Understanding and Managing POSTURAL ORTHOSTATIC TACHYCARDIA SYNDROME

PACC

November 12th, 2026

UW Medicine

What is Postural Orthostatic Tachycardia Syndrome (POTS)

Symptoms vs Syndrome

- Chronic disorder of orthostatic intolerance characterized by excessive standing heart rate
- Non-postural chronic symptoms are also significant
- Estimated up to 1% US Population
- Predominantly female, up to 90%
- ~ 70% report substantial functional impairment
- Often a delay of 2+ years to diagnosis

POTS

CONSENSUS CRITERIA

Postural Orthostatic Tachycardia Syndrome

CLINICAL CONSENSUS CRITERIA 2015 Heart Rhythm Society

1. Postural intolerance
   - Frequent symptoms that occur upon standing such as lightheadedness, palpitations, tremor, generalized weakness, blurred vision, difficulty thinking, and fatigue

Postural Orthostatic Tachycardia Syndrome

CLINICAL CONSENSUS CRITERIA

1. Postural intolerance
2. Excessive increase in heart rate upon standing
   - Increase in heart rate of ≥30 bpm in adults or ≥40 bpm in individuals 12 to 19 years of age

Postural Orthostatic Tachycardia Syndrome

CLINICAL CONSENSUS CRITERIA

1. Postural intolerance
2. Excessive increase in heart rate upon standing
3. Absence of orthostatic hypotension
   - ≤20 mmHg drop in SBP and ≤10 mmHg drop in DBP

Postural Orthostatic Tachycardia Syndrome

CLINICAL CONSENSUS CRITERIA

1. Postural intolerance
2. Excessive increase in heart rate upon standing
3. Absence of orthostatic hypotension
4. Chronic symptoms
   - Symptoms present on most days for at least 3 months

Postural Orthostatic Tachycardia Syndrome

CLINICAL CONSENSUS CRITERIA

1. Postural intolerance
2. Excessive increase in heart rate upon standing
3. Absence of orthostatic hypotension
4. Chronic symptoms
5. **Not better explained by another diagnosis**

POTS

ONSET, SYMPTOMS, AND COURSE

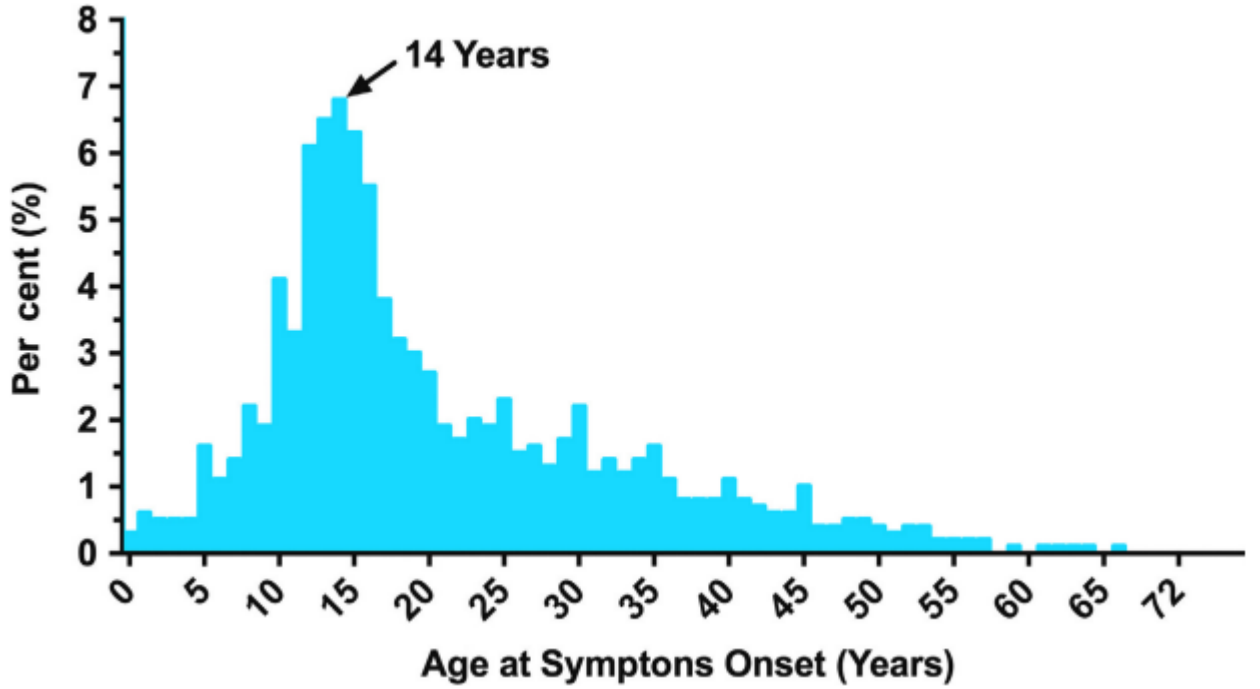
POTS - CLINICAL SYMPTOMS AND COURSE

EPIDEMIOLOGY

- Prevalence of ~ 0.2% based on 4 published reports
- > 70% female (Estimates as has high as 90%)

POTS - CLINICAL SYMPTOMS AND COURSE

- Peak Incidence 13-29 years



Online, community-based, cross-sectional survey including **4835 individuals**

Shaw BH *et* al. J Intern Med 2019;286

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POTS - CLINICAL SYMPTOMS AND COURSE

MODE OF ONSET

Acute, < 1 Month (7-12%)
Subacute, 1- 3 Months (14-48%)
Insidious, > 3 Months (6-22%)

→ ~75%

Multiple acute/ subacute episodes of worsening are common (personal observations)

Online, community-based, cross-sectional survey including **4835 individuals**

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Shaw BH *et* al. J Intern Med 2019;286

POTS - CLINICAL SYMPTOMS AND COURSE

PROVOKING OR TRIGGERING FACTORS

Infection (21-46%)
Surgery (6-12%)
Pregnancy (4%)
Vaccination (3-10%)
Accident (2-3%)
Puberty (2-7%)
Concussion (2-23%)
Emotional Stress or Trauma (2%)

Online, community-based, cross-sectional survey including **4835 individuals**

Shaw BH *et* al. J Intern Med 2019;286

POTS - CLINICAL SYMPTOMS AND COURSE

PRESENTING SYMPTOMS

Lightheadedness (99%)
Fast Heart Rate (97%)
Presyncope (94%)
Shortness of Breath (88%)
Palpitations (87%)

Kichloo A et al. J Innov Cardiac Rhythm Manage 2021;12

POTS - CLINICAL SYMPTOMS AND COURSE

Most individuals experience many symptoms

	All patients	Female patients 193	Male patients 33
10 symptoms	191 (84.9)	170 (88.1)	21 (63.6)*
15 symptoms	128 (56.9)	118 (61.1)	10 (30.3)†
20 symptoms	33 (14.7)	30 (15.5)	3 (9.1)

No., (%).

*P=0.0003 female vs male patients.

†P=0.001 female vs male patients.

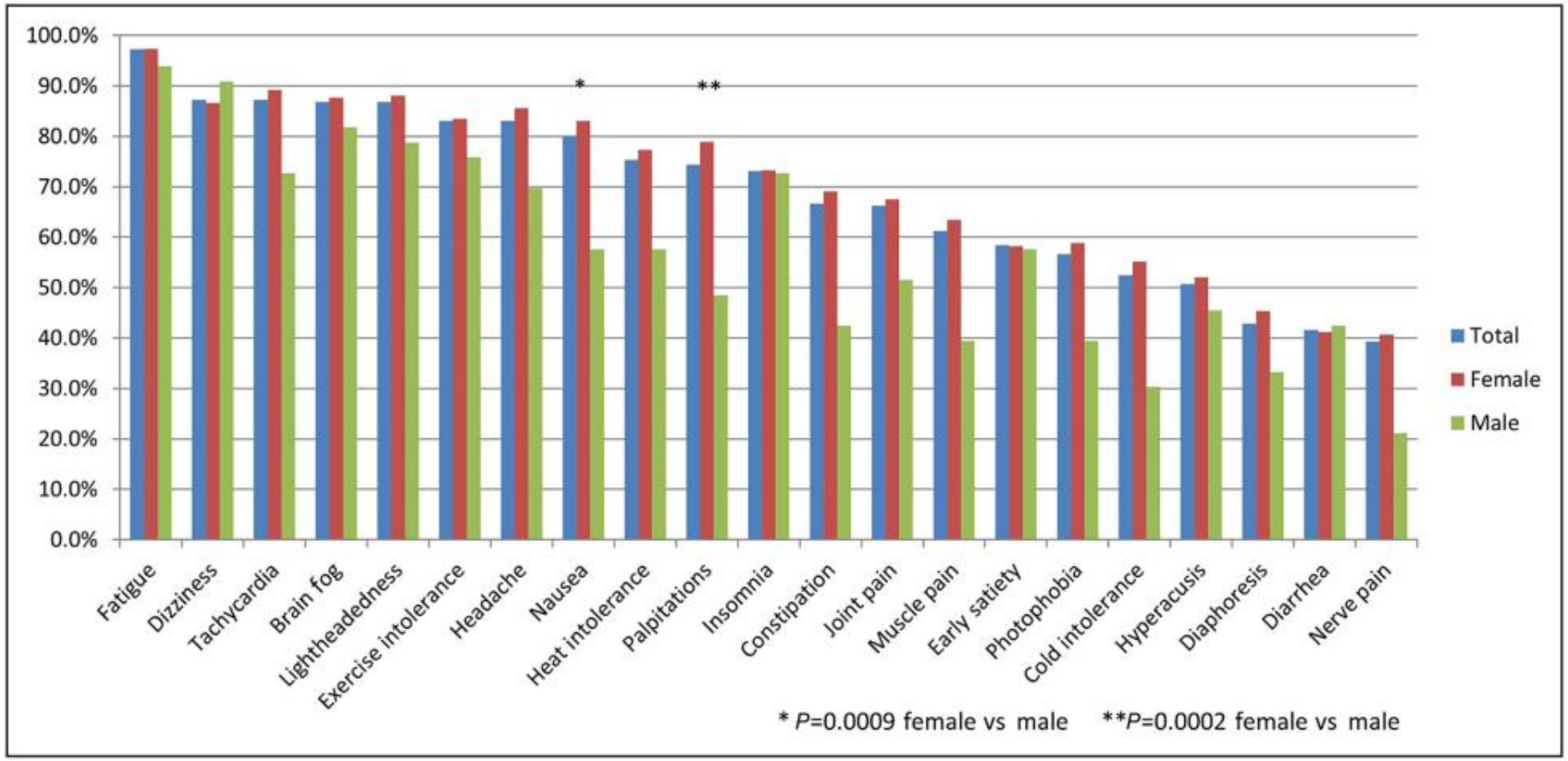
N=227

Boris JR *et* al. J Am Heart Assoc 2024;13

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POTS - CLINICAL SYMPTOMS AND COURSE

Was this symptom significant to you at any time?

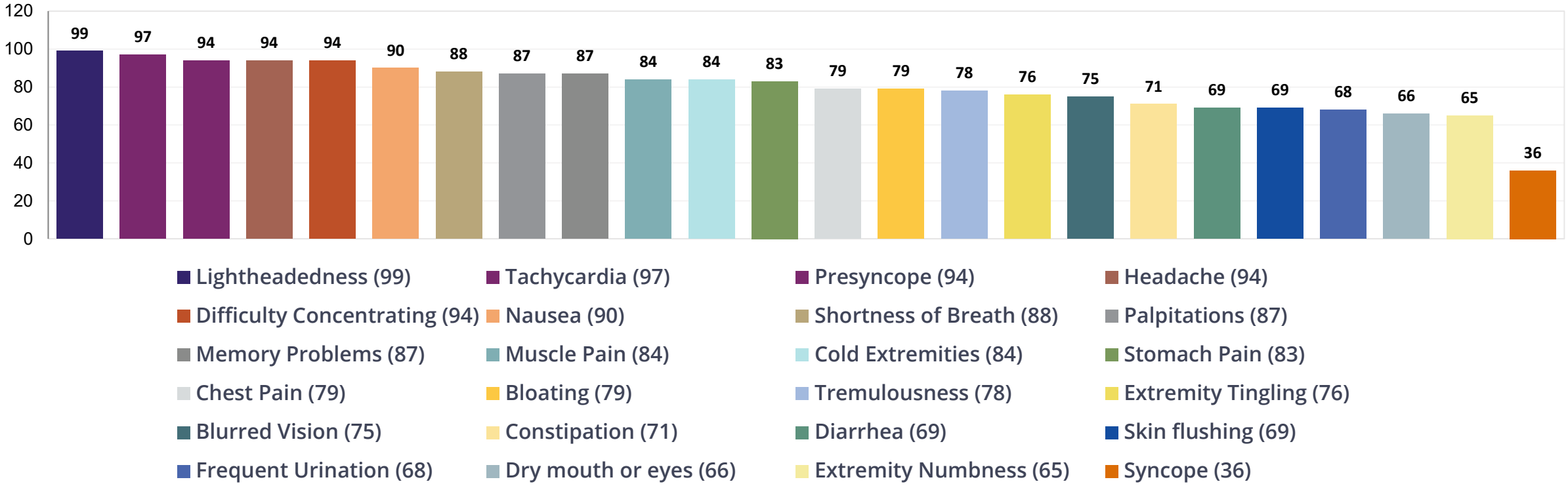


Boris JR *et* al. J Am Heart Assoc 2024;13

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POTS - CLINICAL SYMPTOMS AND COURSE

Symptom Profile



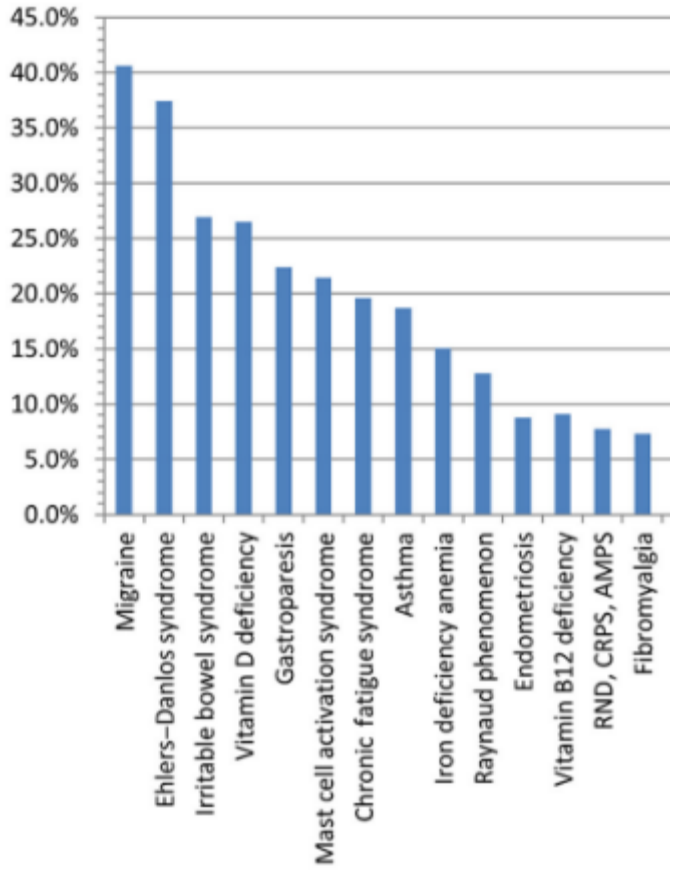
Online, community-based, cross-sectional survey including **4,835 individuals**

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Shaw BH *et* al. J Intern Med 2019;286

POTS - CLINICAL SYMPTOMS AND COURSE

Common Co-Morbid Diagnosis



Co-morbidities in patients diagnosed with Postural Orthostatic Tachycardia Syndrome.

Comorbidity	Number (%) (of 3933 respondents)
Migraine headaches	1557 (40%)
Irritable bowel syndrome	1192 (30%)
Ehlers-Danlos syndrome	994 (25%)
Chronic Fatigue Syndrome	809 (21%)
Asthma	798 (20%)
Fibromyalgia	786 (20%)
Raynaud's phenomena	610 (16%)
Iron deficiency anemia	628 (16%)
Gastroparesis	548 (14%)
Vasovagal syncope	499 (13%)
Inappropriate sinus tachycardia	448 (11%)
Mast cell activation disorder	353 (9%)
Autoimmune disease	616 (16%)
Hashimoto's thyroiditis	228 (6%)
Celiac Disease	133 (3%)
Sjogren's Syndrome	112 (3%)
Rheumatoid Arthritis	93 (2%)
Lupus	81 (2%)
Other	160 (4%)

Boris JR *et* al. J Am Heart Assoc 2024;13

Shaw BH *et* al. J Intern Med 2019;286

POTS

PATHOPHYSIOLOGY

POTS - **PATHOPHYSIOLOGY**

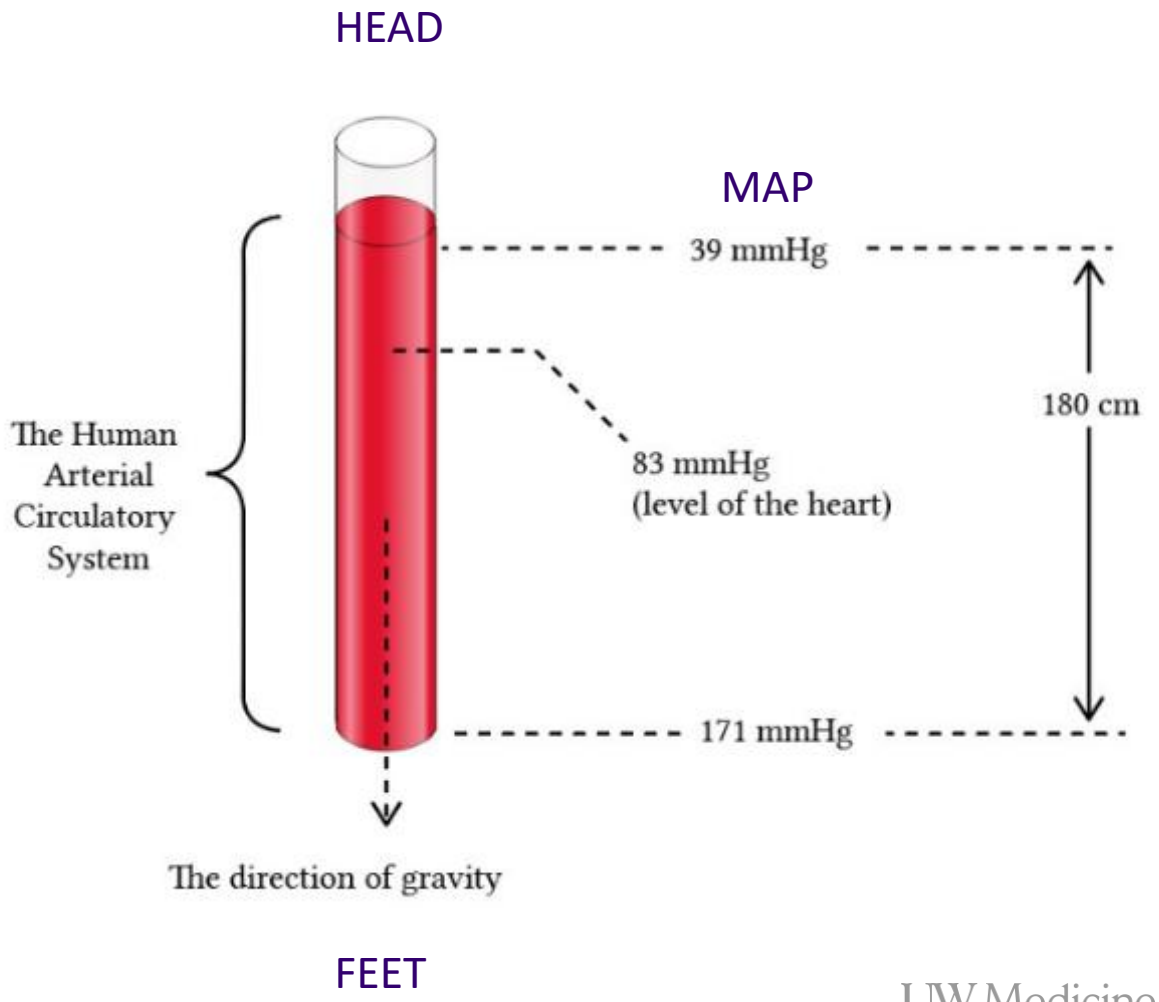
- Postural tachycardia is etiologically nonspecific
- Common feature – Real or functional central hypovolemia
- THINK Mild hypovolemic shock (eg due to hemorrhage)
  - Reduced cardiac venous return, decreased preload, and reduced cardiac output
  - Strong adrenergic-mediated vasoconstriction

CO	x	SVR	=	MAP
(HR x SV)		(PVR + Other)		

POTS - PATHOPHYSIOLOGY

PHYSIOLOGIC CHANGES WITH UPRIGHT POSTURE

- Arterial Effects:
  - Decreased perfusion pressure in superior regions
    - Cerebral vessels dilate
  - Increased perfusion pressure in dependent regions
    - Slow plasma loss across leaky vascular bed

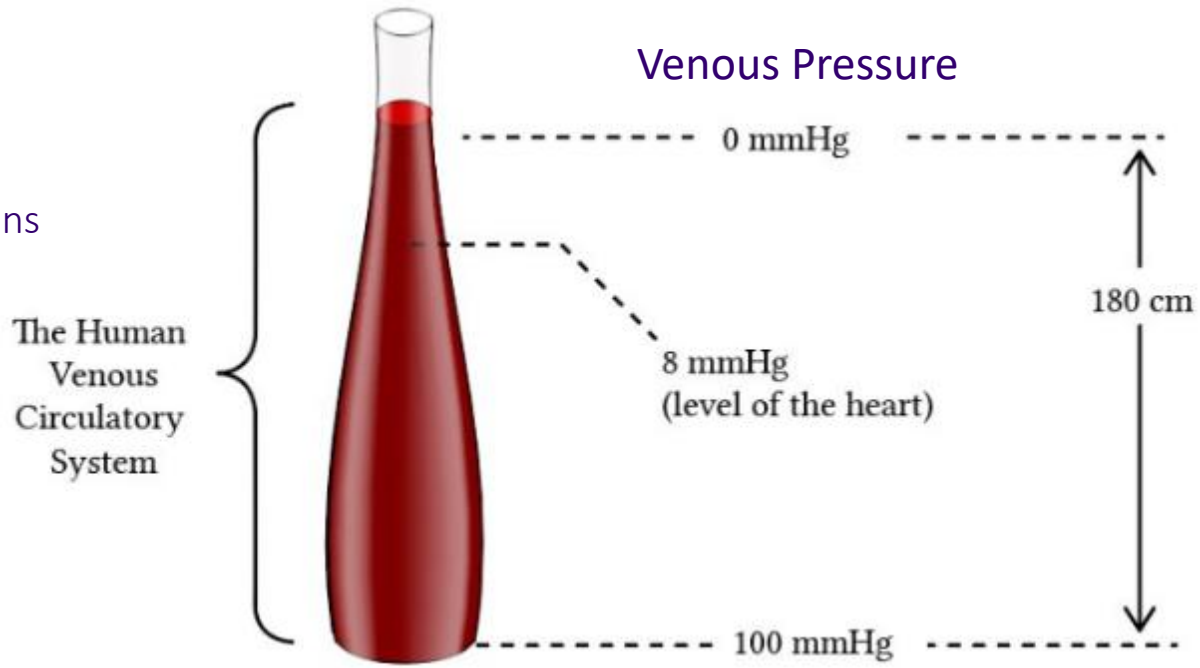


POTS - PATHOPHYSIOLOGY

PHYSIOLOGIC CHANGES WITH UPRIGHT POSTURE

- Arterial Effects:
  - Decreased perfusion pressure in superior regions
  - Increased perfusion pressure in dependent regions
- Venous Effects:
  - Redistribution of venous blood volume into dependent regions
  - **Decreased cardiac venous return**
  - **Decreased RV and LV stroke volume**
  - Decrease cardiac output

Redistribution of ~ 10% total blood volume

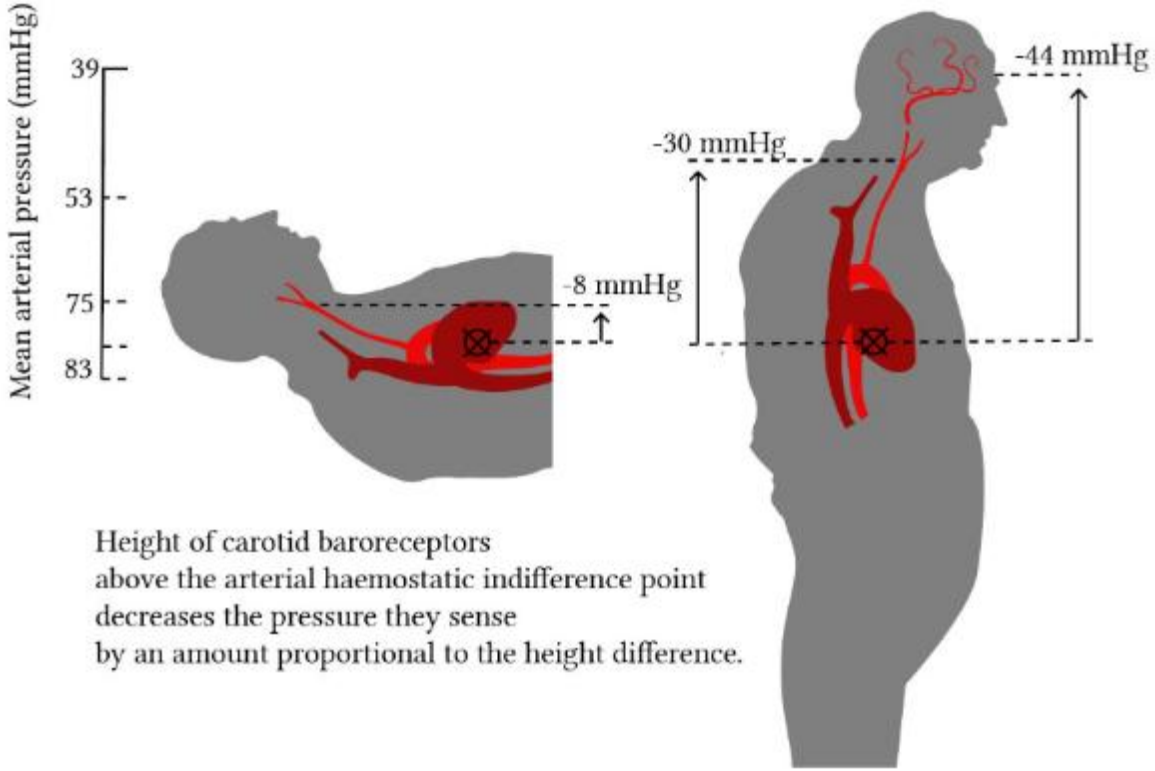


POTS - PATHOPHYSIOLOGY

PHYSIOLOGIC CHANGES WITH UPRIGHT POSTURE

- Arterial Effects:
  - Decreased perfusion pressure in superior regions
  - Increased perfusion pressure in dependent regions
- Venous Effects:
  - Redistribution of venous blood volume into dependent regions
  - Decreased cardiac venous return
- Baroreflex:
  - Reduced baroreceptor pressure
  - Activation of baroreceptor reflex

Change in baroreceptor pressure with standing



POTS - PATHOPHYSIOLOGY

PHYSIOLOGIC CHANGES TO STANDING

- Arterial Effects:
  - Decreased perfusion pressure in superior regions
  - Increased perfusion pressure in dependent regions
- Venous Effects:
  - Redistribution of venous blood volume into dependent regions
  - Decreased cardiac venous return
- Baroreflex:
  - Reduced baroreceptor pressure
  - Activation of baroreceptor reflex
  - Increased HR by reduced vagal tone (immediate)
  - Increased peripheral vascular resistance (slight delay)

Haemodynamic Effects of Seated Posture in the Sedated Patient

Parameter	Change from supine to seated position
Blood pressure	Increases 0-40%
Cardiac output	Decreased 12-20%
Heart rate	Remains largely unchanged
Systemic vascular resistance	Increases 50-80%
Cerebral blood flow	Decreases 15%

Derangedphysiology.com, Koonan and Hope 1983

POTS

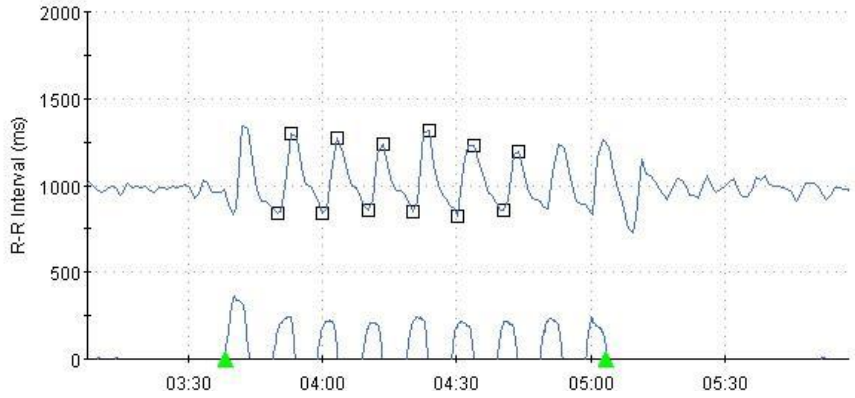
AUTONOMIC TESTING

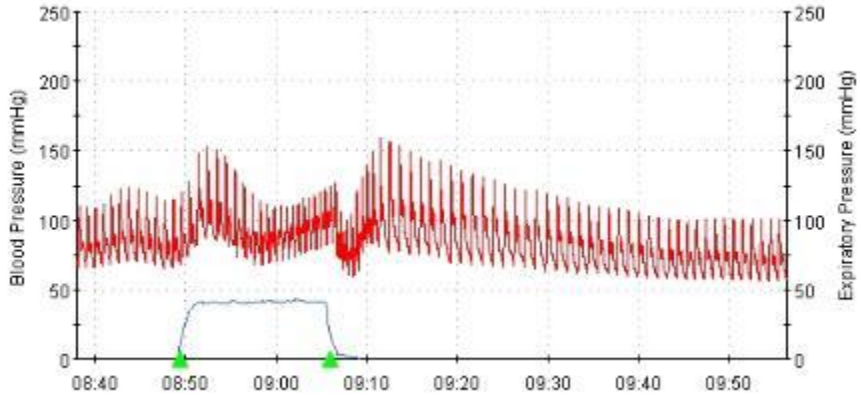
Cardiovascular Autonomic Testing

CARDIOVAGAL BAROREFLEX FUNCTION

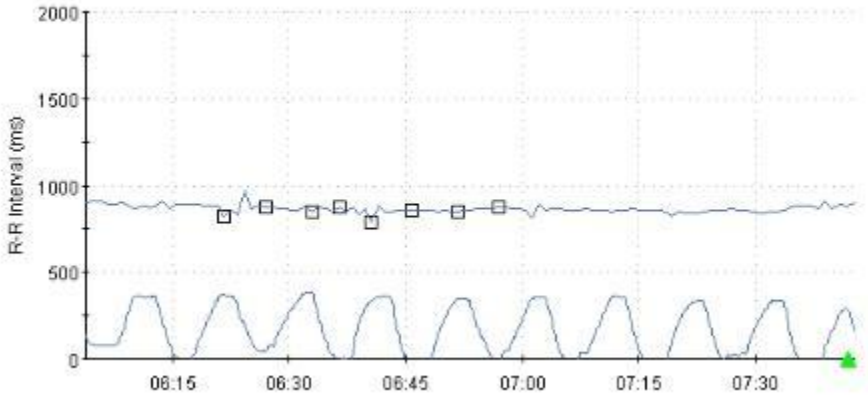
ADRENERGIC VASOMOTOR FUNCTION

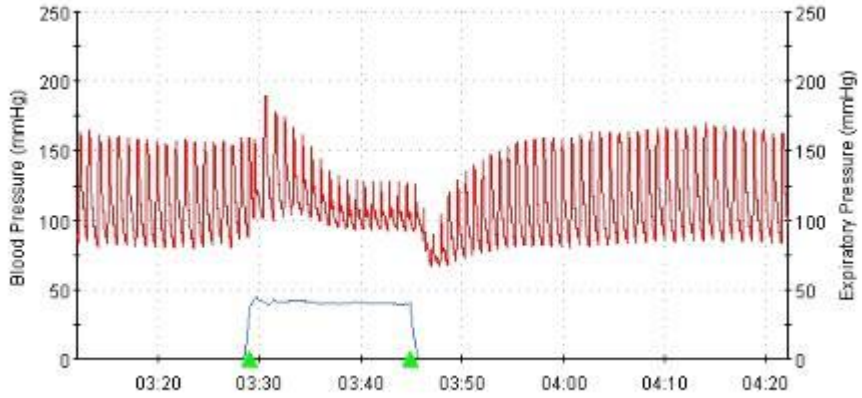
NORMAL





IMPAIRED

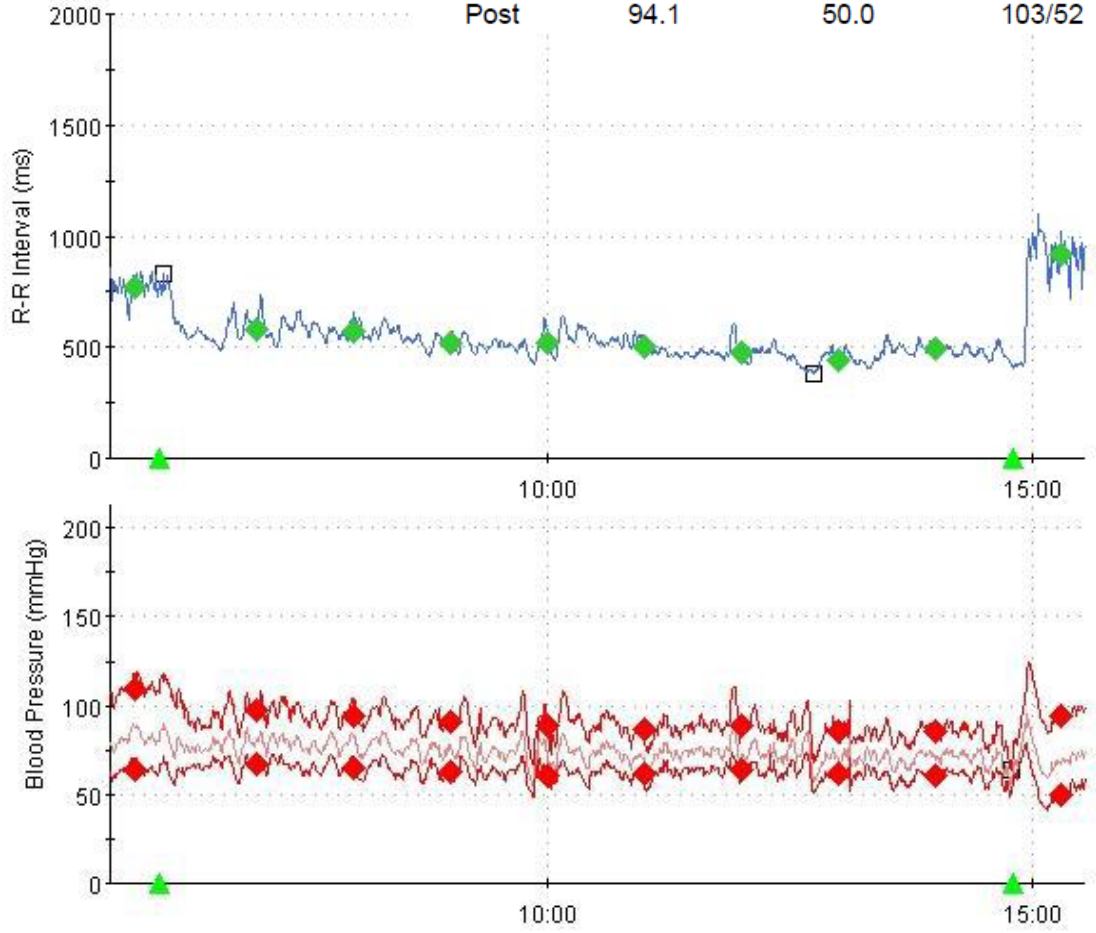




HEADS UP TILT

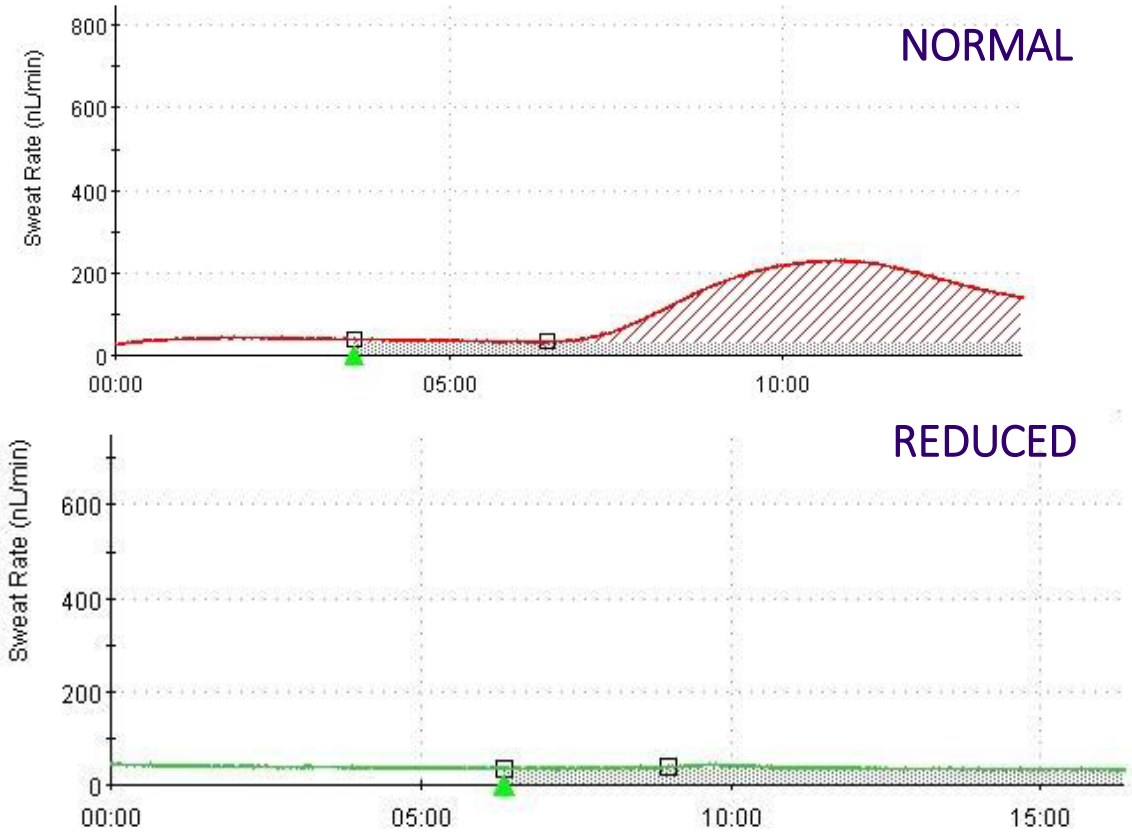
Symptoms: lightheadedness, nausea, heart racing

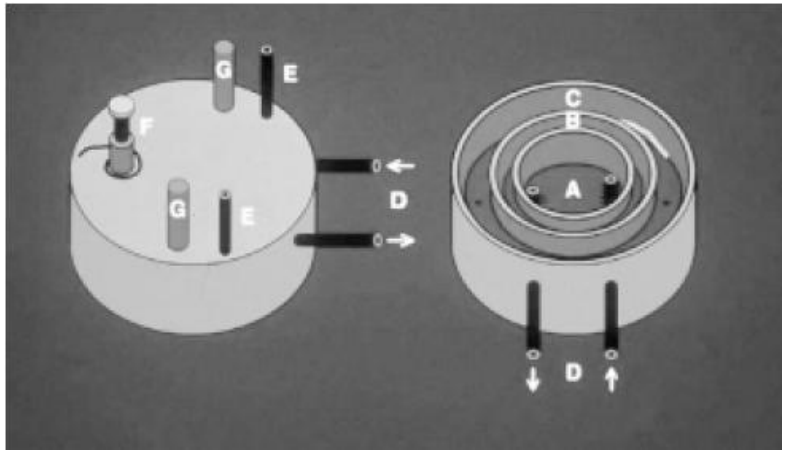
Time	SBP	DBP	Cuff BP	HR	Δ SBP	Δ DBP	Δ HR
Pre	109.5	64.1	97/70	77.7			
1.0	97.0	66.9	110/70	103.6	-12.6	2.8	25.8
2.0	94.6	65.0		104.6	-14.9	1.0	26.9
3.0	91.0	63.0	109/64	115.9	-18.5	-1.1	38.2
4.0	88.6	61.1		114.7	-21.0	-2.9	37.0
5.0	87.0	62.0	104/69	120.0	-22.5	-2.1	42.3
6.0	89.3	63.7		125.8	-20.3	-0.4	48.0
7.0	85.5	61.7	104/85	135.7	-24.0	-2.3	58.0
8.0	85.0	60.3		122.4	-24.5	-3.7	44.6
Post	94.1	50.0	103/52	65.6	-15.4	-14.1	-12.2

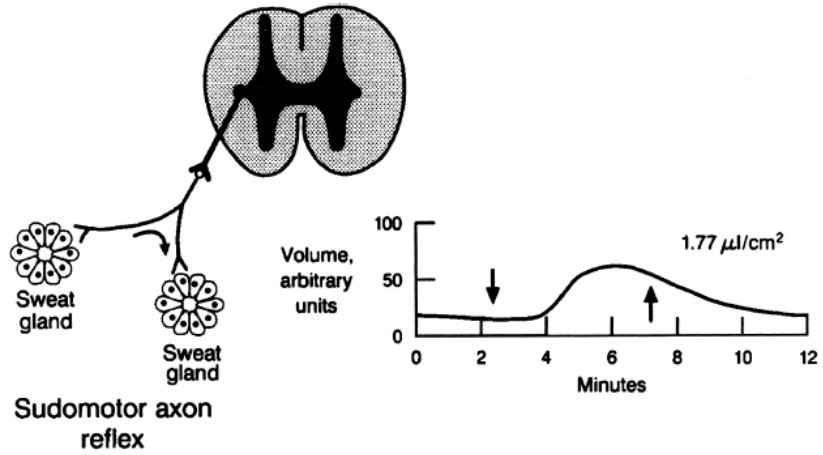


Quantitative Sudomotor Axon Reflex Test QSART

Autonomic C-Fiber



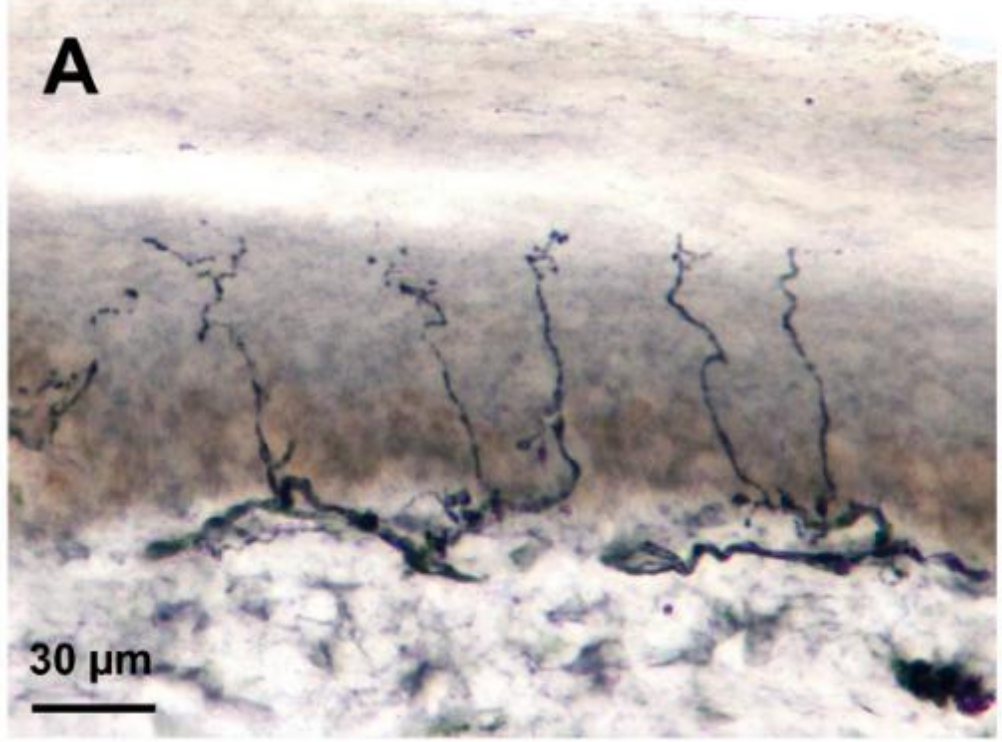




Skin Biopsy
Intra-Epidermal Nerve Fiber Density

Somatic C-Fiber

PGP 9.5-immunolabeled intraepidermal nerve fibers (IENFs)



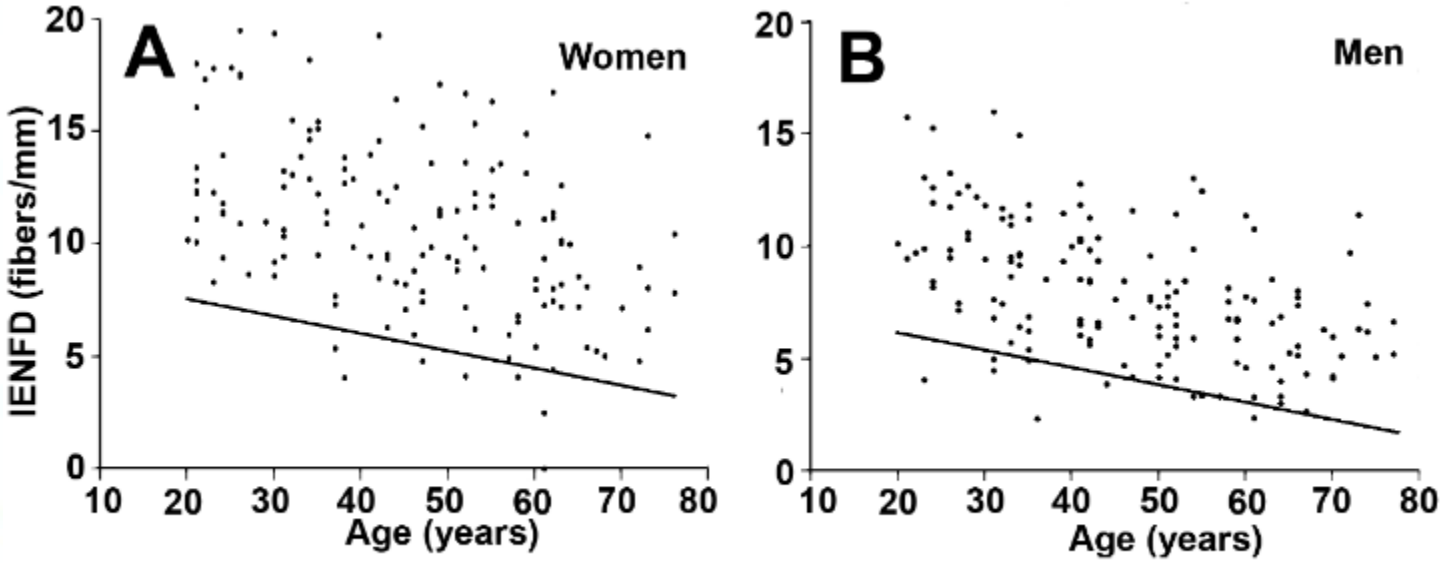


Fig 2. Intraepidermal nerve fiber density. Scatterplot showing intraepidermal nerve fiber density (IENFD) values in the distal leg in healthy subjects according to gender and age (A: women, B: men). Line depicts 5th percentile.

Collongues N, Samama B, Schmidt-Mutter C, Chamard-Witkowski L, Debouverie M, Chanson J-B, et al. (2018) Quantitative and qualitative normative dataset for intraepidermal nerve fibers using skin biopsy. 2018 PLoS ONE 13(1).

POTS

NEUROPATHIC

Neuropathic POTS

Mild, selective distal autonomic neuropathy

Haemodynamic Effects of Seated Posture in the Sedated Patient	
Parameter	**Change from supine to seated position**
Blood pressure	Increases 0-40%
Cardiac output	Decreased 12-20%
Heart rate	Remains largely unchanged
Systemic vascular resistance	Increases 50-80%
Cerebral blood flow	Decreases 15%

- Frequently Acute or Subacute (Peak symptoms within ~ 3 months)
- Onset is often preceded by physical stressor (eg infection, surgery, injury, pregnancy)
- Differs from Distal Small Fiber Neuropathy (DSFN)
  - Nerve conduction studies are always normal in nPOTS
  - Individuals with DSFN have dysfunction in both somatic sensory (eg burning dysesthesias, decreased pin prick) and sympathetic (eg acral coldness, blotchy skin, hyperhidrosis) systems
- Differs from autoimmune autonomic neuropathy (AAN/AAG)
  - Individuals with AAN have generalized autonomic c-fiber involvement while dysfunction in nPOTS is limited and distal
  - Cardiovascular autonomic testing shows both baroreflex and adrenergic vasomotor dysfunction in AAN but only mild adrenergic vasomotor dysfunction in POTS

Singer W *et* al Neurology 2004;62:612–618

POTS

HYPOVOLEMIC

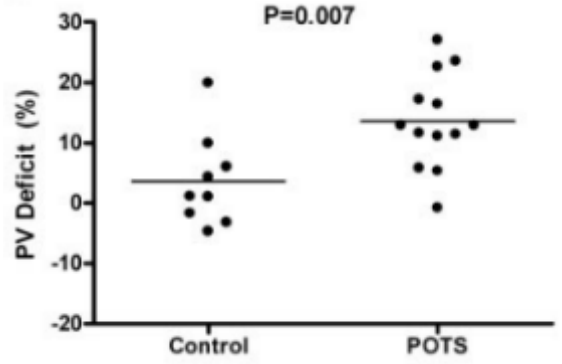
Hypovolemic POTS

- Mechanism: Decreased plasma volume

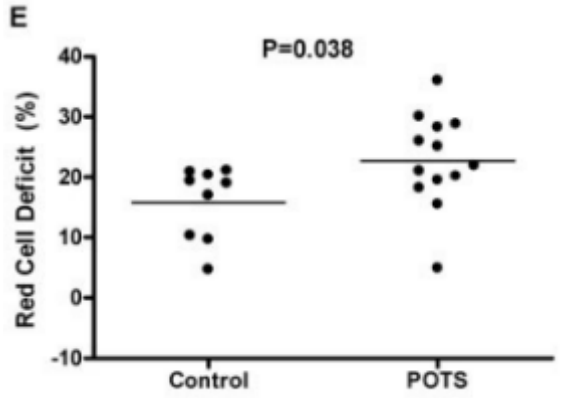
HAEMODYNAMIC EFFECTS OF SEATED POSTURE IN THE SEDATED PATIENT

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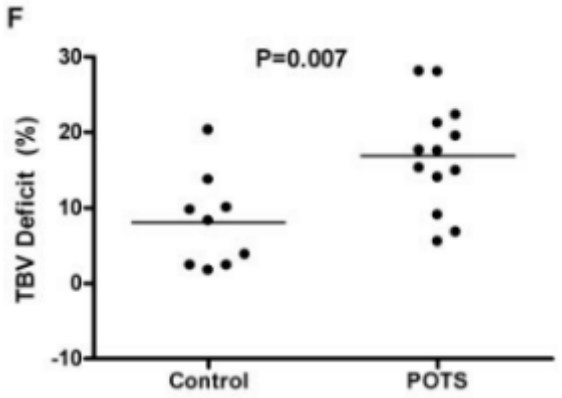
Raj *et al* 2005 Prospective study of neurohumoral factors in POTS (n=15) and healthy controls (n=14)



Deficit of plasma volume



Reduced red cell mass



Total blood volume deficit

Hypovolemic POTS

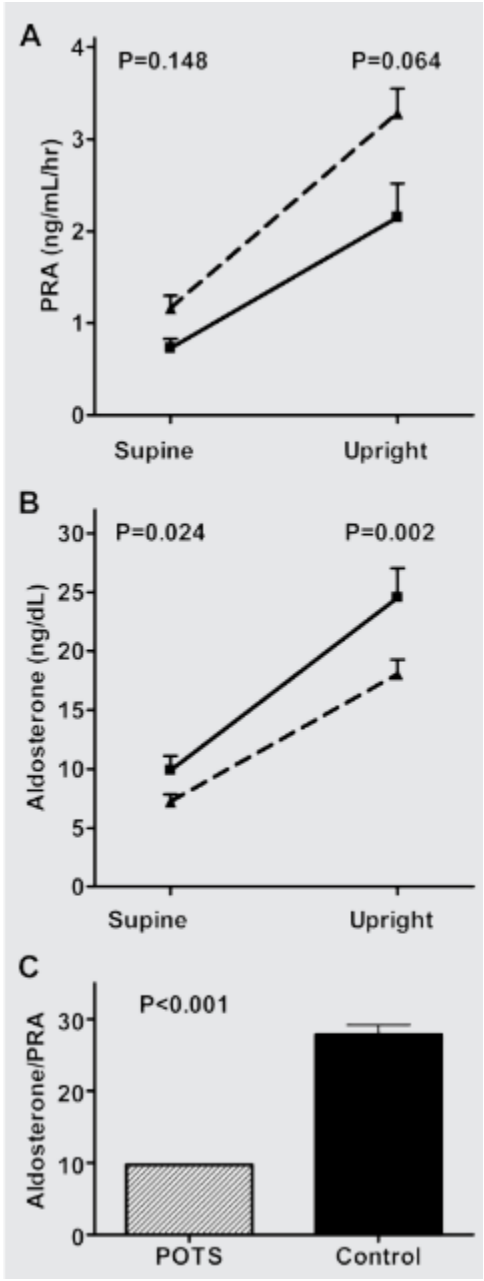
- The Renin - Aldosterone Paradox

➢ Raj *et al* 2005

Inappropriately low Renin and aldosterone in the setting of reduced volume

➢ Raj and Robertson 2007 (114 POTS, 92 Controls)

Reduced supine and upright plasma aldosterone



POTS
Controls

Trend towards higher plasma renin activity in POTS

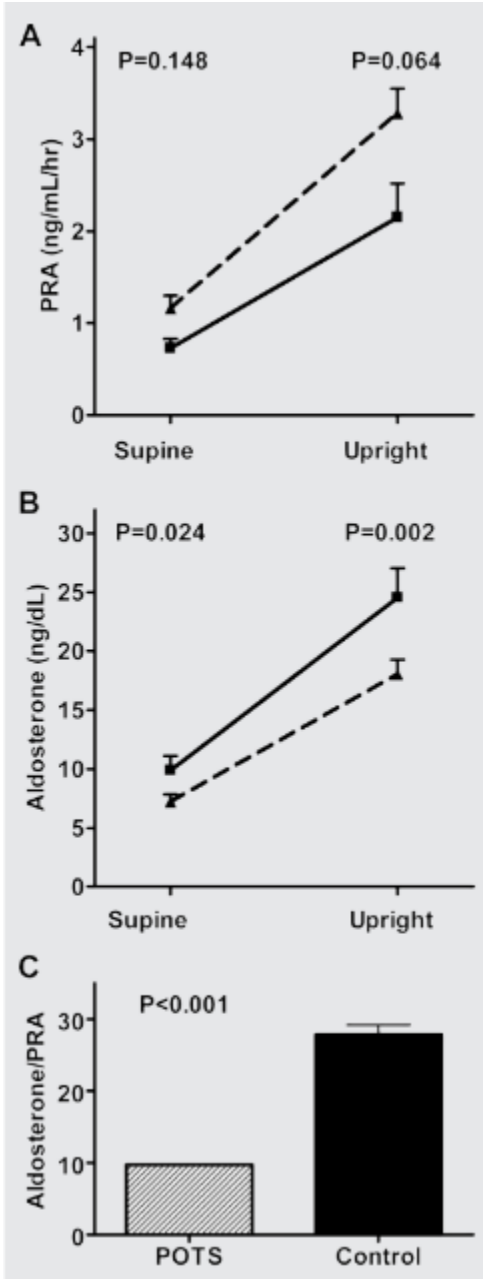
Supine and upright plasma aldosterone levels are lower in POTS

Aldosterone is inappropriately reduced for given PRA

Hypovolemic POTS

Summary

1. Central Hypovolemia leads to reduced venous return
2. The expected compensatory stimulation of the renin–angiotensin system is reduced - the “renin–aldosterone paradox”
3. Strong sympathetic activation (and fast HR) is in compensation for decreased cardiac venous return, reduced LV stroke volume, and decreased cardiac output.
4. Elevated supine catecholamines reflect increased sympathetic activation (independent of posture) and contribute to increased resting HR
5. **24 Hour Urine Na excretion < 100 mmol is suggested to identify reduced volume**



POTS
Controls

Trend towards higher plasma renin activity in POTS

Supine and upright plasma aldosterone levels are lower in POTS

Aldosterone is inappropriately reduced for given PRA

POTS

HYPERADRENERGIC

Hyperadrenergic POTS

Mechanism: Central sympathetic over-activation

- **POTS Criteria + Upright plasma NE > 600 pg/ml**

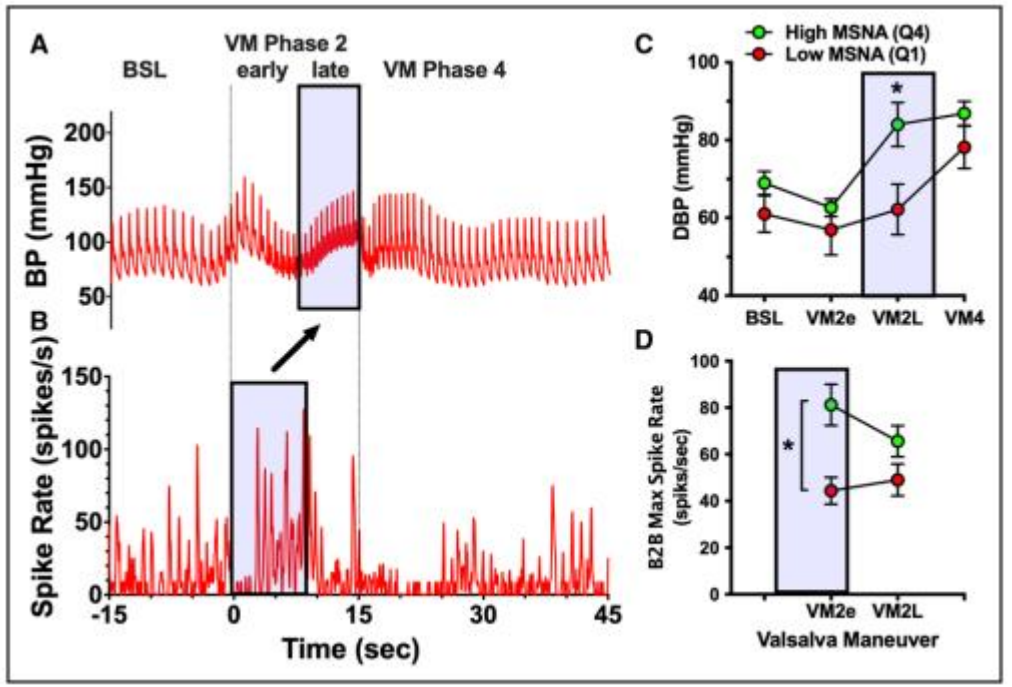
- Okamoto LE *et* al 2024.

  A diastolic blood pressure increase >17 mm Hg during the late phase 2 of the Valsalva maneuver identified patients with:

  - Hyperadrenergic POTS
  - High resting sympathetic nerve activity (ie, hyperadrenergic phenotype)
  - Predicted clinical improvement with the central sympatholytic guanfacine

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Okamoto LE *et al* Hypertension 2024;81

POTS

HYPERVIGILANT??

Crimean War 1853

- DaCosta's syndrome 'irritable heart' 1871

- Functional disorder of the heart seen in veterans from British troops in India, Crimean war, and US civil war (300 cases reported)
- Age 16 to 25
- Symptoms of palpitation, fast (or occasionally slow) heart rate, cardiac pain, distress, building in severity with exertion 'becoming so violent that the patient would fall on the ground insensible'
- Almost always began with digestive symptoms (eg diarrhea)
- Outcomes included complete remission, partial improvement, and persistent disorder leading to organic heart disease (eg hypertrophy)

Kuroski, J 2023. Valley of Death: 33 Historic photos from the Crimean war

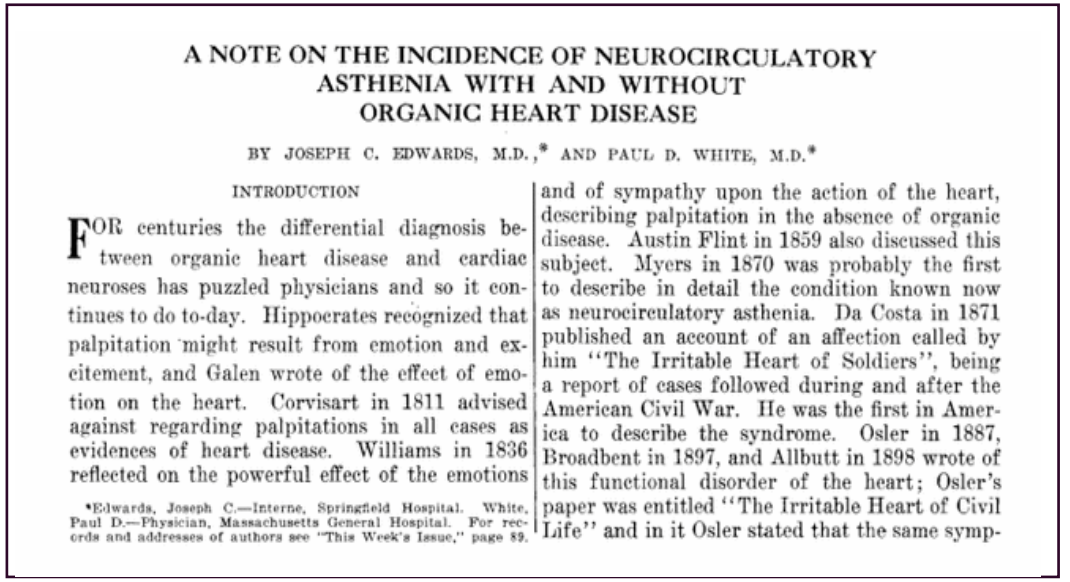
World War I

- Soldier's Heart, Effort Syndrome

- 1919 Thomas Lewis describes Soldier's Heart characterized by cardiovascular symptoms and fatigue in soldiers returning from WWI
- 1925 Grant reports on 665 men with effort syndrome with no increase in incidence of heart disease
- 1933 Lewis describes that "…the syndrome is not peculiarly a soldier's malady or an athlete's malady; it is one of the commonest chronic afflictions of **sedentary town dwellers**."

Capt. F. Hurley (1917) An episode after the Battle of Zonnebeke. Australian Infantry moving forward to resist a counterattack

Post WWII



A NOTE ON THE INCIDENCE OF NEUROCIRCULATORY ASTHENIA WITH AND WITHOUT ORGANIC HEART DISEASE

BY JOSEPH C. EDWARDS, M.D.,* AND PAUL D. WHITE, M.D.*

INTRODUCTION

FOR centuries the differential diagnosis between organic heart disease and cardiac neuroses has puzzled physicians and so it continues to do to-day. Hippocrates recognized that palpitation might result from emotion and excitement, and Galen wrote of the effect of emotion on the heart. Corvisart in 1811 advised against regarding palpitations in all cases as evidences of heart disease. Williams in 1836 reflected on the powerful effect of the emotions and of sympathy upon the action of the heart, describing palpitation in the absence of organic disease. Austin Flint in 1859 also discussed this subject. Myers in 1870 was probably the first to describe in detail the condition known now as neurocirculatory asthenia. Da Costa in 1871 published an account of an affection called by him "The Irritable Heart of Soldiers", being a report of cases followed during and after the American Civil War. He was the first in America to describe the syndrome. Osler in 1887, Broadbent in 1897, and Allbutt in 1898 wrote of this functional disorder of the heart; Osler's paper was entitled "The Irritable Heart of Civil Life" and in it Osler stated that the same symp-

*Edwards, Joseph C.—Interne, Springfield Hospital. White, Paul D.—Physician, Massachusetts General Hospital. For records and addresses of authors see "This Week's Issue," page 89.

- Neurosis and Neurocirculatory Asthenia

- 1941 Wood describes experience with 300 patients and indicates that effort syndrome is **more common in women** but described in different terms (eg neurosis). He concluded that effort syndrome is **a cardiovascular disturbance associated with psychiatric states**.

- 1950 Wheeler defines Neurocirculatory Asthenia (JAMA 142: 1950)
  - "…a state of ill health characterized **by a large number of symptoms** including breathlessness, palpitation, chest pain, nervousness, fatigue, headache, dizziness, sighing, attacks or spells, apprehension, trembling, and discomfort in crowded places, in the absence of other disease which might reasonably account for these symptoms'
- 1972 Cohen and White. Neurocirculatory asthenia complex (anxiety neurosis, effort syndrome) is distinct from manic depression
  - The disorder runs in families
  - Twice as common in women
  - Walking leads to an abnormal rise in blood lactate

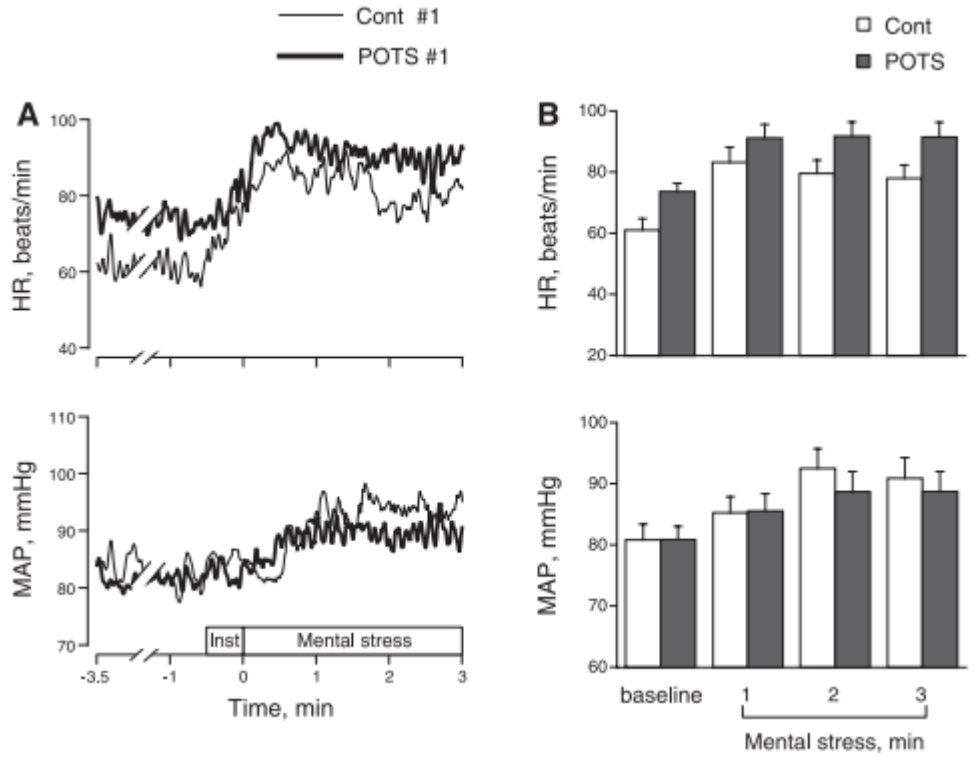
Challenges to Neurocirculatory Asthenia

- Soldier's Heart, Effort Syndrome

- 1950 Friedberg in *Diseases of the Heart*
  - *'Despite the distinctive titles, it is not a nosological entity. It is nothing more than a moiety of the more general picture of psychoneurosis, which, in the cases under discussion, chances to assume entirely or predominantly the garb of cardiac or circulatory symptoms'*
- 1951 *NEJM* Henry Miles and Stanley Cobb
  - 'We object to a concept of disease that is implicit in a **purely descriptive diagnosis** . . . . In working towards a dynamic understanding of any illness the multiplicity of **etiologic factors should be emphasized**'

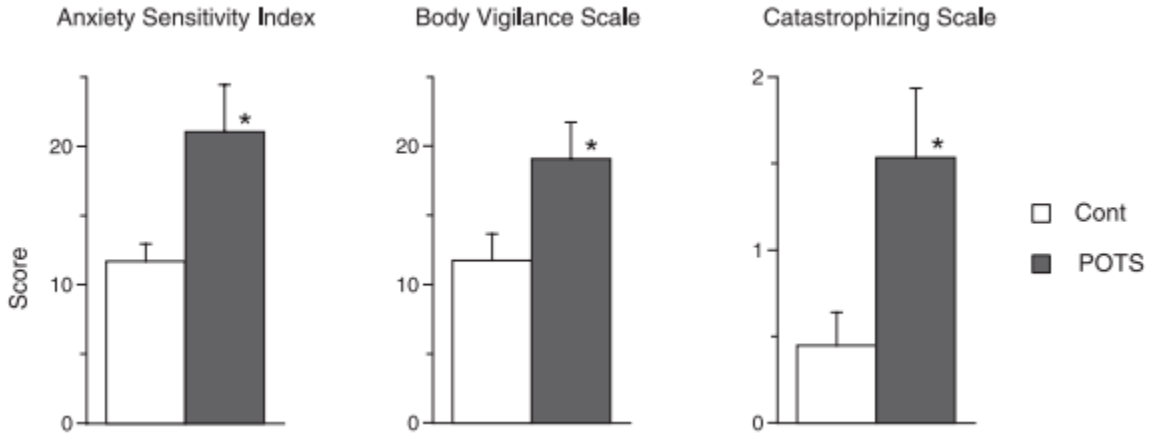
Hypervigilant POTS

- Mechanism: Increased anxiety and somatic vigilance



➢ Masuki *et al* 2007 (POTS 14, Control 10)

- Anxiety, somatic vigilance, and catastrophic cognitions were significantly higher in POTS
- They were not related to the HR responses during LBNP or mental stress



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Masuki S *et al* J Appl Physiol 102: 896 –903, 2007

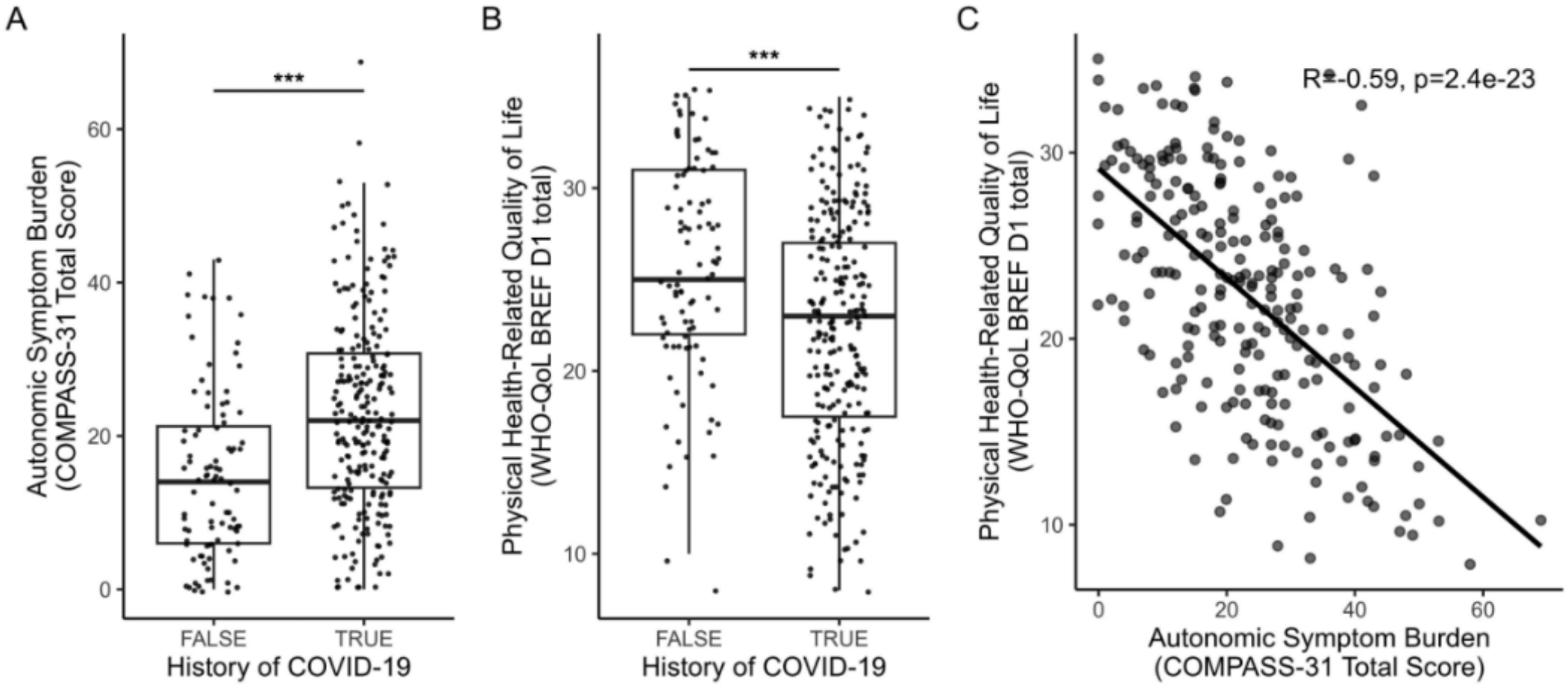
POTS - CLINICAL SYMPTOMS AND COURSE

Impact of Prior History of Traumatic Stress on Autonomic and Multi-System Symptoms Following COVID-19 Infection

Chronic Stress
Volume 9: 1–13
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POTS - CLINICAL SYMPTOMS AND COURSE

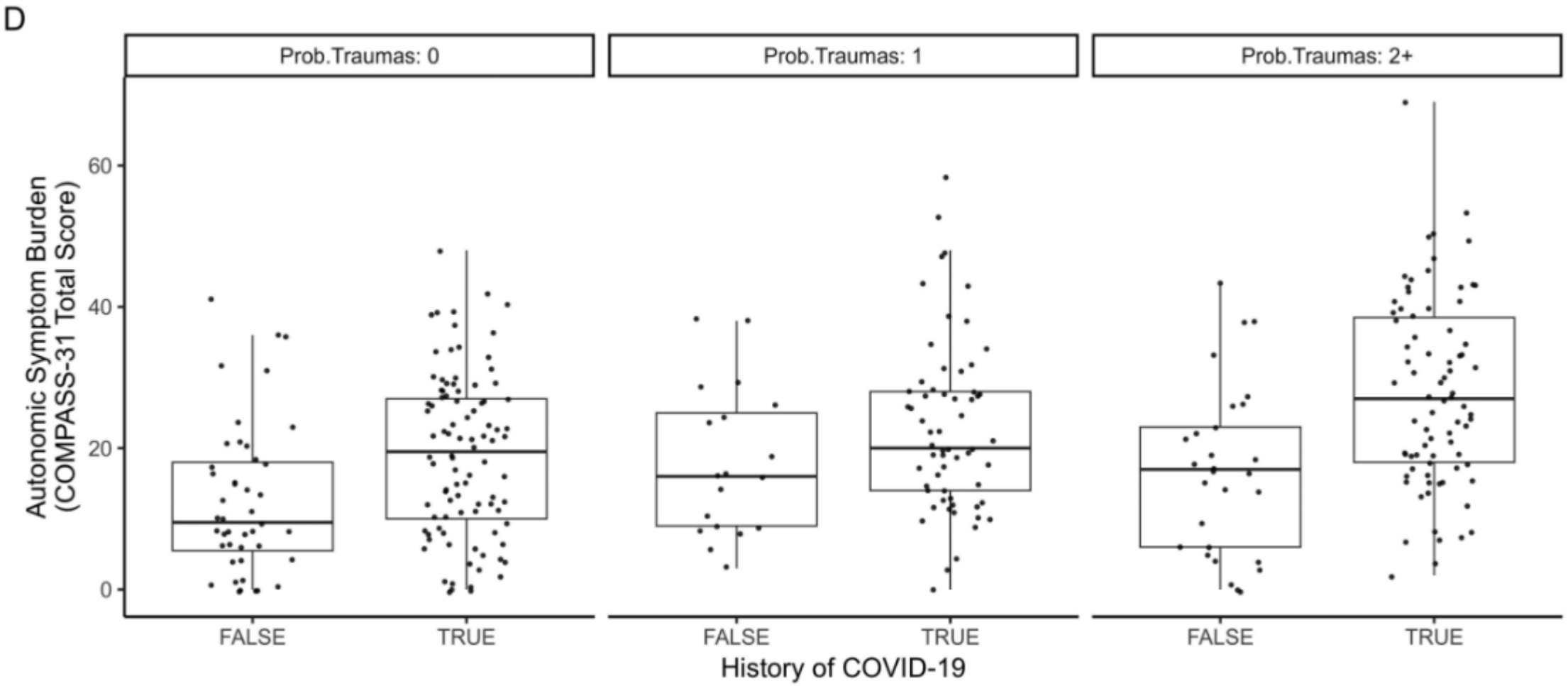


Online, self report survey including **404 individuals**

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Hendrickson RC *et* al. Chronic Stress 2025;9

POTS - CLINICAL SYMPTOMS AND COURSE

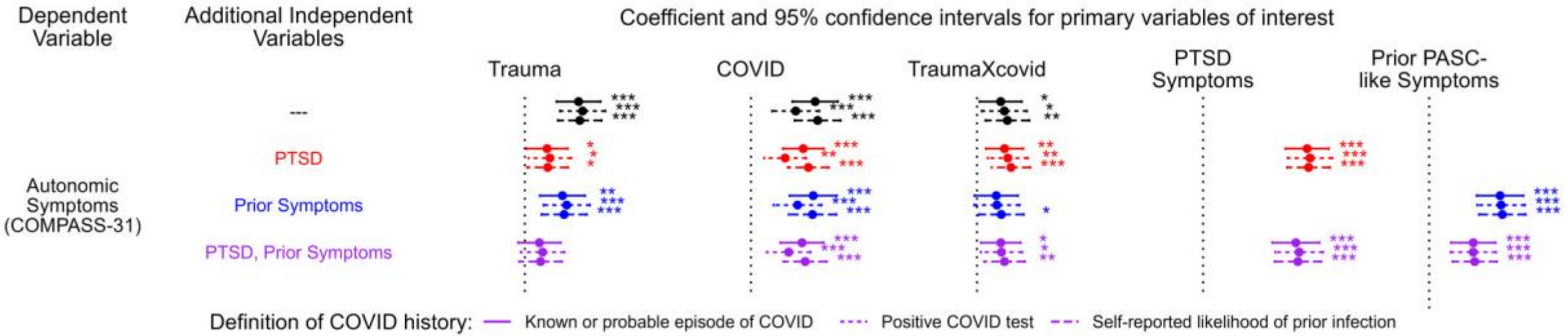


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Hendrickson RC *et* al. Chronic Stress 2025;9

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POTS - CLINICAL SYMPTOMS AND COURSE



Point estimates and 95% confidence intervals for the coefficients from multivariable regression models using normalized data, to indicate the relative contribution of each of the plotted factors to the total current autonomic symptom burden.

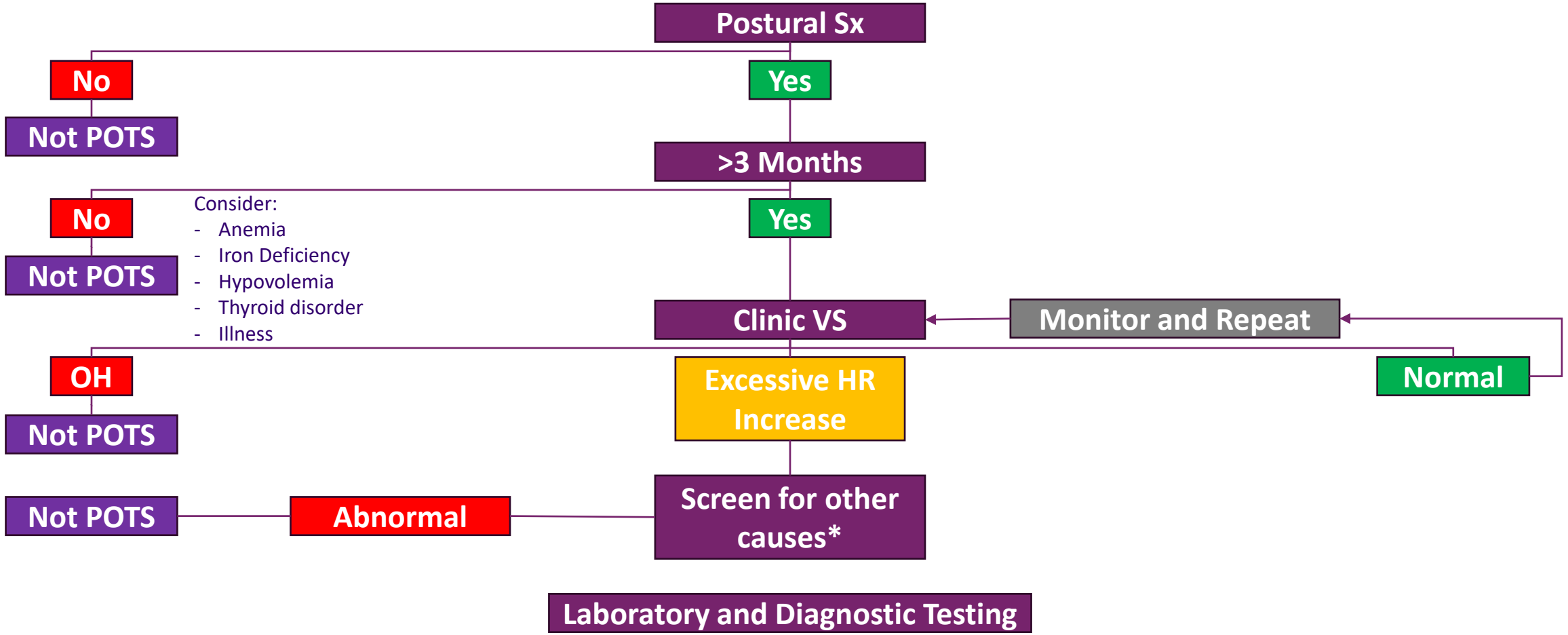
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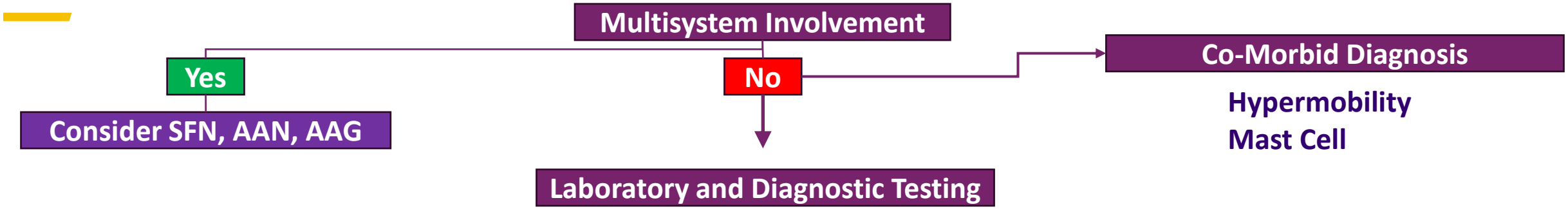
POTS

DIAGNOSTIC EVALUATION

Clinical and diagnostic evaluation of POTS



Clinical and diagnostic evaluation of POTS



Routine: CBC with diff, CMP, Ferritin, Iron studies, TSH
Consider: 24H Urine sodium, Renin Aldosterone, ANA, SSA, SSB, Autoimmune thyroid panel

If concern for neuropathy/ ganglionopathy: Skin Bx, Ganglionic AChR Ab, ESR, CRP, ANCA, Hep B/C, HIV, Lyme serologies, Copper, Ceruloplasmin

If GI Symptoms prominent: Celiac Panel, Nutritional panel

If Sicca Symptoms prominent: SSA/SSB, Consider Lip biopsy for minor salivary gland evaluation

If history of syncope: Cardiac ambulatory monitoring (evaluate for autonomically mediated ectopy), TTE
If prominent exertional dyspnea, concern for outflow obstruction or pulmonary HTN: CPET

Clinical and diagnostic evaluation of POTS

Test	Neuropathic	Hypovolemic	Hyperadrenergic	Hypervigilant
Exam – Small Fiber	-	-	-	-
ANS – Cardiovagal	-	-	-	-
ANS – Vasomotor	**Mild**	-	**Valsalva DBP increase > 17 mmHg**	**?**
QSART	**Mild, Patchy**	-	-	-
Skin Bx – IENFD	**+/-**	-	-	-
24 H Urine Na	**+/-**	**< 100 mmol**	**+/-**	**+/-**
Upright Plasma NE	**< 600 pg/ml**	**< 600 pg/ml**	**> 600 pg/ml**	**?**
EMG/NCS	-	-	-	-

POTS Therapy

- No FDA approved medications

- No multicenter, long-term, randomized controlled trials
- Multiple Non-pharmacologic and pharmacologic therapies are often needed
- Polypharmacy is common
- Possible benefit matching pharmacologic mechanism to best guess pathophysiology

POTS Therapy

Cardiovascular conditioning

- The Dallas protocol developed by Dr Levine and modified by CHOP autonomic program https://www.dysautonomiainternational.org/pdf/CHOP_Modified_Dallas_POTS_Exercise_Program.pdf
- The UTAH ADAPT Program Utah ADaPT Protocol (Provider Manual) 10.9.24 | Neurology Department | U of U School of Medicine

Joyner MJ. Exercise training in postural orthostatic tachycardia syndrome: blocking the urge to block β-receptors? *Hypertension*. 2011;58(2):136–137.

Fu Q, Vangundy TB, Shibata S, et al. Exercise training versus propranolol in the treatment of the postural orthostatic tachycardia syndrome. *Hypertension*. 2011;58(2):167–175.

POTS Therapy

Increase circulating blood volume

- Oral hydration
  - 2-3 L fluid per day
  - 10-12 grams of salt per day
- Compression
  - Waist high compression garment
  - Abdominal binder

Ganesh R, Bonnes SLR, DiBaise JK. Postural tachycardia syndrome: nutrition implications. *Nutr Clin Pract.* 2020;35(5):818–825.

POTS Therapy

Breathing exercises?

Physiotherapy interventions

- education on proper breathing techniques
- breathing retraining exercises
- frequent meetings with a specialized respiratory physiotherapist

Reilly CC, Floyd SV, Lee K, et al. Breathlessness and dysfunctional breathing in patients with postural orthostatic tachycardia syndrome (POTS): the impact of a physiotherapy intervention. *Auton Neurosci.* 2020;223:102601.

POTS Therapy - Medications

Neuropathic

- 1st - Midodrine, Droxidopa, (Pyridostigmine)
- 2nd - Fludrocortisone
- 3rd – Ivabradine (with midodrine or droxidopa)

Hypovolemic

- 1st - Fludrocortisone
- 2nd – Midodrine OR droxidopa PLUS beta blocker OR Ivabradine
- 3rd - Desmopressin (Difficult to use, hyponatremia)

Hyperadrenergic

- 1st - Propranolol, (other beta blockers), (calcium channel blockers if Raynaud's and/or chest discomfort)
  Clonidine, (Guanfacine)
- 2nd - Mixed alpha-beta block (eg carvedilol, metoprolol + prazosin)

QUESTIONS?