



The Active Stand and Tilt Tests

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Abbreviations

PoTS	Postural Tachycardia Syndrome
HR	Heart rate
AST	Active stand testing
HUT	Head-up tilt
VOSS	Vanderbilt Orthostatic Symptom Score

Assessment of Orthostatic Tachycardia

Clinical evaluation of orthostatic tachycardia is critical to the diagnostic assessment of postural tachycardia syndrome (PoTS). A key diagnostic criterion for PoTS is a heart rate (HR) increase of ≥ 30 BPM within 10 minutes of positional change from supine to standing, and without orthostatic hypotension ($>20/10$ mmHg reduction) [1]. Active stand testing (AST) and head up tilt table testing (HUT) can both be used to evaluate the presence of this tachycardia. While there are methodological differences between the two tests, the commonalities of assessing orthostatic tachycardia in PoTS will be discussed first.

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Continuous measurement of beat-to-beat blood pressure (BP) and heart rate (HR) are preferable during both AST and HUT. If continuous monitoring is not available, HR and BP readings should be recorded at regular time intervals [2]. HR measurements using pulse oximetry, non-invasive brachial blood pressure cuff measurements or manual palpation are acceptable in the clinical diagnostic setting, but do not allow for detection of non-sinus rhythm. Incremental blood pressure readings using a non-invasive brachial arm cuff are sufficient to rule out orthostatic hypotension in the setting of a diagnosis of PoTS.

For a diagnosis of PoTS, orthostatic tachycardia must be accompanied by a history of consistent orthostatic symptoms in daily life, which lessen with recumbence. Orthostatic symptoms often occur during an orthostatic test, and can be measured at the end of orthostasis using a symptom scale such as the Vanderbilt Orthostatic Symptom Score (VOSS) [3]. This scale rates nine common orthostatic symptoms from a scale of 0–10. The presence of orthostatic symptoms during the clinical exam is not necessary for a PoTS diagnosis.

The HR increment of 30 bpm that is the key diagnostic sign for PoTS is typically calculated relative to the baseline, pre-orthostasis supine period. However, Roma et al. have argued that the pre-test HR may not reflect the participants' true resting HR, due to pre-test anxiety [4]. They propose

that two minutes of supine recovery from orthostasis should also be considered when assessing the patients' maximum HR increment. The addition of this period increased the number of PoTS patients reaching diagnostic threshold by 10–30%, however the impact on specificity is unknown.

As the diagnostic criterion for PoTS is orthostatic tachycardia within 10 minutes of orthostasis from a supine posture, the optimal duration for the orthostatic test is 10–11 minutes [5]. This allows the patient to be evaluated for orthostatic tachycardia within the timeframe for PoTS diagnosis. Although orthostatic tachycardia before 10 minutes can occur, an abbreviated test could miss the requisite orthostatic tachycardia in some patients [6, 7]. Conversely, longer tests may allow for detection of some PoTS patients (so-called "late PoTS [8]"), but reduces specificity significantly (20% for HUT, 53% for AST).

Patients should be instructed to not move or voluntarily contract their leg muscles throughout the duration of the test in order to limit the contribution of the skeletal muscle pump to venous return [4]. Prior to orthostasis, the patient should lie supine for at least 5 minutes to allow heart rate and blood pressure to stabilize [9]. During HUT, the tilt table should be raised from supine to at least 60° [9] in one movement, and not in incremental angles over a certain time period. Due to the passive nature of the HUT, patients may experience vasovagal syncope, despite no medical history of syncope.

Sustained orthostatic tachycardia with a ≥ 30 BPM increase in the absence of a blood pressure decrease $>20/10$ mmHg confirms orthostatic tachycardia [10]. The addition of chronic orthostatic symptoms (≥ 3 months) confirms PoTS. It is expected that heart rate will increase upon initial active standing due to unloading of the baroreceptors, and brief initial orthostatic hypotension (reduction in blood pressure $>40/20$ mmHg immediately upon standing) may also be present [11]. If the HR increases transiently in response to the initial BP decrease, and then returns to baseline levels in the following minutes of tilt, a diagnosis of PoTS is not appropriate. The AST shows a greater initial blood pressure decrease, and HR increase than HUT [12].

General Considerations

Diurnal Variability: Orthostatic heart rate changes and baroreflex sensitivity fluctuate throughout the day [13]. Orthostatic tachycardia has been shown to be worse in PoTS patients in the morning than later in the day [14]. Symptoms of orthostatic intolerance are also more often experienced during morning testing versus later in the day [15]. Therefore, consideration into timing should be given when interpreting results of the AST and HUT. Patients should be tested in the morning when they are likely to have a more pronounced orthostatic heart rate increase, and may be more likely to demonstrate associated symptoms. Afternoon tests that are borderline for PoTS may be repeated in the morning.

Influence of Menstrual Cycle: Phase of the menstrual cycle during testing may affect the patient's results. Worsening orthostatic intolerance is associated with the early follicular or luteal (premenstrual) phases [1, 16–18]. Menstrual cycle phase should be recorded, and repeat testing should be considered in patients who are suspicious for PoTS, but do not have a positive testing result.

Medications: Drugs that affect heart rate, sympathetic nervous activity, or blood volume should be withheld prior to the orthostatic test.

Pediatric Considerations: The AST for the diagnosis of PoTS has not been validated in a pediatric population [19]. A 10 minute HUT is considered the standard diagnostic tool [19]. As orthostatic tachycardia is more common in children than adults, pediatric patients should demonstrate an orthostatic HR increase of ≥ 40 BPM in addition to symptoms of orthostatic intolerance for a diagnosis of PoTS. As well, symptoms of orthostatic intolerance may not occur during HUT. A study of 22 pediatric patients, found that 7 did not experience symptoms on HUT, despite being diagnosed with PoTS [20].

Additional Considerations: Patients should be tested in a fasted state or at least 2 hours postprandial to avoid acute fluid shifts and vasodilation that can occur in response to eating and cause postprandial hypotension [21].

Patients should refrain from alcohol for 24 hours prior to the test to avoid its diuretic effects, and the consequential reduction in plasma volume. The testing room should be kept at a comfortable temperature (20–22 °C) to mitigate the well-known effects of heat stress on exacerbating orthostatic intolerance [22]. Lastly, excitatory stimuli (bright lights, loud noises) should be minimized since they can directly alter blood pressure and heart rate.

Advantages and Disadvantages of Active Stand Testing and the Head up Tilt Test

Both AST and HUT present various advantages and disadvantages in the clinical diagnosis of PoTS. In the Heart Rhythm Society 2015 consensus statement on the diagnosis and management of PoTS, AST was rated as a class I diagnostic recommendation, and HUT as a class IIb recommendation [10]. AST is convenient, cost-effective and can be performed in the primary care physician office. The AST can therefore help to make a diagnosis of PoTS without the need for specialist referral or a specialized testing centre, which could lead to a delay in diagnosis and treatment. Passive standing testing may be utilized in patients unable to stand unsupported, as the patient stands against a wall [4]. Active standing mimics standing in everyday life, which may help to recreate specific symptomology or experiences for diagnostic purposes [5]. However, it may be difficult to standardize this testing, as muscle tensing is more difficult to control.

Orthostasis with HUT allows evaluation over a longer duration of time than AST [10], and elicits higher heart rates than AST [23]. The HUT is useful in situations where the patient is unable to stand, or has a high fall risk or risk of syncope. However, HUT requires expensive, specialized equipment and the test may not be covered by insurance. Both HUT and AST may provoke orthostatic tachycardia in patients who do not have PoTS [7], which must be carefully considered in making a diagnosis (Fig. 1).

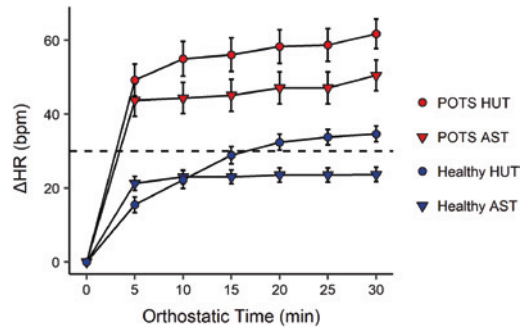


Fig. 1 The cardiac response to head-up tilt (HUT) and active stand test (AST) in patients with postural tachycardia syndrome (PoTS) and healthy controls. Note that the heart rate response to HUT is larger for both PoTS patients and healthy controls. The dashed horizontal line is the 30 bpm Δ HR criterion currently in use for the diagnosis of PoTS. Figure recreated with permission from [23]

Conclusion

Should one type of test be selected over the other for the diagnosis of PoTS? Different physiological findings may be evident in AST versus HUT, due to the role of the skeletal muscle pump [23]. A study of PoTS patients and healthy controls found a significantly higher orthostatic heart rate increase on HUT versus AST [23]. In this study, HUT and AST had similar sensitivities (93% and 87%, respectively), but specificity was lower for HUT (40% vs. 67% for AST). A different study of patients with orthostatic intolerance as well as healthy controls found similar HR measurements between AST and HUT [2]. Reflex tachycardia specific to initial orthostatic hypotension may be greater in the initial minutes of AST, compared to HUT, and this should be considered in the evaluation of early AST HR responses [12]. A summary of the comparisons between AST and HUT are found in Table 1.

Overall, the AST should be used as a first line tool in the diagnostic assessment of PoTS. Referral to a specialist centre with HUT and other autonomic testing may be considered if the patient does not experience symptom improvement with initial treatment [10], is limited in their ability to complete the AST, or another

Table 1 Summary of active stand and head up tilt testing

	Active stand testing	Head up tilt testing
Heart rate evaluation	First line diagnostic tool for PoTS	Elicits greater orthostatic tachycardia
Blood pressure evaluation	May elicit initial orthostatic hypotension	
Usage	May be performed in the physician's office	Requires specialized equipment
Sensitivity (%)	87	93
Specificity	67	40

diagnosis requiring prolonged passive standing for diagnosis (e.g. delayed orthostatic hypotension or vasovagal syncope) is being considered.

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