Childs Nerv Syst (2016) 32:427–436
DOI 10.1007/s00381-015-2988-8

REVIEW PAPER

Current approaches to the clinical assessment of syncope in pediatric population

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Received: 5 December 2015 / Accepted: 21 December 2015 / Published online: 5 January 2016

Abstract
Introduction Syncope is one of the most common clinical problem in children. This disorder is characterized by transient, spontaneously self-terminating loss of consciousness with brief duration and complete recovery. This situation is usually alarming for the families of patients. The mechanism of syncope is transient global brain hypoperfusion to levels below those tolerated by cerebrovascular autoregulation. Syncope can occur with many different etiologies in the pediatric population.
Classification Syncopes are divided into three major categories as neurally mediated syncope, cardiovascular-mediated syncope, and non-cardiovascular syncope.
Clinical features The major challenge in the assessment of children with syncope is that most children are asymptomatic at the time of their presentation, therefore making a careful and detailed history and a comprehensive physical examination essential in all patients. A trigger stimulus is detected in some cases, and this is an important clinical clue for the diagnosis. Cardiac causes of syncope in children are rare but can be life threatening and have the highest risk of morbidity and mortality. Misdiagnosis of epilepsy is common in patients presenting with syncope; therefore, the differential diagnosis between epileptic seizures and syncope is very important. It should be remembered that the evaluation of syncope in children is costly and diagnostic workup has a limited diagnostic yield.
Conclusion The aim of this article is to present different types of syncope and to provide new practical clinical approaches to the diagnosis, investigation, and management in the pediatric population.

Keywords Syncope · Children · Classification · Management · Treatment · Economic impact

Highlight Syncope is one of the most common clinical problem in children. It can occur with many different etiologies. Cardiac causes of syncope in children are rare but can be life threatening. The differential diagnosis between epileptic seizures and syncope is very important. We present current approaches to the clinical assessment of syncope in pediatric population.

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Introduction

Syncope is a transient self-limiting condition involving a brief loss of consciousness and postural tone, lasting from 8–10 s to 1–2 min. The word syncope originates from the Greek word "synkoptein" which means to cut short. It involves a loss of cerebral function due to a lack of energy substrate, followed by rapid spontaneous recovery without neurologic deficits. Frequent reasons for loss of cerebral function can be summarized as follows: loss of blood volume, decreasing oxygen capacity of blood, low blood glucose, hypotension, loss of vascular tonus, insufficient cardiac systole, and stenosis of brain vessels [1–5]. It occurs at any age, with different frequencies and different etiologic factors

[1–5]. The most common cause of syncope in adults is cardiac disease. However, functional disorders are seen more commonly in the childhood period, such as vasovagal syncope, orthostatic hypotension, hyperventilation, and breath-holding spells. Asystole and anoxia may stimulate epileptic convulsions, and ictal asystole during epileptic convulsions may also trigger syncope [2]. The most frequent reasons for impaired consciousness apart from epilepsy are breath-holding spells and syncopes.

Classification

Syncopes are classified as neurally mediated (vasovagal, situational, carotid sinus hypersensitivity, glossopharyngeal syncope), cardiogenic (arrhythmias, functional heart, vascular problems), and non-cardiogenic ones (orthostatic hypotension, neurologic, metabolic, endocrine, psychogenic, drug associated) [4, 6–9]. The classification and etiology of pediatric syncope are summarized in Table 1.

Epidemiology

Approximately 30–50 % of children have syncope at least once in their lives till the adolescent period, and most of them are girls. One in every 2000 admissions to children's emergency departments presents with syncope [10, 11]. The rate of syncope in the 15–17-year-old adolescent group was reported as 9 %, and this ratio increased to the end of adolescent period [12, 13]. The peak incidence of syncope in children appears at around the age of 15–19 years with a higher rate in girls [10–13]. Syncope frequency was reported as 15 % in children under 18 years old [14]. The syncope incidence in children and adolescents was found as 86.5/100.000 [15].

Clinical features

Sudden transient loss of consciousness is mostly caused by epileptic seizures and psychological events. Migraine, transient ischemic attacks, and severe vestibular dysfunctions are less common [16]. All events resulting in cortical hypoxia and anoxia may lead to syncope. Prolonged standing, hot weather, emotional stress, and any painful or unpleasant stimuli may trigger syncope. Even having a hot shower, stretching early in morning, or tearing a strand of hair may lead to syncope in children. Prodromal symptoms such as nausea, vomiting, lightheadedness, and weakness may be seen. Some cases may feel extremely hot, cold, or sweaty. Hyperventilation, yawning, tinnitus, and visual symptoms such as lights seeming too bright, fuzzy, or tunnel vision have also been reported before syncope onset [1–5, 7, 17–20]. Some patients with recurrent attacks may be aware of symptoms and thus may avoid falling down, but they do not remember the moment of fainting. A small number of patients can remember the early

Table 1 The classification of syncope in childhood

Neurally mediated syncope
1. Neurocardiogenic (vasovagal)
   - Emotional stress induced (pain, fear, blood phobia, etc.)
   - Orthostatic stress induced
2. Situational syncope
   - Respiratory (cough, sneeze, laugh, head turning)
   - Gastrointestinal stimulation (swallowing, defecation, postprandial)
   - Post micturition
   - Post exercise
   - Others
3. Carotid sinus syncope
   - Presence of mechanic carotid sinus triggers
   - Absence of mechanic carotid sinus triggers
4. Glossopharyngeal and trigeminal neuralgia syncope

Cardiogenic syncope
- Arrhythmias
- Structural heart defects
- Functional heart defects
- Vascular heart abnormalities

Non-cardiogenic syncope
1. Orthostatic hypotensive syncope
   - Primary autonomic disorder
   - Secondary autonomic disorder
   - Drug-induced orthostatic hypotension
   - Hypovolemia related
2. Postural orthostatic tachycardia syndrome
3. Metabolic reasons of syncope
   - Hypoglycemia
   - Hypoxia
   - Electrolyte imbalance
4. Psychogenic syncope
   - Anxiety
   - Panic attack
   - Depression
   - Somatization
5. Drug-induced syncope
   - Antihypertensives, diuretics, barbiturates, tricyclic antidepressants, alcohol, antiarrhythmics, macrolides, antihistamines, antipsychotics, MAO inhibitors, levodopa, prazosin, benzodiazepines
6. Triggered reflex syncope
7. Airway obstruction induced syncope
8. Hyperventilation-induced syncope
9. Neurologic Syncope
   - Cerebrovascular diseases
   - Increased intracranial pressure
   - Migraine

phase of syncope but do not remember the actual moment of falling down. Sudden onset of falling down, progressive decrease in muscle tonus, and loss of consciousness have been seen in these patients. After a couple of minutes, the color and consciousness of the patient returns to normal. Short myoclonic jerks and tonic and clonic convulsion-like movements can be seen during the unconscious period [1–5, 7, 17–20]. A recent study revealed that 50 % of all cases had clonic hand-arm movements and 10 % had urinary incontinency [8]. This situation must be differentiated from a true epileptic seizure. Occasionally occurring tongue injuries do not mean epileptic seizure. On the other hand, hypoxia resulting from syncope may trigger a real epileptic convulsion and this is called an anoxic epileptic seizure. Those with this condition make up a most confusing group [21]. Convulsive movements may lead to a misdiagnosis of seizure by the physician. It was reported that 20 % of patients admitted with syncope had medications for epilepsy [22, 23]. It was shown that 31.8 % of patients were misdiagnosed as having epileptic convulsions [24]. The main clues in the differential diagnosis of epilepsy and syncope are summarized in Table 2. On occasions when the heart rate is less than 40 beats/min or more than 150 beats/min, asystole lasts more than 4 s, systolic blood pressure is less than 50 mmHg, and oxygen pressure is ≤20 mmHg, anoxia may happen and end with syncope [2]. An exact diagnosis cannot be made in more than 40 % of patients with syncope, and they usually recover by themselves; in only less than 1–2 % of sufferers an important underlying pathology was found [5, 16, 25, 26].

Neurally mediated syncopes (reflex syncopes)

Neurally mediated syncope is a heterogeneous group of functional disturbances in which cardiovascular reflexes that are normally effective in controlling the circulation become intermittently ineffective in response to the stimuli, resulting in transient failure of blood pressure control due to vasodilation and/or bradycardia which leads to the development of global cerebral hypoperfusion. The most common neutrally mediated syncopes are neurocardiogenic syncope, situational syncopes, and glossopharyngeal neuralgia syncope syndrome.

Neurocardiogenic syncope

Neurocardiogenic syncope, also known as vasovagal syncope, is the most common cause of syncope and constitutes 61–80 % of all pediatric syncope cases [26]. It is a benign condition characterized by a self-limited attack of systemic hypotension. Stimulation of the intramyocardial mechanoreceptors (stretch receptor or C fiber) is implicated in neurocardiogenic syncope. Vagal C-type nerve fiber impulse from the myocardium is sent to the brain stem, causing a *Bezold-Jarisch reflex*. This reflex leads to the suppression of the sympathetic nervous system, along with stimulation of the brain stem vagal neurons, resulting in paradoxical bradycardia and peripheral vasodilation. This condition leads to a decrease in preload and results in decreased cardiac output [27, 28] (Fig. 1). Therefore, in the first moments of vasovagal syncope, an empty heart is seen on echocardiography. There is an abnormal or exaggerated autonomic response due to various stimuli, the most common of which are prolonged standing, standing up very quickly, and/or excessive emotion. These stimuli result in the pooling of venous blood in the lower extremities. Sudden vasomotor loss of tonus leads to systemic hypotension, bradycardia, and asystole. When patients fall down, effective blood flow to the brain is immediately restored, allowing the person to regain consciousness. If the person does not fall into a fully supine position and the head remains elevated above the trunk, a state similar to a seizure may occur (Table 2). When the patient lies on his/her back, venous return, blood pressure, and heart rate return to normal. The patient then

Table 2 Differential diagnosis of syncope and epileptic seizures

Clues	Syncope	Epileptic seizures
Provocative stimulus	Frequent, typical	Rare (light, noise)
Aura	Frequent (sweating, pallor, visual blurring, nausea, vomiting)	Rare (abdominal pain, odor)
Skin appearance	Typically pale	May be cyanotic (bluing of lips, nails, or skin)
Seen time	Awake	Awake or asleep
Loss of consciousness	Usually less than 1–2 min	Often longer than 5 min
Involuntary movements	Short duration (<15 s), desynchronized arrhythmic	Usually long duration rhythmic, synchronized
Time of involuntary movements	Begin after falling	Begin while standing or after falling
Loss of tonus	Present	Rare
Tongue biting	Rare	Frequent
Incontinence	Rare	Frequent
Recovery	Rapid and difficult to stand before complete recovery	Confusion often prolonged, but stand early in recovery
Symptoms after recovery	Nausea, vomiting, pallor	Pain in muscles

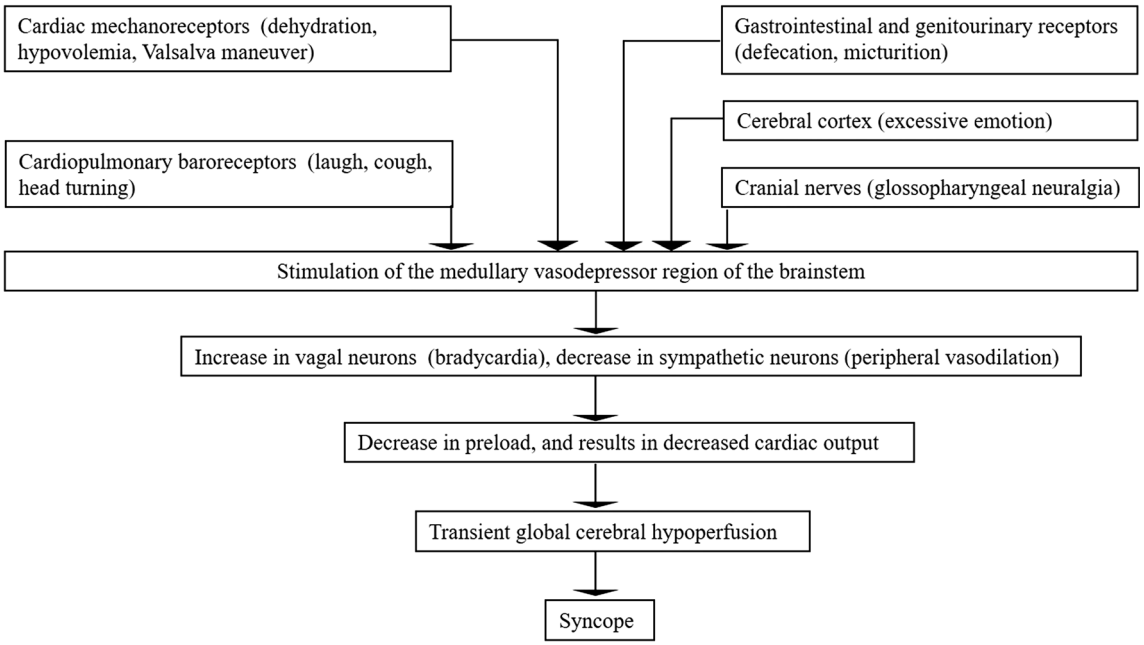

Fig. 1 Pathophysiologic mechanism of neurally mediated syncope

regains consciousness. In a few minutes, children may return to normal activities, but if sufferers try to sit or stand too soon after they regain consciousness, they may pass out again [3, 4, 6–9, 14, 19, 26, 28]. Vasovagal syncope causes anxiety in patients and their relatives, but its character is benign. Therefore, informing patients and their families, to reassure them, is very important.

Stimulation of the medullary vasodepressor region of the brain stem may develop owing to the activation of various receptors, such as cardiac mechanoreceptors, cardiopulmonary baroreceptors, cranial nerves, cerebral cortex, and mechanoreceptors of the gastrointestinal and genitourinary systems (Fig. 1).

Situational syncopes

These are reflex syncopes related to particular kinds of situations (Table 1). Urinating or defecating, weight lifting, laughing, coughing, gastroesophageal reflux, Valsalva maneuver, intubation, and swallowing trigger the autonomic nervous system; due to some reflexive mechanisms, vasodepressor and/or cardioinhibitory response is stimulated and syncope occurs (Fig. 1). It is more common in adults, and there are no prodromal signs [1, 7, 19, 27].

Glossopharyngeal neuralgia syncope syndrome

Glossopharyngeal neuralgia syncope syndrome was first described in 1910 as a pain localized in the tongue and throat, radiating to the ipsilateral ear which leads to short episodes of bradycardia, asystole, and hypotension, after which syncope occurs. It can be idiopathic or secondary to cerebellopontine tumors, laryngeal and rhinopharyngeal tumors [29], parapharyngeal abscesses [30], traumas [31], Paget's disease or skull base tumors [32], or even after carotid angiography [33]. There are various mechanisms in the pathogenesis. The first is cardiac syncope which is caused by irritation of the branch of the glossopharyngeal nerve to the carotid sinus (Hering's nerve), due to adhesions between the bonds of the roots of the vagal and glossopharyngeal nerves [34, 35]. Another is that in which some of the visceral sensory fibers of the glossopharyngeal nerve may come into connection with the fibers of the carotid sinus nerve causing stimulation of the latter, thus activating the baroreceptors of the carotid sinus, resulting in bradycardia, asystole, premature atrial contractions, or hypotension that can lead to syncope [35]. Some antiepileptics like carbamazepine are used to prevent paroxysms of pain; also, temporary and permanent pacemakers may be used to control the syncopal attacks but surgery is the final step in treatment [36].

Cardiovascular syncope

Although a cardiac cause of syncope is rare in children, it has a higher mortality and higher incidence of sudden death. Cardiac diseases constitute 2–6 % of all types of syncope. McHarg et al. [11] reported that only 6 % of 108 pediatric patients had cardiac-originated syncope.

The main cardiac diseases that frequently cause syncope are aortic stenosis, hypertrophic cardiomyopathy, coronary abnormalities, cardiac rhythm problems (Wolf-Parkinson-White syndrome, congenital AV blocks, long QT syndrome), and postoperative conduction problems. Rarely myocarditis, other forms of cardiomyopathy, pulmonary hypertension, and aortic dissection in Marfan's syndrome may also cause syncope [1–9, 11, 13, 14, 18, 19, 25]. Bradycardia can be caused by sinus node dysfunction and atrioventricular conduction disorders. Tachycardia may be the result of paroxysmal supraventricular tachycardia, ventricular tachycardia, and fibrillation. Drugs and electrolyte imbalances may lead to cardiac rhythm problems and end with syncope. The main etiologies of cardiovascular syncope in childhood are summarized in Table 3. A detailed medical history, physical examination, and ECG are among the most important steps for the definite diagnosis and prognosis. Bricker et al. [37] suggested that ECG should be taken with an EEG recording in every patient that described a sudden loss of consciousness. A 24-h ECG monitoring (Holter) and ECG recording during exercise were recommended by Nousiainen et al. [38] in patients who had syncope and sudden cardiac death history in their families.

Table 3 Etiologies of cardiovascular syncope in childhood

Arrhythmias
1. Bradyarrhythmias
•Sinus node dysfunction
•Complete atrioventricular block
•Kearns-Sayre syndrome
•Pacemaker dysfunction
2. Tachyarrhythmias
•Supraventricular tachycardia (Wolff-Parkinson-White syndrome)
•Ventricular tachycardia (channelopathies like long QT syndrome, short QT syndrome, Brugada syndrome; drug-induced or catecholaminergic ventricular tachycardias)
Structural heart disorders
1. Hypertrophic obstructive cardiomyopathies
2. Atrial septal defect (Holt-Oram syndrome)
3. Familial arrhythmogenic right ventricular dysplasia
4. Tetralogy of Fallot
5. Cardiac masses
6. Valvular dysfunction (including prosthetic valves)
Functional heart disorders
1. Non-obstructive hypertrophic cardiomyopathy
2. Dilated cardiomyopathy
3. Myocarditis (viral, rheumatic, Lyme disease, Kawasaki disease)
Vascular heart disorders
1. Aortic stenosis
2. Coronary anomalies

Non-cardiovascular syncopes

Orthostatic hypotension-related syncope

A sudden drop in blood pressure or inappropriate increase in relation to heart rate may lead to syncope. Blood congestion occurs in the lower extremities of people who stand still. The autonomic nervous system engages (activation of sympathetic and inhibition of parasympathetic system) when cardiac output and blood pressure decrease. Heart rate, peripheral vascular resistance, cardiac output, and finally, blood pressure increase. Cerebral perfusion is preserved. Orthostatic hypotension is characterized by decompensation of the decrease in cerebral perfusion. Having a systolic blood pressure <90 mmHg or a >20 mmHg drop is accepted as a pathologic finding. Orthostatic hypotensive syncope is triggered by conditions that decrease venous return like anemia, sweating, and bleeding; hypovolemia associated with gastrointestinal loss with severe diarrhea; dehydration; and the use of drugs that affect orthostatic reflex (phenothiazines, sedatives, nitrates, antidepressants, antihypertensives, calcium channel blockers). The heart rate increases in orthostatic hypotension-related syncope. The main problem is the loss of consciousness due to a sudden decrease in blood pressure. It is more common in adults but has also been reported in children who have a disease that affects the autonomic nervous system, such as diabetic neuropathy, amyloidosis, pernicious anemia, spinal cord injuries, syringomyelia, or Addison's disease [7, 27, 39, 40].

Postural orthostatic tachycardia syndrome

One of the conditions with an unexplained underlying mechanism that ends with syncope during the childhood period is postural orthostatic tachycardia syndrome (POTS). It is a condition in which a change from a supine position to an upright position causes an abnormal decrease in cerebral perfusion but an increase in heart rate [41]. It is more common in adolescent girls.

It is characterized by a heart rate increase ≥30 beats/min from supine to standing (5~30 min) and symptoms that worsen with standing and improve with recumbency. The recently published consensus statement notes that an increase of >40 beats/min should be used for patients in the age range 12~19 years [42]. Symptoms should last ≥6 months, and there should be an absence of other overt causes of orthostatic symptoms or tachycardia (e.g., active bleeding, acute dehydration, medications). The head-up tilt test is the standard diagnostic method to assess a patient's reaction to postural change. This involves placing the patient on a tilt table and measuring blood pressure and heart rate. Then, the table is tilted upright to a 60–80° vertical angle for approximately 45 min and blood pressure and heart rate are again measured,

either continuously or at least every 2~3 min [43]. These patients are usually misdiagnosed as having panic attacks or chronic anxiety. In the literature, there are also reports that there is a direct relation between POTS and Chiari type 1 malformation and symptoms resolved after surgical intervention [44, 45].

Metabolic causes of syncope

Metabolic reasons cause syncope unrelated with posture. Symptoms like light headedness, pallor, and sweating may be seen. Duration of consciousness is longer, and symptoms may persist until the underlying cause is treated. The main metabolic disorders that lead to syncope are hypoglycemia, hypocalcemia, hypomagnesemia, hyperammonemia, electrolyte imbalance, drugs (antihypertensives, diuretics, barbiturates, tricyclic antidepressants, alcohol, antiarrhythmics, macrolides, antihistamines, antipsychotics, MAO inhibitors, levodopa, prazosin, and benzodiazepines), intoxication, anorexia nervosa, hyperventilation, hypoxia, and hypocapnia [7, 19, 27].

Triggered reflex syncope

Gastaut et al. [46] reported that this syncope is most common in intellectually disabled people. It is caused by breath holding and the Valsalva maneuver. After breath holding for a couple of minutes, the child becomes pale, loses tonus, becomes unconscious, and falls down. It is hard to differentiate from absence and atonic convulsions. Holding the breath during expiration and not during inspiration is a discriminative feature that is used to differentiate from breath-holding spells. Aicardi et al. [47] described triggered reflex syncope in girls with Aicardi syndrome and in children with psychologic behavior disorders having normal intelligence. They also reported that diagnosis is made with specific long-term EEG records and that fenfluramine is effective in the treatment.

Hyperventilation-induced syncope

The rate and depth of ventilation increase with anxiety, panic disorders, and depression. Hyperventilation induces hypocapnia, cerebral vasoconstriction, and hypotonicity. This condition is also called hyperventilation syndrome and is more commonly seen in adolescent girls. It is believed that spontaneous hyperventilation plays an important role in loss of consciousness, especially in sensitive persons, in vasovagal syncope. Immink et al. [48] described the relation between hyperventilation-induced hypocapnia and a reduction in cerebral perfusion leading to syncope. Additionally, a reduction in $PaCO_2$ leads to a decrease in peripheral vasomotor tonicity and blood pressure [48]. Tetanic cramps, tingling of the face, headache, chest pain, and dizziness lead to blackout and may provoke anxiety and hyperventilation. If hyperventilation persists, loss of consciousness may occur. Rebreathing into a paper bag may stop the attack, but it is not recommended. This is because deaths have occurred in patients with acute myocardial infarction, pneumothorax, and pulmonary embolism who were initially misdiagnosed with hyperventilation syndrome and treated with paper bag rebreathing. The main therapy involves determining the real problem that causes anxiety and teaching methods that relieve the symptoms [1].

Syncope induced with airway obstruction

This type is rarely seen in children and usually occurs by accident as a result of suffocation. However, sometimes, it is done on purpose by adults, especially by mothers (Munchausen syndrome). The mother usually smothers the child with her breast and syncope occurs [2]. Diagnosis is very difficult, and it is usually only understood after careful and long-term observations or during video-EEG monitoring. The most important fact noted is that in each life-threatening event, the mother is found near her child. Generally, such mothers are seen to be very fond of their children and they can describe the child's symptoms in great medical detail. They deny any accusations against them and may even kill their children if they believe that they are blamed for it.

Psychogenic syncope

This is one of the most common causes of syncope in adolescents. Attacks are more common than in neurocardiogenic syncope, and they can even be seen every day. There is no triggering factor or trauma in the history. Patients usually lie in a supine position after syncope, and they choose where they will fall down. They have normal physical examination and blood pressure. Attacks occur near other people, and no real loss of consciousness is seen. They usually fall down artistically and gently. No physical injury is seen afterwards. There is no hypotension or bradycardia. After careful observation, it is not hard to conclude that the reason for syncope is psychogenic. Respiratory changes, sweating, or pallor is not seen. However, hyperventilation related to anxiety and emotional problems may result in difficulties in respiration, tachypnea, chest pain, and paresthesia. This clinical picture is the result of hypocapnia-triggered cerebral vasoconstriction. Having hyperventilation-associated syncope and the absence of trauma are helpful clues that assist in differentiating psychogenic syncope from other causes. Syncope may be seen during panic attacks, depression, somatization, and anxiety disorders [49].

Neurologic syncope

Although various studies have documented the occurrence of syncope during migraine, the pathogenesis is not well

understood. Prodromal symptoms such as bilateral visual symptoms, dysarthria, vertigo, diplopia, nystagmus, and/or ataxia suggest brain stem or cerebellar ischemia [28]. Increased intracranial pressure can lead to syncope. Cerebral hypoperfusion during the increased pressure is believed to be involved in the pathogenesis. Cerebral venous sinus thrombosis can cause an elevation in intracranial pressure due to inadequate venous drainage. Transient elevations of intracranial pressure leading to syncope are a phenomenon which has been previously described in patients with refractory cerebral venous sinus thrombosis [50].

Evaluation and management

Syncope causes serious anxiety problems in some family members and doctors. A detailed history of the event followed by a comprehensive physical examination will help in the identification of etiological causes. Questions should be asked about triggering factors like painful stimulants, blood puncture, hot weather, hunger, lack of sleep, fever, prolonged standing, micturition, or defecation [4, 7, 8, 19, 20, 25, 26, 28, 49]. In evaluation, the main aim is to decide whether loss of consciousness is related to real syncope or not. Also, it is very important to exclude cardiovascular causes due to a high mortality and high incidence of sudden death. The basal laboratory tests (complete blood count, glucose, electrolytes, urine test, and serum toxin scan) and ECG are usually enough, and there is no need for further investigations for the diagnosis of most patients. The obtained results should be used as a guide for further diagnostic studies in patients with suspected diagnosis. Despite elaborate investigations, in 26–40 % of patients, the etiology still cannot be found [17, 51, 52]. The systemic approach to children with syncope is summarized in Fig. 2.

In the evaluation of patients, it is important to focus on other possible serious etiologies like neurologic and psychiatric disorders. In addition to the information that patients give, specific data can be gathered from the witnesses of the event.

Detailed cardiovascular examination is required for patients that experience syncope during exercise. An electrocardiogram of all patients with syncope must be taken. Cardiac rhythm, corrected QT interval, and heart rate should be evaluated in each patient. It was shown that echocardiography does not help if you do not have suspicious findings in the history and physical examination. The diagnostic value of echocardiography is 0.5–10 % [51–54]. The head-up tilt test was used for the first time in 1986 for the diagnosis of vasovagal syncope. The test is performed with a table tilted to 60–80° for 45 min. If the patient develops presyncope, syncope, or sudden fall, the test result is considered as positive. The test results are evaluated as vasodepressor syncope if the patient developed presyncope, syncope, or sudden fall with blood pressure depression without a significant decrease in heart rate during symptoms, and cardioinhibitory syncope if a significant reduction occurs in heart rate without a decrease in blood pressure. If significant reduction occurs in blood pressure and heart rate, it is defined as mixed pattern syncope. The diagnostic value of the head-up tilt test, which can be applied after 3 years of age, is reported as 41–75 % [55]. However, the repeatability, sensitivity, and specificity of the test are low. The diagnostic value of the Holter test ranges between 0.4 and 19 % [56]. EEG investigation is performed very commonly in the evaluation of patients with syncope. However, the diagnostic value of this test is 1.5 %, which is very low [57]. Neuroimaging is a common method used in the evaluation of syncope. Because of these investigations, syncope evaluation may cost a great deal. The average cost of patients with syncope is $1055, and the diagnostic cost is $6928 in the USA [58].

Treatment

The main aim of the treatment of these patients is to prevent the recurrence of syncope attacks and the mortality risks caused by them [1–4, 6–8, 19, 20, 22, 27, 28]. The initial management is to stabilize the patients, focusing on the airway, breathing, and circulation (ABC). Intravenous access, oxygen administration, and cardiac monitoring should be performed. The patient should be evaluated for metabolic causes and should be treated for the specific cause.

The treatment choices for syncope vary depending on the underlying causes. If the cause of syncope is of vasovagal origin, education for appropriate physical maneuvers to counteract the effects of gravity on the circulation and appropriate hydration is usually sufficient to avoid loss of consciousness. All physical countermaneuvers decrease pooling of venous blood in the lower limbs and abdomen and/or increase peripheral arterial resistance. The main physical counter-maneuvers involve the assumption of a supine posture, elevation of the legs and lowering the head, leg crossing and tensing of the abdominal muscles [59]. Also, patients should keep away from personal and environmental triggering factors [4, 6, 7, 14, 20, 27]. If severe syncope attacks persist, medical treatment may be started after consulting the opinion of a cardiologist. Beta-blockers, mineralocorticoids like fludrocortisone, alpha-agonists, serotonin reuptake inhibitors, erythropoietin, theophylline, clonidine, and scopolamine are the main types of drugs used [3, 7, 14, 28].

Neurocardiogenic syncope is a benign condition that lasts a short time and resolves itself spontaneously. Recurrence of

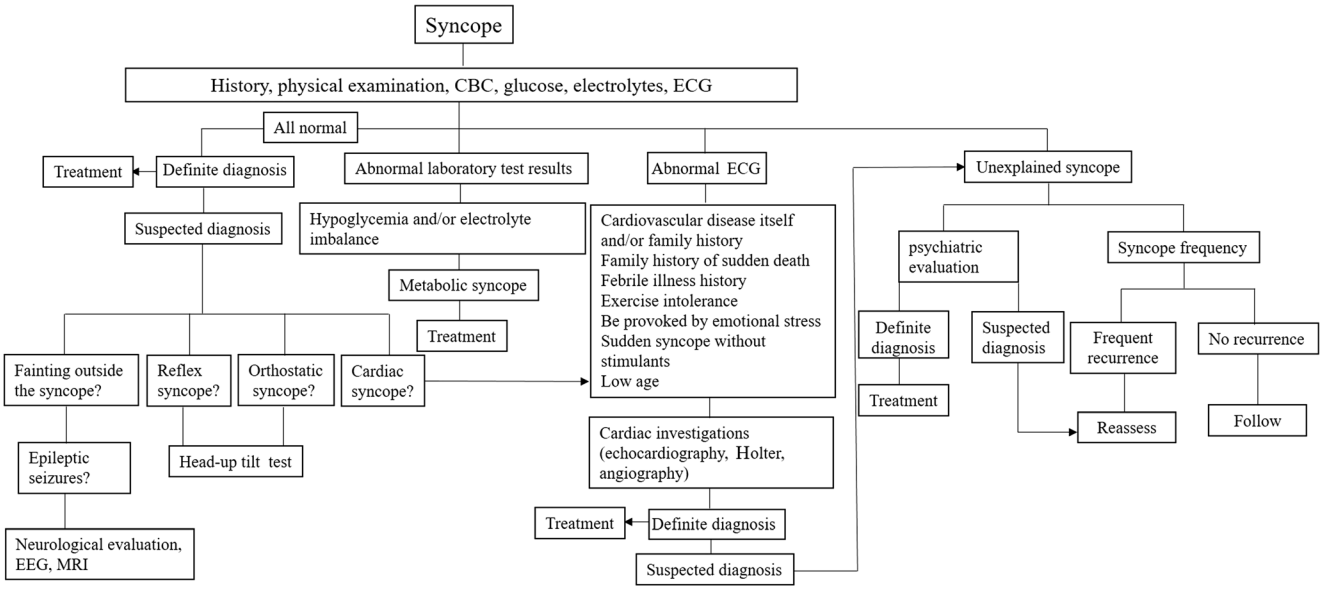

Fig. 2 Systematic approach to syncope in children

syncope in almost all patients can be prevented with simple precautions and pharmacological approaches. However, attacks cause psychological stress to the child and family and daily activities may be restricted because of trauma risk. The family and patient should be informed that this disease has a benign character. The prodromal symptoms of syncope should be emphasized. Also, patients should learn how to protect themselves from trauma caused by sudden falls. They should be reassured by telling them that the risk of sudden death is very low. They should also be advised to they can be relieved by avoiding factors like hunger, prolonged standing, hot weather, and humid climate that can provoke syncope. The first-line non-medical therapy in children is physical exercise. Leg or arm stretching, squatting, and standing on tiptoes increase blood pressure, and therefore, these delay loss of consciousness. Attacks may be lessened by avoiding stress and other triggering factors (hot weather, hypovolemia, prolonged standing), having a comfortable life, drinking enough water, keeping the head elevated during sleep, and using elastic, abdominal bandages and psychological support. Knowing the prodromal symptoms, doing the maneuvers to prevent attacks (lying backwards, some physical maneuvers), avoiding hypotensive drugs and alcohol, and taking additional salt and water in the case of orthostatic hypotension are the main treatment methods [1, 3, 4, 6, 8, 20, 28].

Medical therapy is not thought to be the first choice in children because drugs have many adverse effects and drug usage is always difficult. In uncontrolled studies made in children, the main drugs used for pharmacological treatment besides non-pharmacological therapies are as follows: beta-blockers, scopolamine, fludrocortisone, theophylline, ephedrine, midodrine, clonidine, and serotonin reuptake inhibitors [60–62]. The efficacy of drugs in children is controversial because there are no prospective controlled studies and the natural course of disease is not known. Today, it is accepted that beta-blockers are a first-line safe drug that can be used for this purpose [62]. Patients who use beta-blockers should be aware of the possibility of headache, hypotension, irritability, depression, and suicide attempts. Studies about the efficacy of pharmacological treatment in children are limited in number. Permanent pacemaker implantation was recommended in the case of severe bradycardia that did not respond to medications [61, 63].

Conclusion

Syncope in the childhood period has a wide clinical spectrum. It could be life saving to detect cardiac and some other causes (metabolic, neurologic, drug induced) of syncope. Syncope should be differentiated from epileptic seizures and psychogenic causes. EEG has a limited benefit in the diagnosis, especially when the physician does not consider epilepsy in the light of history and physical examination. ECG is always suggested to rule out cardiac diseases that can cause death. However, echocardiography, head-up tilt test, and Holter monitoring have few benefits in children that have a normal physical examination and history. Therefore, a detailed history should be taken, careful physical examination should be performed, and routine laboratory tests and electrocardiogram must be conducted in every child with syncope. Further laboratory investigations, EEG, head-up tilt test, echocardiography, and Holter monitoring should be performed in selected patients.

Author contributions HP conceived the study. HP, AKB, and OP were involved in the planning, reviewing the literature, and writing of the review.

Compliance with ethical standards

Conflict of interest The authors declared no potential conflicts of interest with respect to research, authorship, and/or publication of this article.

Funding The authors received no financial support for the research, authorship, and/or publication of this article.

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