorithms show promise in syncope reduction for the extreme cases requiring permanent pacing [20].
Current pacing guidelines endorsed by the Heart Rhythm Society and the American College of Cardiology give a class IIa recommendation for pacing in common fainting as being "reasonable for syncope without clear, provocative events and with a hypersensitive cardioinhibitory response of 3 s or longer [14]." Pacing is not recommended for hypersensitive cardioinhibitory responses with vague or no symptoms or for situational syncope when the trigger can be avoided (class III) [14]. Care should be taken to recognize that pacing is extreme therapy for syncope in children and adolescents, and the guideline recommendations do not discriminate between adults and children. Studies of pacing for syncope have not

included children, and the consequences and long-term complications of pacemakers in children are not negligible.

Implantable loop recorders

Though not truly an assistive device, ILRs are cardiac rhythm monitoring devices that may be implanted for a number of indications. In syncope of unclear etiology, ILRs may be useful in differentiating syncope from primary arrhythmia or common fainting. As described above, a hyperexaggerated cardioinhibitory response detected by ILR in a clinical syncope may help discriminate pacemaker responders versus nonresponders [22].

Physical/speech therapy and exercise

- Individuals with enough prodromal warning of syncope can reduce their syncope burden through the use of muscle-tensing maneuvers which can easily be taught in the primary care office or in consultation with a physical therapist.

Physical countermaneuvers

Physical countermaneuvers that involve the tensing of muscle groups in the arms and legs have been shown to reduce syncope burden if used early in the prodrome period [23–25]. As the effect of gravity is a major contributor to syncope, the easiest of these countermaneuvers is assumption of a supine position. However, there may be social or safety hurdles to this approach in a variety of situations in children and adolescents. Leg crossing and tensing of the abdominal and thigh muscles has been shown to be effective in aborting episodes of common fainting [26, 27]. Similar benefit has been shown with arm tensing [25]. Isometric handgrip is also thought to be useful, but has not been as well studied. Moderate aerobic and isometric exercise is recommended to assist with conditioning for physical countermaneuvers.

Pediatric considerations

- Driving safety should be considered when evaluating the teenager with syncope.
- Practitioners should be familiar with local statutes and regulations regarding driving following syncope.

- Restrictions on driving for the teenager with cardiac syncope should be made in consultation with the cardiologist.

Driving restrictions

Restrictions on driving following an episode of syncope vary based on local regulations and statutes, and practitioners are highly encouraged to be aware of local regulations. In areas where no local statutory guidance is given, one should use their best clinical and ethical judgment in determining safety to operate a vehicle. The American Heart Association (AHA) and Heart Rhythm Society (HRS) have published basic guidelines, but they are based on consensus opinion only and may not be in line with local regulations [28, 29]. The AHA and HRS recommend no restrictions for the first episode of, or mild and infrequent, common fainting. For severe symptoms undergoing treatment, 3 weeks of restriction is recommended and complete restriction for untreated severe or severe and refractory common fainting [28, 29]. Restrictions are often different for commercial driving, but this not typically a concern for adolescent drivers.

Conclusion

In summary, pediatric syncope is a common and usually benign symptom. Acute and primary care clinicians can distinguish common fainting from cardiogenic causes of syncope by the history, physical exam, and ECG. Clinicians should be aware of various treatments for common fainting and indications for referral.

Compliance with Ethics Guidelines

Conflict of Interest
Ben Blevins declares that he has no conflict of interest.

Human and Animal Rights and Informed Consent
This article does not contain any studies with human or animal subjects performed by any of the authors.

Disclaimer
The views expressed in the article are those of the author and do not necessarily reflect the official policy or position of the Department of the Navy, Department of Defense, or the US Government.

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