For the Faint of Heart
Developing a Simple Consistent Approach to Diagnosis of Syncope/PoTS

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The following relationships with commercial interests related to this presentation existed during the past 12 months:

“No relationships to disclose”
No off label usages to be discussed...
Patient One

- Teen girl, previously healthy
- Attending a beauty pageant
- Stood up and left the auditorium
- As she walked through the door she became very dizzy
Patient One

• She blacked out and fell to the floor
• LOC 30-45 seconds
• Tonic-clonic movements
• Upward eye deviation
• No incontinence
• Complete recovery in < 1 minute
Patient One

- Easter Sunday, watching TV
- Stood up to walk out of the room
- She felt very dizzy and lightheaded
- She abruptly lost consciousness and fell to the floor
Patient One

• Once again she had some tonic-clonic movements, her eyes deviated upwards, and she was noted to be very pale

• This episode also lasted about 20 seconds and was followed by a prompt and complete recovery
Patient Two

• 12 year old male with several months history of dizziness when standing.
• Associated racing heart beat lasting for several minutes beyond dizziness.
• Recently seen by ID for chronic fatigue.
• Grades have dropped as symptoms have progressed. He describes his thinking as fuzzy on symptomatic days.
Patient Three

- 5 year old child referred due to passing out episodes.
- Seen in ER last night.
- Passed out during blood draw.
17 year old male with intermittent chest pain, palpitations, dizziness.

Has passed out several times while sitting without body position change.

Unconscious for about 5-10 minutes before awakening.
The Questions

• Do these events herald a potentially life-threatening disorder?
• What tests, if any, are indicated?
• Can patient participate in competitive sports?
Objectives

• Define syncope and it’s common forms
• Outline the differential diagnosis
• Discuss the appropriate evaluation

• Review the management
You need to be Sherlock
Before you do CSI...
Syncope: Definition

- A temporary, atraumatic loss of consciousness and postural tone resulting from an abrupt, transient, diffuse, and reversible impairment of cerebral function
Syncope: Epidemiology

- Precise incidence unknown
- Accounts for only 0.125% of pediatric ER visits
- 15% of children experience syncope by adolescence
- 47% of college students report having fainted at least once
Syncope: Differential Diagnosis

- Cardiac (5-10%)
  - Dysrhythmias
  - Obstructive cardiac lesions
  - Myocardial disease

- Noncardiac
  - Neurally mediated (75%)
  - Neurologic (10%)
  - Psychogenic
  - Metabolic/Other
Syncope: Cardiac

- Dysrhythmias
  - Tachydysrhythmias
  - Bradydysrhythmias
- Obstruction
  - Outflow
  - Inflow
- Myocardial disease
Syncope: Noncardiac

- Neurally mediated
  - Neurocardiogenic (vasovagal)
    - Vasodepressor
    - Cardioinhibitory
    - Mixed
  - Emotional
  - Reflex/Situational
  - Excessive vagal tone
  - Carotid sinus hypersensitivity
Syncope: Noncardiac

• Orthostatic
  – Prolonged standing/bedrest
  – Hypovolemia/Anemia
  – Dysautonomia
  – Drugs/Medications

• Neurologic
  – Seizures
  – Migraines
  – Narcolepsy/Cataplexy
Syncope: Noncardiac

• Metabolic
  – Hypoglycemia
  – Hypoxia
  – Electrolyte disorders

• Psychogenic
  – Hyperventilation syndrome
  – Conversion disorder
Neurally-mediated Syncope

• Pathophysiology
Neurally-mediated Syncope

• Pathophysiology
Neurally-mediated Syncope

- Pathophysiology
Syncope: History

• Past medical history
• Family history
• Current
  – Chronicity
  – Circumstances
  – Characteristics
    • Prodrome
    • Duration of LOC
    • Recovery

"The facts, Ma'am. Just the facts."
Jane D Smitx is a 15 year old female who was seen in the Cardiology Clinic at the request of Dr John Doe for evaluation of Dizziness/Syncope/Presyncope.

The symptoms have been occurring for {EVERY SEVERAL TIME UNITS:26709}.
Jane experiences the symptoms {EVERY SEVERAL TIME UNITS:26709}.
The events may occur while they are {AT REST OR EXERCISING MORE:26727}.
The onset of the events are {ABRUPT GRADUAL:26729}.
They last for {FREQUENCY DETAIL 2:26715} {Time; seconds to years:5003} before resolving {ABRUPT GRADUAL:26729}.
The events are associated with {ASSOC PALPITATIONS SYMPTOMS:26731}.
She denies experiencing {ASSOC PALPITATIONS SYMPTOMS:26731}.
She has previously been evaluated {EVALUATION LOCATION:26719} and {PALPITATIONS TEST/NO TEST:26733} with {NORMAL/ABNORMAL:24902} results.
Treatment has included {PALPITATIONS TREATMENTS:26734} with {DESC; POOR/FAIR/GOOD/EXCELLENT:19665} response.

Hydration: estimates ounces daily -
Urination: estimates frequency daily -
Caffeine: estimates ounces daily -
Activity/Exercise:
Sleep: Estimates hours sleep daily –
Diet: Amount, Type, Supplements -

Family History:
Seizures: Dysrhythmia: CHD: Cardiomyopathy:
SCD in the Young/Sports: Stroke/MI under 50 years:

PMH:
Meds:
Syncope: Physical Examination

• Vital Signs
  – Height, weight, HR, & RR
  – BP – supine and standing

• General
  – Overall state of health
  – Evidence of systemic illness
  – Fundoscopic exam
Syncope: Physical Examination

- Cardiovascular
  - Heart rate & rhythm
  - Precordial activity
  - Quality of pulses
  - Murmurs
  - Gallops, rubs, & clicks
Syncope: Physical Examination

- Neurological
  - Mental status
  - Cranial nerves
  - Muscle tone & strength
  - DTRs
  - Coordination
  - Gait
Syncope:
Diagnostic Studies

- ECG (all patients)
- Simple Orthostatics (HRs and BPs)
- If indicated by history/physical
  - Electrolytes, Ca++, glucose, BUN, creatinine
  - Hgb/Hct
  - Drug levels, Pregnancy test
  - Brain CT/MRI
The Grading of Orthostatic Intolerance

Grade 0
Normal orthostatic tolerance

Grade I
1. Orthostatic symptoms are infrequent, or only under conditions of increased orthostatic stress**
2. Able to stand >15 minutes on most occasions
3. The subject typically has unrestricted activities of daily living

Grade II
1. Orthostatic symptoms are frequent, developing at least once a week Orthostatic symptoms commonly develop with orthostatic stress
2. Able to stand >5 minutes on most occasions
3. Some limitation in activities of daily living is typical

Grade III
1. Orthostatic symptoms develop on most occasions, and are regularly unmasked by orthostatic stresses
2. Able to stand >1 minute on most occasions
3. Marked limitation in activities of daily living

Grade IV
1. Orthostatic symptoms are consistently present
2. Able to standing <1 minute on most occasions
3. Patient is seriously incapacitated, being bed- or wheel chair bound because of orthostatic intolerance
Syncope/presyncope is common if patient attempts to stand
Syncope: Diagnostic Studies

- Additional studies with appropriate consultation
  - Holter monitor/cardiac event recorder
  - Echocardiogram
  - Head upright tilt study
  - Treadmill exercise test
  - Electrophysiology study
  - EEG
Neurally-mediated Syncope RX

• Nonpharmacologic Treatment
  – Avoidance of factors that trigger syncope
  – Lying down/sitting down during pre-syncope
  – Crossing or flexing legs prior to standing
  – Increasing salt and fluid intake
  – Eating regularly
  – Eliminating offending medications/drugs
Neurally-mediated Syncope RX

• Pharmacologic therapy
  – Hydroflurocortisone (Florinef)
  – Beta blockers
  – Alpha adrenergic agents (pseudoephedrine)
  – Disopyramide
The Patient: Episode 3

- Driving her car home; parents following in a separate vehicle
- Palpitations and dizziness
- Attempted to pull over but passed out
- Hit a telephone pole (@ about 10-20 mph)
- No injury
The Patient: Episode 3

- Removed from the car by her father
- Unresponsive and dusky
- Tonic-clonic movements and urinary incontinence
- No apparent respirations or pulse
- Dad administered two rescue breaths
The Patient: The Saga Continues

- She was taken to the ED, evaluated, and released!!
- Two more episodes of syncope at home
- Family contacted her Neurologist and she was admitted to the hospital (PICU)
The Patient: The Saga Continues

- After a visit by her boyfriend, she experienced another syncopal event
- The cardiac monitor demonstrated:
The Patient: The Saga Continues

- The episode resolved spontaneously
- A 12-lead ECG was performed
  - QTc = 490 ms
- She was loaded with lidocaine and then transitioned to Nadolol
- She has been asymptomatic for 4 years
Syncope

• Consider cardiac causes when syncope occurs:
  – During exertion
  – When supine
  – Without a prodrome
  – After palpitations
  – In a patient with heart disease or an abnormal ECG
Syncope: Consultation

Consultation is indicated when….

- Syncope occurs during or immediately after exercise
- Syncope is preceded by chest pain or palpitations
- Syncope is atypical or recurrent (> 2-3 times)
- Abnormal physical examination/ECG
- Associated with seizures
- Abnormal family history
Postural Orthostatic Tachycardia Syndrome

A challenging dysautonomia
Review Article

The Postural Tachycardia Syndrome (POTS): Pathophysiology, Diagnosis & Management

Satish R Raj MD MSCI

Autonomic Dysfunction Center, Division of Clinical Pharmacology, Departments of Medicine & Pharmacology, Vanderbilt University, Nashville, Tennessee, USA.

**Table 1:** Criteria for the Postural Tachycardia Syndrome

1. Heart rate increase ≥30 beats per minute from supine to standing (5-30 min)

2. Symptoms get worse with standing and better with recumbence.

3. Symptoms lasting ≥6 months

4. Standing plasma norepinephrine ≥600 pg/ml (≥3.5 nM)

5. Absence of other overt cause of orthostatic symptoms or tachycardia (e.g. active bleeding, acute dehydration, medications).
**Box 1 Classification of postural tachycardia syndrome**

**Primary forms**
- Partial dysautonomic
- Immune mediated pathogenesis
- Adolescence
- Hyperadrenergic state

**Secondary forms**
- Diabetes mellitus
- Amyloidosis
- Heavy metal poisoning
- Sjogren syndrome
- Hypokinesia syndrome
- Paraneoplastic syndrome

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**Box 3 Signs to look for in suspected orthostatic intolerance**

- Pallor
- Tachycardia
- Hypoxia
- Postural hypotension
- Arrhythmia
- Focal neurological deficit

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**Box 4 Investigations in a case of suspected orthostatic intolerance**

- Blood: FBC, glucose levels, electrolytes, thyroid function tests, bone profile, serum cortisol
- ECG
- Cervical spine x ray
- Catecholamine levels (blood and urine)
- 70° head tilt table test
- EEG
- Brain CT scan
- Sweat test
- Sudomotor function test

CT, computed tomography; ECG, electrocardiogram; EEG, electroencephalogram; FBC, full blood count.
Other POTS Symptoms

- Weakness: 50%
- Sense of Tremor: 38%
- Bladder Dysfunction: 9%
- Fatigue: 50%
Which of the following POTS symptoms have you experienced?

- Headaches: 90.2% (644)
- Nausea: 86.1% (629)
- Abdominal Pain: 76.1% (543)
- Chronic Pain (General): 74.3% (532)
- Chest Pains: 78.4% (560)
- Heart Palpitations: 91.3% (656)
- Shortness of Breath: 84.5% (603)
- Fatigue: 97.2% (694)
- Insomnia / Problems Sleeping: 83.8% (598)
- Brain Fog: 93.6% (664)
- Sweating Abnormalities: 72.3% (516)
- Weakness: 87.1% (629)
- Dizziness Upon Standing: 95.6% (678)
- Bladder Dysfunction: 42.6% (304)
- Tremors: 58.1% (415)
- Other: 36.1% (262)

Of the symptoms you experience, which cause you the most distress and/or discomfort?

- Headaches: 37.1% (644)
- Nausea: 31.3% (629)
- Abdominal Pain: 19.3% (543)
- Chronic Pain (General): 34.9% (532)
- Chest Pains: 22.8% (560)
- Heart Palpitations: 35.1% (656)
- Shortness of Breath: 28.5% (603)
- Fatigue: 71.9% (694)
- Insomnia / Problems Sleeping: 31.3% (598)
- Brain Fog: 43.8% (664)
- Sweating Abnormalities: 14.5% (516)
- Weakness: 31.3% (629)
- Dizziness Upon Standing: 48.5% (678)
- Bladder Dysfunction: 8.1% (304)
- Tremors: 11.7% (415)
- Other: 14.7% (262)

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### TABLE 1

Orthostatic Symptoms as Frequency (%) in Patients with POTS

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Frequency</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Orthostatic symptoms</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Light headed or dizziness</td>
<td>118</td>
<td>78</td>
</tr>
<tr>
<td>Palpitations</td>
<td>114</td>
<td>75</td>
</tr>
<tr>
<td>Presyncope</td>
<td>92</td>
<td>61</td>
</tr>
<tr>
<td>Exacerbation by heat</td>
<td>81</td>
<td>53</td>
</tr>
<tr>
<td>Exacerbation by exercise</td>
<td>81</td>
<td>53</td>
</tr>
<tr>
<td>Sense of weakness</td>
<td>76</td>
<td>50</td>
</tr>
<tr>
<td>Tremulousness</td>
<td>57</td>
<td>38</td>
</tr>
<tr>
<td>Shortness of breath</td>
<td>42</td>
<td>28</td>
</tr>
<tr>
<td>Chest pain</td>
<td>37</td>
<td>24</td>
</tr>
<tr>
<td>Exacerbation by meals</td>
<td>36</td>
<td>24</td>
</tr>
<tr>
<td>Exacerbation associated with menses</td>
<td>22</td>
<td>15</td>
</tr>
<tr>
<td>Hyperhidrosis</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>Loss of sweating</td>
<td>8</td>
<td>5</td>
</tr>
<tr>
<td><strong>Nonorthostatic symptoms</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nausea</td>
<td>59</td>
<td>39</td>
</tr>
<tr>
<td>Bloating</td>
<td>36</td>
<td>24</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>27</td>
<td>18</td>
</tr>
<tr>
<td>Constipation</td>
<td>23</td>
<td>15</td>
</tr>
<tr>
<td>Abdominal pain</td>
<td>23</td>
<td>15</td>
</tr>
<tr>
<td>Bladder symptoms</td>
<td>14</td>
<td>9</td>
</tr>
<tr>
<td>Vomiting</td>
<td>13</td>
<td>9</td>
</tr>
<tr>
<td>Pupillary symptoms (glare)</td>
<td>5</td>
<td>3</td>
</tr>
<tr>
<td><strong>Diffuse associated symptoms</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fatigue</td>
<td>73</td>
<td>48</td>
</tr>
<tr>
<td>Sleep disturbance</td>
<td>48</td>
<td>32</td>
</tr>
<tr>
<td>Migraine headache</td>
<td>42</td>
<td>28</td>
</tr>
<tr>
<td>Myofascial pain</td>
<td>24</td>
<td>16</td>
</tr>
<tr>
<td>Neuropathic type pain</td>
<td>3</td>
<td>2</td>
</tr>
</tbody>
</table>

Figure 2 – Acrocyanosis in POTS

One of the more striking physical features in the postural tachycardia syndrome (POTS) is the gross change in dependent skin color that can occur with standing. The panel shows the legs of 2 people who have been standing for 5 minutes, a healthy control subject (left) and a patient with POTS (right). The patient with POTS (right) has significant dark red mottling of her legs extending up to the knees while standing, while the control subject does not have a similar discoloration.
During the process of being diagnosed, did any physicians ever suggest or insinuate that your symptoms were psychological?

No - 21.5%

Yes - 78.5%

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How long were you experiencing symptoms before you were officially diagnosed with POTS?

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After the onset of POTS symptoms, how many doctor's did you see before receiving a diagnosis of POTS?

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If you had to choose the single, most effective treatment you've experienced, what would it be?

- Medication (if so, what medication) - 52.7%
- Other - 25.6%
- Exercise - 10.8%
- Diet - 10.9%

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Routine Evaluation of POTS
1. Heads Up Tilting
2. Plasma catecholamines, supine, and standing
3. 24-hour urinary sodium
4. ECG

Additional Tests
1. Autonomic reflex screen
2. Thermoregulatory sweat test
3. Ganglionic antibody
4. Exercise testing
5. Cardiac echo and Holter monitor
**Postural Tachycardia Syndrome (POTS)**

PHILLIP A. LOW, M.D.,* PAOLA SANDRONI, M.D., Ph.D.,* MICHAEL JOYNER, M.D.,†
and WIN-KUANG SHEN, M.D.‡

From the *Department of Neurology, †Department of Anesthesiology,
and ‡Department of Cardiovascular Diseases and Internal Medicine, Mayo Clinic, Rochester, Minnesota, USA

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### TABLE 4

Some Distinguishing Features of Common Types of POTS

<table>
<thead>
<tr>
<th>POTS Category</th>
<th>HR on HUT</th>
<th>BP on HUT</th>
<th>Plasma NE</th>
<th>QSART/TST</th>
<th>Ganglionic Antibody</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neuropathic</td>
<td>↑↑</td>
<td>Mild ↓</td>
<td>N</td>
<td>Distal anhidrosis</td>
<td>Sometimes positive in low titers</td>
</tr>
<tr>
<td>Hyperadrenergic</td>
<td>↑↑↑</td>
<td>BP↑</td>
<td>&gt; 600 pg/mL</td>
<td>Normal</td>
<td>Absent</td>
</tr>
<tr>
<td>Deconditioned</td>
<td>↑</td>
<td>PP ↓</td>
<td>N or ↑</td>
<td>Normal</td>
<td>Absent</td>
</tr>
</tbody>
</table>

HUT = head-up tilt; PP = pulse pressure; QSART = quantitative sudomotor axon-reflex test; TST = thermoregulatory sweat test.
Heart rate (HR) and blood pressure (BP) with upright tilt in postural tachycardia syndrome (POTS).

**Figure 1 – Hemodynamics with Upright Posture in POTS**

The tracings for heart rate, blood pressure, and tilt table angle are shown for a patient with the postural tachycardia syndrome (POTS: **left**) and for a healthy control subject (**right**) during a 30 minute tilt head-up test. With head-up tilt, the heart rate immediately increases in POTS and peaks at over 170 bpm prior to the end of the tilt. In contrast the heart rate of the healthy control subject rises to just over 100 bpm. The patient with POTS does not experience a reduction in blood pressure during the tilt test. It is largely unchanged during the test.
The 3 panels show the blood volumes of control subjects and patients with POTS compared to that expected based on their individual height, weight and gender. Data are shown for plasma volume (PV; Panel A), red cell volume (RC; Panel B) and total blood volume (TBV; Panel C). The plasma volume and total blood volume of the control subjects was similar to their expected values. The patients with POT had a deficit of their plasma volume (Panel A), red cell volume (Panel B) and total blood volume (Panel C) compared to the control group. Figures adapted with data from Raj SR, Biaggioni I, Yamhure PC, Black BK, Paranjape SY, Byrne D, Robertson D. The Renin-Aldosterone Paradox and Perturbed Blood Volume Regulation Underlying the Postural Tachycardia Syndrome. Circulation 2005; 111:1574-1582.
1. Exercise
Multiple studies have highlighted the importance of regular exercise in improving symptoms and quality of life in POTS. Initially many POTS patients can’t tolerate this due to their symptoms. The key is to start slowly, build up, and do it regularly. It’s proven to work.

2. Increase Fluid Intake
Dehydration must be avoided. In general, POTS patients should aim to have ≥2 liters per day. At times of dizziness, drinking 2 glasses of water over a few minute period may help to raise blood pressure and improve symptoms.

3. MoreSalt
Create your own running playlist on your iPod or smartphone. Having a good upbeat workout songs can boost your mood and motivate you to run.

4. Compression Devices
Compression stockings prevent pooling of blood in the lower extremities. Effective stockings full length to the waist, rather than just knee high. The most effective degree of compression will be at least 30 mmHg.

5. Muscle Tensing
When we stand blood pools in the legs. In POTS, the normal counter-mechanisms are dysfunctional. It’s proven that tensing the leg muscles when standing can facilitate the circulation and improve orthostatic intolerance.

6. Diet
Increase fluid and salt intake. Lower carbohydrate and smaller sized meals are recommended. Caffeine should be limited particularly in hyperadrenergic POTS. Alcohol and energy drinks should be avoided. These with GI symptoms should consider the possibility of intolerance to gluten and dairy and consider a trial of avoidance.

7. Routine Changes
Often symptoms are worse in the morning, and it may be advisable to schedule exercises in the afternoon. Take extra time to stand up. Sitting down in the shower may be helpful. When dizzy or faint, lie down and elevate the legs to minimize risk of trauma. It’s important to have enough sleep, and good sleep hygiene, avoid napping and set a regular sleep time.
### Table 2 Summary of treatment options existing for POTS with the corresponding levels of evidence

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Level of evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-pharmacological</td>
<td></td>
</tr>
<tr>
<td>Water and salt supplementation</td>
<td>III</td>
</tr>
<tr>
<td>Exercise</td>
<td>Ib</td>
</tr>
<tr>
<td>Elastic support hosiery</td>
<td>IV</td>
</tr>
<tr>
<td>Pharmacological</td>
<td></td>
</tr>
<tr>
<td>Fludrocortisone</td>
<td>III</td>
</tr>
<tr>
<td>Midodrine</td>
<td>IIb</td>
</tr>
<tr>
<td>Beta-blockers</td>
<td>III</td>
</tr>
<tr>
<td>Central sympatholytic agents</td>
<td>III</td>
</tr>
<tr>
<td>Pyridostigmine</td>
<td>IIb</td>
</tr>
<tr>
<td>Ivabradine</td>
<td>III</td>
</tr>
<tr>
<td>Octreotide</td>
<td>III</td>
</tr>
<tr>
<td>Erythropoeitin</td>
<td>III</td>
</tr>
<tr>
<td>ddAVP/desmopressin</td>
<td>IV</td>
</tr>
<tr>
<td>Selective serotonin reuptake inhibitors</td>
<td>IV</td>
</tr>
<tr>
<td>Methylphenidate</td>
<td>IV</td>
</tr>
</tbody>
</table>

Level of evidence: Ia, systematic review or meta-analysis of RCTs; Ib, at least one RCT; Ila, at least one well-designed controlled study without randomization; IIb, at least one well-designed quasi-experimental study; III, well-designed non-experimental descriptive studies, such as case—control or cohort studies; IV, expert opinion. Only the highest level of evidence has been selected for each modality.
Treatment strategies for POTS.

Blair P. Grubb, and Beverly Karabin Circulation. 2008;118:e61-e62
Table 2: Treatments for the Postural Tachycardia Syndrome

<table>
<thead>
<tr>
<th>Sar Num</th>
<th>Therapy</th>
<th>Dosage</th>
<th>Mechanism</th>
<th>Drawbacks</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Water</td>
<td>8-10 cups/day (2.2-2.5 L/day)</td>
<td>Blood volume expansion</td>
<td>Hyponatraemia</td>
</tr>
<tr>
<td>2</td>
<td>Increase Dietary Salt</td>
<td>200-500 mEq Na^+/day</td>
<td>Blood volume expansion</td>
<td>Difficult to augment sufficiently without supplements</td>
</tr>
<tr>
<td>3</td>
<td>NaCl tablets</td>
<td>1 gm tablet PO TID</td>
<td>Blood volume expansion</td>
<td>Poor taste; nausea &amp; dyspepsia (take after meals)</td>
</tr>
<tr>
<td>4</td>
<td>Elastic support hose</td>
<td>30-40 mmHg counter-pressure, waist high</td>
<td>Enhanced venous return</td>
<td>Hot, itchy &amp; uncomfortable; edema above stocking if only legs high</td>
</tr>
<tr>
<td>5</td>
<td>Exercise</td>
<td>30 min x 3 times per week; both aerobic &amp; resistance</td>
<td>Blood volume expansion; reverse deconditioning</td>
<td>Vigorous exercise may worsen symptoms and result in prolonged fatigue</td>
</tr>
<tr>
<td>6</td>
<td>Acute IV Saline</td>
<td>1 L IV over 1-3 hours IV</td>
<td>Blood volume expansion</td>
<td>Effective at acute heart rate control; inconvenient; medical setting needed</td>
</tr>
<tr>
<td>7</td>
<td>Chronic IV Saline</td>
<td>1 L IV q2days-qdaily</td>
<td>Blood volume expansion</td>
<td>Anecdotal benefit only; requires central line; risks of access complications &amp; infection; logistically difficult</td>
</tr>
</tbody>
</table>

Medications to Augment Blood Volume

<table>
<thead>
<tr>
<th>Sar Num</th>
<th>Medication</th>
<th>Dosage</th>
<th>Blood volume expansion</th>
<th>Edema; fluid retention; Hypokalemia; Headache; Hypertension</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Fludrocortisone</td>
<td>0.05-0.1 mg PO OD-BID</td>
<td>Blood volume expansion</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Desmopressin (DDAVP)</td>
<td>0.1-0.2 mg PO OD-BID</td>
<td>Blood volume expansion</td>
<td>Hypotension; Headache; Edema</td>
</tr>
<tr>
<td>10</td>
<td>Erythropoietin</td>
<td>2000-3000 IU SQ 1-5/week</td>
<td>Blood volume expansion</td>
<td>Expensive; requires injection</td>
</tr>
</tbody>
</table>

Medications to Decrease Sympathetic Tone

<table>
<thead>
<tr>
<th>Sar Num</th>
<th>Medication</th>
<th>Dosage</th>
<th>Blood volume expansion</th>
<th>Hypotension; Fatigue; Drowsiness; Constipation; Dry Mouth</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Clonidine</td>
<td>0.05-0.2 mg PO BID</td>
<td>Agonist of pre-synaptic alpha-2 receptor; decreases SNS traffic</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>Methyl dopa</td>
<td>125-250 mg PO TID</td>
<td>False neurotransmitter; decreases SNS traffic</td>
<td></td>
</tr>
</tbody>
</table>

Other Medications

<table>
<thead>
<tr>
<th>Sar Num</th>
<th>Medication</th>
<th>Dosage</th>
<th>Blood volume expansion</th>
<th>Hypotension; Drowsiness; Fatigue; Headache; Nightmares</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Propranolol</td>
<td>10-20 mg PO BID-QID</td>
<td>Beta-adrenergic receptor antagonist;</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Midodrine</td>
<td>25-10 mg PO TID</td>
<td>Alpha-1 adrenergic receptor agonist;</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Pyridostigmine</td>
<td>30-60 mg PO TID</td>
<td>Acetylcholinesterase inhibitor;</td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>Modafinil</td>
<td>100 mg PO BID</td>
<td>Stimulant; mechanism unclear; May reduce mental clouding; increase in heart rate;</td>
<td></td>
</tr>
</tbody>
</table>

NaCl – Table salt; PO – by mouth; OD – once daily; BID – twice daily; TID – three times daily; QID – four times daily; IV – intravenous;
Cardiac Origins of the Postural Orthostatic Tachycardia Syndrome

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Figure 2  Blood Volume and Left Ventricular Mass in POTS Patients Before and After 3 Months of Exercise Training as Well as in Controls

Values are expressed as individuals and median (25th, 75th percentiles). **p < 0.01 compared with before training in the postural orthostatic tachycardia syndrome (POTS). ††p < 0.01 compared with controls.
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Dallas, Texas

Figure 3  Heart Rate Responses During 10-Min Stand in POTS Patients Before and After Exercise Training as Well as in Controls

Values are expressed as individuals and median (25th, 75th percentiles). **p < 0.01 compared with before training in postural orthostatic tachycardia syndrome (POTS) in the same posture. ††p < 0.01 compared with controls in the same posture.
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Figure 4  Effects of Training on Patients’ Quality of Life Assessed by the 36-Item Short-Form Health Survey

Values are expressed as individuals and median (25th, 75th percentiles). **p < 0.01 compared with before training in postural orthostatic tachycardia syndrome.