APTA Acute Care
An Academy of the American Physical Therapy Association

APTA Academy of Cardiovascular & Pulmonary Physical Therapy℠

ADULT VITAL SIGN INTERPRETATION IN ACUTE CARE GUIDE 2021

Joint Task Force of APTA Acute Care and the Academy of Cardiovascular & Pulmonary Physical Therapy of the American Physical Therapy Association

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Disclaimer: This document is intended to provide education and guidance on vital sign interpretation for adult populations but does not replace sound clinical judgment. While vital signs are the primary determinants to assess patient readiness for mobility and response to activity, these values need to be corroborated with other patient findings. Although recommendations are provided for various conditions, individual patient vital signs and co-morbidities should guide clinical decision making. Any questions of medical stability should be discussed with the healthcare team. It is recommended to read the introduction prior to going to any other section of this document for important contextual information.

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Introduction

The purpose of obtaining vital signs (VS) is to detect and monitor physiologic states and assess activity responses to aid in exercise prescription. VS determine patient risk for adverse events, such as cardiovascular episodes and syncope. Compared to outpatient settings, hospitalized patients present more often with abnormal or labile VS and are at a higher risk of immediate events requiring acute care physical therapists to assess and monitor VS with greater frequency. Assessing pulse rate (PR), respiratory rate (RR), temperature, and blood pressure (BP) are essential components of a systems review in a physical therapy (PT) examination.[1] Additionally, tissue oxygenation, measured by pulse oximetry, is necessary to assess hypoxemia. Physical therapists should correlate current VS values with other data points such as symptoms, baseline VS, medication schedule, lab values, and comorbidities when making decisions about patient care.

Normal Values:
- Values presented are for adults
- Baseline health and fitness influence VS, particularly PR and BP

Frequency of VS Monitoring:
- VS at rest help determine readiness for PT intervention, in conjunction with other findings
- VS during PT interventions and recovery assess hemodynamic and oxygenation responses and stability
- PT providers (physical therapists and physical therapist assistants) should follow the institution policy and procedures regarding activity
- PT providers should monitor VS for adverse reactions, especially during medication adjustments, transfusions, or other procedures
- Critical Care: (refer to Vital Sign Interpretation in the Intensive Care Unit for more details)
  - Intensive care units (ICU) involve more specialized monitoring and invasive treatments that cannot be handled safely in the general wards/floors
  - VS should be assessed continually during PT interventions in the ICU

Accuracy of Measurement:
- Accuracy of VS measurement and documentation is of extreme importance, but education on techniques is beyond this guideline's scope
- Poor technique can cause inaccurate BP measurement[2]
- The Academy of Cardiovascular and Pulmonary Physical Therapy offer several videos
- (#VitalsAreVital) to guide PT providers and students to perform VS accurately
- VS are dynamic measurements that can be influenced by many factors
  - Caffeine, smoking, stress, agitation/delirium, and other factors can contribute to an elevated PR, RR, and BP
  - Medications and administration timing can influence VS
  - BP is exceptionally dynamic; interpretation in the context of trends is best
  - Documentation should include the patient position, extremity, or activity during VS measurement (i.e. sitting, supine, rest, mobility)

Vital Sign Interpretation for General Adult Population

Blood Pressure (BP)

- **Blood pressure (BP)** = Cardiac Output (CO) x Total Peripheral Resistance (TPR)
  - CO = Stroke Volume (SV) x Heart Rate (HR)

Categories[3*]	Systolic (SBP) (mmHg)		Diastolic (DBP) (mmHg)
Normal	< 120	and	< 80
High-normal/Elevated/ Pre-hypertensive	120 - 129	and	< 80
Stage 1 Hypertension	130 - 139	or	80 - 89
Stage 2 Hypertension	≥ 140	or	≥ 90
Hypertensive Crisis	≥ 180	and/or	> 120

*Other organizations (International Society of Hypertension, American College of Physicians, American Academy of Family Physicians, 8th Joint National Committee) not listed in this table have guidelines regarding hypertension categories. Refer to these references for additional evidence.[150-152]

- **Hypotension**: < 80 mmHg SBP; < 60 mmHg DBP[4,5]
- **Mean Arterial Pressure (MAP)**: Average pressure of the blood in the arteries during a cardiac cycle; can serve as an indicator of perfusion to vital organs
  - MAP = [SBP + (2 x DBP)]/3[6]
  - **Normal MAP**: 70 - 110 mmHg[7-9]
    - MAP < 60 mmHg can result in ↓ perfusion of vital organs
    - Consult with the medical team if MAP < 65 mmHg to determine appropriateness of activity
    - Low values can be a sign of stroke, internal bleeding, sepsis, etc.
    - High values can be a sign of kidney failure, heart failure, etc.
- **Pulse Pressure (PP)** = SBP - DBP
  - Normal PP range: 40 - 60 mmHg[10]
  - PP outside of the normal range is a significant factor in the development of heart disease
    - Low or "narrowed" (< 25% SBP) can be a sign of heart failure (HF) (low SV), aortic valve stenosis, blood loss, etc.[10]
    - Chronic elevation (> 59 mmHg) can be a sign of arterial resistance, HF, ↑ SBP, aging, etc.[7,1]

BP - Clinical Considerations

- Assess for BP trends as normal fluctuations occur (e.g. nocturnal or postprandial dipping)[12]
  - SBP ↑ with hypervolemia and ↓ with hypovolemia
- **Normal Exercise Response**
  - SBP ↑ in a linear fashion, 10 mmHg per Metabolic Equivalent (MET) until physiologic maximum (dampened response in patients on beta blockers)[13] (Refer to Pharmacology Section for more details)
  - Monitor BP post PT intervention until returns to baseline
- **Hypertension (HTN)**
  - HTN is generally asymptomatic, so symptoms should not drive the need for VS assessment
    - Monitor for the following symptoms: headaches; visual impairments; confusion; pounding in chest, neck, or ears
  - In most cases, there is no known cause
  - Potential causes: hypercalcemia; thyroid diseases; full bladder; sympathetic stimulation; stress/ anxiety; white coat HTN; hypervolemia[11,14]
  - Cardiovascular risk ↓ with ↓ BP, but dosage amounts of antihypertensive medications may be associated with ↑ adverse effects, including ↑ fall risk[15]

Hypotension

- Potential causes:
  - Parasympathetic stimulation, hyperkalemia, hypokalemia, hypocalcemia, anoxia, acidosis, hypovolemia, bedrest
  - Cardiac dysrhythmia[16] (Refer to Heart Rate/Pulse Rate Section for more details)
  - Medications (Refer to Pharmacology Section for more details)
  - Adrenal insufficiency
  - Valsalva:
    - To prevent, ask the patient to breathe rhythmically, count, or talk during PT intervention
    - Monitor for the following symptoms: lightheadedness/dizziness; nausea; breathlessness
- Orthostatic (postural) hypotension is a ↓ SBP > 20 mmHg or ↓ DBP > 10 mmHg on standing within three minutes
  - Monitor for the following symptoms: lightheadedness; diaphoresis; dizziness; confusion; blurred vision

- **Older Adults**: **Cognition and Blood Pressure**
  - Treatment of HTN to ↓ SBP to < 140 mmHg can ↓ the development of cognitive impairment[17,18]
  - Hypotension (< 120/75 mmHg) is associated with ↓ cognitive function in older adults[19]
  - Orthostatic hypotension is more prevalent in people with dementia. Cerebral hypoperfusion is associated with cognitive impairment in a study of adults ≥ 50 years old. People with orthostatic hypotension demonstrated ↓ scores on tests of global cognitive function and memory vs. those without orthostatic hypotension, especially in women.[20]
  - The average orthostatic SBP response is found to be significantly ↓ in older adults with dementia, so a larger drop in SBP from sitting to standing ↑ the odds of a dementia diagnosis[21]

Heart Rate (HR) and Pulse Rate (PR)

- **Normal resting rate**: 60 - 100 beats/min
- **Tachycardia**: > 100 beats/min
  - Relative tachycardia: ↑ resting PR > 20 beats/min from usual/baseline
- **Bradycardia**: < 60 beats/min
  - Relative bradycardia: ↓ resting PR > 20 beats/min from usual/baseline
- **Heart Rate (HR)**: measured by ECG (ventricular rate)
  - ↑ resting HR is associated with risk of all-cause and cardiovascular mortality. Mortality ↑ as resting HR ↑, but there is significant ↑ risk of cardiovascular mortality with resting HR > 90 beats/min.[22] Specifically, this is recognized in older vs. younger adults.[23]
- **Pulse Rate (PR)**: pulses palpated at an artery or measured by pulse oximetry

Pulse Grade	Description[24]
Absent (0)	No perceptible pulse
Thread (1+)	Barely perceptible, easily obliterated with slight pressure
Weak (2+)	Difficult to palpate, slightly stronger than thread, can be obliterated with light pressure
Normal (3+)	Easy to palpate, requires moderate pressure to obliterate
Bounding (4+)	Very strong, hyperactive

HR and PR - Clinical Considerations

- **Normal response with exercise**: ↑ 10 beats/min per MET then returns to pre-exercise level in 3-5 minutes[13]
  - Consider using Borg Rating of Perceived Exertion (RPE) Scale and Breathlessness Scale as additional measurement tools
- It is important to consider the clinical significance of the dysrhythmia both at rest and in response to PT intervention[16]
  - Electrolyte imbalances can ↑ risk of dysrhythmias

- Most abnormal rhythms have a negative impact on CO that can lead to symptoms such as hypotension, weakness, fatigue, dizziness, syncope, diaphoresis, and mental confusion, and thus must be considered clinically or hemodynamically significant
- If patient's pulse is irregularly irregular or regularly irregular, the clinician should auscultate apical HR for at least 60 seconds[25]
- Must determine if the resting dysrhythmia is clinically/hemodynamically significant (↓ CO) to decide if PT intervention is appropriate
  - If PT is determined to be appropriate, then it is important to analyze the impact of the intervention on the patient's dysrhythmia If the dysrhythmia is worsening and/or symptoms of compromised CO are occurring or ↑, then the appropriate decision would likely be to ↓ the exercise workload or stop the intervention depending on the magnitude of the change.

- Postural orthostatic (autonomic) tachycardia syndrome (POTS): PR of > 120 beats/min or an ↑ of > 30 beats/min from supine to standing with no ↓ in BP
  - POTS is multifactorial with contributions from impaired sympathetically mediated vasoconstriction, excessive sympathetic drive, volume dysregulation, impaired carotid baroreceptor control, baroreceptor failure, and deconditioning[26,27]
  - Monitor symptoms e.g. fatigue, light-headedness, exercise intolerance, cognitive impairment

Respiratory Rate (RR)[24]

- **Normal resting rate (Eupnea)**: 12 - 18 breaths/min with equal rate and depth
- **Bradypnea**: < 10 breaths/min
  - Potential causes: opioids; hypothyroidism; brain disorders
- **Tachypnea**: > 24 breaths/min (usually shallow)
  - Potential causes: pain; emotion; fever; metabolic disorders; ↓ elasticity of lungs (emphysema); resistance to air passages (asthma); hypoxemia; hypercapnia; ↓ tidal volume; an abnormally low blood pH (acidosis)

RR - Clinical Considerations

- Drug and alcohol-related depression of RR can cause respiratory arrest
- Sitting and standing have ↓ work of breathing compared to supine
- Use Borg RPE Scale for monitoring (not to exceed 4 - 5/10 during activity) or the talk test ("just barely can respond in conversation" during activity)[28,29]
- For individual's RR = 45 breaths/min use caution; if RR = 50 breaths/min no exercise[30]

Blood Oxygen Saturation (SpO2)[31]

- **Normal**: > 95%
- **Below average for population**: 91 - 94%
- **Collaborate with team**: < 90%

Blood Oxygen Saturation - Clinical Considerations[32]

- SpO_2 = peripherally measured O_2 saturation via pulse oximetry. If peripheral blood flow is adequate, SpO_2 is a good approximation of SaO_2
- SpO_2 is an index of partial pressure of oxygen (O_2) and may ↓ if O_2 diffusion ↓
- If SpO_2 is low, there is ↓ O_2 delivery to the peripheral tissue
- Document if patient is on room air or the amount of supplemental O_2, the O_2 delivery device, and conditions under which measurement is taken
- Monitor for the following signs and symptoms of hypoxemia e.g. confusion, wheezing, changes in HR, diaphoresis, clubbing, changes in nail bed color
- Inaccurate readings may occur with movement, damage to nail bed or nail polish, blisters, or poor perfusion (cold fingers)
  - Ear or forehead monitor may be required
  - Check PR against pulse oximeter HR to verify accuracy of pulse oximeter reading
  - Fingertip monitors have the least accuracy compared to other monitors
- Inaccurate readings often occur with dark-skinned individuals[33,34]

- Black patients more likely than white patients to have falsely high readings, overestimating arterial oxygenation during hypoxia
- Individuals with type 2 diabetes with glycated hemoglobin (HbA1c) > 7% may result in a falsely high reading
- Persons with advanced, chronic obstructive pulmonary disorders may retain carbon dioxide (CO_2), so supplemental O_2 should be used judiciously (Refer to Lung Disease Section for more details)
  - Check physician orders for titration of O_2

Temperature[24,35]

- **Normal core body temperature**: 35.5 - 37.5°C (95.9 - 99.5°F)
  - Oral: 37°C (98.6°F)
  - Axillary: 36.45°C (97.6°F)
  - Rectal: 0.27°- 0.38°C (0.5° - 0.7°F) > oral temperature
  - Lowest point in body temperature usually occurs at ~4 a.m. and the peak occurs at ~6 p.m.
- **Hypothermia**: Rectal temperature of < 35°C (95°F)
  - Early stage (35° - 32.8°C; 95° - 91°F) signs and symptoms e.g. shivering ↑ BP and PR, vasoconstriction, and diuresis
  - Intermediate stage (32.2° - 24°C; 90° - 75°F) signs and symptoms e.g. ↓ in metabolism, ↓ PR, ↓ BP, ↓ RR, muscular rigidity, tremor, respiratory and metabolic acidosis
  - Third stage (when all attempts at compensation by the temperature regulatory center fail) signs and symptoms e.g. ↑ HR, ↓ BP, ↑ RR, leukocytosis, acidosis, ↑ pulmonary wedge pressure, and right atrial pressure
  - Potential causes: dermal disease (i.e. burns, psoriasis); drug-induced; exposure to cold weather conditions or cold water; metabolic disorders; and neuromuscular inefficiency[36]
  - Hypothermia caused by infection with bacteremia is associated with ↓ systemic vascular resistance and ↑ cardiac index (CI) than patients who are non-bacteremic with hypothermia
- **Hyperthermia** (febrile): Oral: > 37.5°C (99.5°F); Rectal: > 38°C (100.5°F)
  - Signs and symptoms e.g. headache, change in gait speed, speech, or mental status
  - Potential causes: exercise with environmental temperatures > 32.2°C (90°F) and humidity > 90%; cancer and related treatments; or infectious conditions

Temperature - Clinical Considerations

- Exercise and heavy exertion may ↑ the core temperature 1 - 1.5°C (2 - 3°F), but usually returns to normal within 30 minutes of cessation of exertion[37]
- Any change of temperature high or low can be a sign of sepsis
  - For every 1°C ↑ in temperature, there is a 13% ↑ in metabolic rate (7% per degree F)
    - ↑ concern for elderly and individuals with restrictive lung disease and cardiovascular disease
    - In the elderly, confusion may be the first sign of an infection instead of temperature change[38]

Vital Sign Interpretation in the Intensive Care Unit (ICU)

ICU – Background

This section includes information to assist PT providers to understand important concepts related to O_2 transport/utilization and clinical applications when monitoring VS in the ICU. Multiple factors influence VS, including medical diagnosis, medical stability, laboratory values, blood chemistry, and pharmacologic interventions. Tissue oxygenation and perfusion of the brain and vital organs are paramount in the VS hierarchy. Mean arterial pressure (MAP), tissue oxygenation, pH, and serum chemistry are primary VS determinants of patient stability. These are major predictors of ICU mortality along with RR, PR, and body temperature utilized in scales like the **APACHE II**.[39]

The key for effective and safe PT management of patients in ICU is to have patient-centered goals and strong interdisciplinary collaboration. Patients with critical illness usually have multiple medical problems and require special considerations. It is imperative that specific discussions about VS with the ICU team and appropriate orders addressing VS ranges are specified.

The PT provider is expected to communicate to the ICU team any deviation from the prescribed ranges during the PT intervention. Due to the high medical complexity of these patients, documentation should indicate a close and continuous monitoring of VS throughout the PT intervention. Additional information which may help with clinical decision making include:

- The recent trends in VS should be reviewed for a better understanding of the patient's clinical condition
- The VS may fluctuate during some medical interventions, such as ventilator weaning, medication titration, adjustments in circulatory support flow rates, and many others.
- A significant change in VS in the absence of a known cause can potentially be a poor prognostic sign
- It is expected for VS to fluctuate frequently and sometimes significantly during PT interventions in ICU

Minimum PT documentation for VS in the ICU is:

- Specific amount of supplemental O_2 and/or circulatory support (e.g. pharmacologic or mechanical)
- VS at rest, with position change, peak exercise/activity, and cool-down/recovery values

Perfusion - Indicates the delivery of blood to vital organs/tissues. It is measured indirectly (Liters/min - L/min) based on the factors described below

Cardiac Output (CO)	• CO = HR x SV (Stroke Volume) • Normal values vary by gender and body size • **Normal adult resting CO**: 4.0 - 8.0 L/min
Cardiac Index (CI)	• Factors in body habitus for CO to allow same normal value levels to be used across patients of varying body sizes • **Normal CI**: 2.5 - 4.0 L/min/m^2

Blood Pressure (BP)	• BP is primarily determined by CO and systemic vascular resistance (SVR). It includes values for the systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP)
	• MAP is average pressure during a single cycle
	  • MAP is largely based on DBP because most of the cardiac cycle is spent in diastole
	  • MAP = [SBP + (2 × DBP)]/3
	  • **Normal MAP**: 70 - 110 mmHg
	  • MAP < 60 mmHg can result in ↓ perfusion of vital organs
	  • Consult with the medical team if MAP < 65 mmHg to determine appropriateness of activity
	• BP can be assessed non-invasively using a cuff/ sphygmomanometer or an electronic cuff. The manual readings are more accurate; however, the electronic cuffs are used in the ICU because they can be cycled/ recorded automatically at set time intervals.
	• BP can be assessed invasively using an arterial line and, in this case, the arterial line transducer must remain at the level of the right atrium for accurate reading
	  • If the transducer is below right atrium will have a false, high reading
	  • If the transducer is above right atrium will have a false, low reading
	  • A BP cuff reading should be used if the PT provider is unable to ensure that the transducer is correctly leveled with the right atrium such as during ambulation

Heart Rate (HR)	• **Normal HR**: 60 - 100 beats/min. • PT providers must monitor patients in the ICU continuously for sudden changes in heart rate or rhythm • It is important for physical therapists to understand the reasons for abnormal HR prior to making clinical decisions, including, but not limited to hypovolemia, anxiety, medications, and pain. • Higher HRs shorten the diastolic time period which is the portion of the cardiac cycle when coronary arteries and ventricles fill

Pulmonary Artery Pressure (PAP)	• **Normal values include**:
	  • **Pulmonary artery systolic pressure (PASP)**: 15 - 25 mmHg
	  • **Pulmonary artery diastolic pressure (PADP)**: 8 - 15 mmHg
	  • **Mean pulmonary artery pressure (MPAP)**: 10 - 20 mmHg
	  • MPAP = [PASP + (2 x PADP)]
	  • **Pulmonary artery wedge pressure (PAWP) or pulmonary artery occlusion pressure (PAOP)**: 6 - 12 mmHg

Cerebral Perfusion Pressure (CPP)	• CPP = MAP - ICP • **Normal CPP**: 60 - 80 mmHg

Intracranial Pressure (ICP)	• **Normal ICP**: 5 - 15 mmHg (acceptable levels as high as 22 mmHg; discuss with medical team)[40,41]
	• ↑ ICP is indicator of excessive compression on the brain, which can lead to cerebral ischemia and herniation
	• ICP is used as proxy for CPP
	• ↑ ICP may trigger an ↑ in arterial pressure to overcome ICP and maintain CPP resulting in relative hypertension, bradycardia, and bradypnea referred to as Cushing's triad, Cushing reflex or vasopressor response
	• The ICP transducer must be leveled with the tragus of the patient's ear to provide an accurate reading
	• Prior to any activity during PT:
	  • The PT provider should coordinate with nursing to verify that the drain is clamped to prevent unintentional excessive cerebrospinal fluid draining[42]
	  • Discuss with the ICU team the target ICP prior to PT intervention
	  • Recognize that ICP will change with any positional changes of the patient
	• During PT intervention:
	  • ICP must be monitored closely and target range strictly followed
	  • ICP transducer must be releveled/recalibrated every time a patient changes position to avoid inaccurate ICP reading
	  • Monitoring of neurological status is imperative throughout PT interventions to assess for changes in pupil reactivity, reflexes, mentation, and arousal which could indicate an ↑ ICP and ↓ CPP

Oxygenation and Ventilation	

Oxygen Saturation
• SpO_2
• SaO_2
• SvO_2
	• SpO_2 = peripherally measured O_2 saturation via pulse oximetry. If peripheral blood flow is adequate, SpO_2 is a good approximation of SaO_2.
	• SaO_2 = oxyhemoglobin saturation measured via arterial blood gas (ABG)
	• **Normal SpO_2 and SaO_2**: 95 - 100%
	  • Need to document how much supplemental O_2 and/or ventilatory support is being used to attain these values
	• SvO_2 = mixed venous O_2 saturation and indirect measure of peripheral O_2 extraction
	  • **Normal SvO_2**: 65 - 75%
	  • If SvO_2 is too high (in presence of hypoxemia), the body is having trouble using (extracting) the circulating O_2
	  • Potential causes: sepsis; poisoning; or other conditions causing abnormal circulatory shunting
	  • If SvO_2 is too low, tissues are extracting an excessive amount of O_2.
	  • Potential causes: ↓ O_2 delivery; ↓ Hgb; ↓ SaO_2 (hypoxemia); ↓ CO (any form of shock, arrhythmia); or ↑ O_2 demand (hyperthermia, shivering, pain, seizures)

Partial pressure of O_2 (PaO_2)	• Partial pressure of O_2 in blood via ABG • **Normal PaO_2**: 80 - 100 mmHg

PaO_2/FiO_2 ratio (aka P/F Ratio)	• Ratio of PaO_2 via ABG to fraction of inspired O_2 (FiO_2) • Widely used indicator of hypoxemia • **Normal PaO_2/FiO_2 (P/F) ratio**: ~ 400 - 500 mmHg (~55 - 65 kPa) • P/F ratio < 200 - 300 mmHg indicates possible need for mechanical ventilation • P/F ratio < 150 indicates severe hypoxemia; medical team should consider prone positioning in ARDS and /or possible ECMO • Improvement is indicated by the patient's ability to maintain normal PaO_2 on less supplemental O_2 (less FiO_2). Therefore, an endurance goal in the ICU may be to have a better P/F ratio versus isolated improvement in SpO_2. • For example, a patient who ambulates in the ICU with an SpO_2 of 90% on room air is oxygenating better than a patient who ambulates with an SpO_2 of 93% but requires 50% face mask to maintain SpO_2
Additional Factors that Affect Oxygen Binding/Transport and Oxygen Consumption	

Body Temperature
Lactate pH Hemoglobin
	• Normal core body temperature: 35.5 - 37.5°C (95.9 - 99.5°F)
	  • Disruption of thermoregulation is common in the critically ill
	  • Severe hyperthermia could lead to multiorgan failure
	  • Hyperthermia also ↓ oxygen-hemoglobin association resulting in ↓ SpO_2
	• Anemia, acidosis, and ↑ lactate levels can all impair O_2 delivery to tissues
	  • pH < 7.35 (acidosis) ↓ oxygen-hemoglobin association resulting in ↓ SpO_2 and impaired O_2 delivery
	  • ↑ blood lactate levels are common in patients in the ICU. Excess lactate accumulation ↓ pH (metabolic acidosis) which ↓ oxygen-hemoglobin association resulting in ↓ SpO_2 and impaired O_2 delivery
	  • Hyperlactatemia on ICU admission is associated with worse prognosis
	  • Anemia can impair tissue oxygenation despite a lack of change in SpO_2/SaO_2 levels (tachycardia may result)

ICU Support Devices and Effects on Vital Signs
Continuous Renal Replacement Therapy (CRRT) - Clinical Considerations
• Monitor for hypotension[43] • PT providers should work within MAP parameters as prolonged duration of MAP < 73 mmHg can accelerate the progression of acute kidney injury[44] • Patients on CRRT usually have multiple medical problems or comorbidities and may also require vasopressor support. PT providers are encouraged to discuss the patient's current medical status with ICU medical team and establish a target MAP range for the PT intervention. • Central venous pressure (CVP) may be a preferred target in hemodynamic therapy during CRRT as it reflects relative changes in blood volume. Maintaining CVP < 8 mmHg during the early phase of septic shock can prevent further damage to renal function and improve the survival rate of critically ill patients.[45]
Extracorporeal Membrane Oxygenation (ECMO) - Clinical Considerations

General
• Different types of ECMO
  • VA = veno-arterial ECMO
  • VV = veno-venous ECMO
• All changes to ECMO support required during the PT intervention should be performed by a qualified ECMO specialist
• Due to the high medical complexity of patients on ECMO support, the PT provider's documentation should indicate close monitoring of VS during the PT intervention

Blood Pressure
- MAP goal is typically > 65mmHg but < 90 mmHg to limit afterload and to promote forward flow[46]
- The a-line waveform can look dampened or even flat; only displaying the MAP. This flattened waveform does not mean that the a-line is inaccurate.[47]
- Hypotension could be due to inadequate flow or inadequate systemic vascular resistance (SVR)

Pulsatility
- Pulsatility = Pulse Pressure/Mean Arterial Pressure (PP/MAP)[48]
- Right after implantation, most VA ECMO patients have poor or no heart pulsatility[47]
- Lack of pulsatility on the arterial waveform could be due to poor myocardial function, excessive ECMO support, inadequate preload, or right ventricular failure; may result in thrombus, myocardial ischemia, or pulmonary edema[46]

Heart Rate and Rhythm
- Monitor ECG for dysrhythmias[46]
- Loss of pulses or cyanosis/coolness of a limb could lead to distal limb ischemia[46]

Oxygenation/Ventilation
- Should be continuously monitored via the ECMO circuit[49]
- ↓ SvO_2 and ↑ lactate suggest inadequate O_2 delivery; excessive O_2 consumption can lead to fever or shivering[46]
- For VV ECMO patients, the saturation target is rarely 100%. A saturation in the low 90s is sufficient.[47]
- Gas exchange - monitor for inadequate partial pressure of oxygen (PaO_2) or excessive CO_2 elimination[46]
- Patients may require additional mechanical ventilation or ECMO support to perform PT intervention due to ↑ CO, O_2 consumption and CO_2 production during the physical activity
- Patients with minimal native lung function (tidal volumes < 200 mL, or no change in PaO_2 with an ↑ in fraction of inspired oxygen (FiO_2) to 1.0 for 30 minutes to assess contribution of lungs to gas exchange) may require ↑ ECMO blood flow during the rehabilitation activity
- Patients with recovering lung function (tidal volumes > 200 mL and incremental change in PaO_2 following ↑ in FiO_2 to 1.0) may require ↑ FiO_2 via the ventilator and/or ↑ ECMO blood flow during the rehabilitation activity. Fluid boluses may be required to avoid complications related to changes to ECMO flow settings

Temperature
- ECMO should not affect temperature.[46] If patient has an ↑ temperature, it could be a sign of infection.

Flow Rate (liters/minute of blood flow that the ECMO circuitry is generating)
- Should be continuously monitored via the ECMO circuit[49]

Intra-Aortic Balloon Pump (IABP) - Clinical Considerations

General
- IABP locations can be femoral or axillary. Patients with femoral IABPs are typically on bedrest with limitations in hip flexion and head of bed elevation. Patients with axillary IABPs can mobilize out of bed and/or ambulate. Protocols may vary depending on institution.
- Patients should be monitored continuously and any change in hemodynamics should be reported to the medical team immediately[50,51]
- When auscultating heart and breath sounds, the IABP will need to be placed on standby. Any changes to IABP settings (including standby mode) should only be performed by trained personnel.[52]

Blood Pressure
- The aortic BP measured from the tip of the IABP on the balloon pump console is likely to be the most accurate or the truest reflection of the patient's central BP; therefore, the BP reading from the IABP is generally considered the gold standard[53]
- As a pulse moves through the arterial system away from the aorta, SBP ↑ and DBP may ↓, because of reflection of the pressure wave. Peripheral SBP i.e., from the radial artery is usually > the aortic SBP, but the MAP measured peripherally may be ↓[50,53]

Pulses
- Monitor pedal and radial pulses on the affected side. If the balloon moves up/down it can occlude perfusion to the limbs.[51,52]
- Monitor for signs of limb ischemia (color, sensation, temperature, movement, and capillary refill)[51,52]

Positive Pressure Ventilation (Invasive and Non-Invasive) - Clinical Considerations

- Continuous VS monitoring for patients on mechanical ventilation is imperative during PT intervention to ensure patient safety
- Target VS parameters should be determined based on current medical status after discussion with ICU team
- BP trends ↓ and HR trends ↑ due to ↑ intrathoracic pressures
- Positive pressure ventilation may ↑ intra-thoracic pressures resulting in ↓ CO and ↓ BP when right ventricular preload is affected. Positive end expiratory pressure (PEEP) further ↑ airway pressures and may ↓ venous return.
- Endotracheal suctioning may precipitate a vasovagal reaction resulting in profound bradycardia and hypotension. The PT provider might consider pre-hyperoxygenation prior to suctioning to avoid O_2 desaturation.

Ventricular Assist Device (VAD) - Clinical Considerations

Blood Pressure

- MAP should be maintained between 70 - 90 mmHg during exercise[58]
- If unable to detect BP with a cuff, an a-line is the most accurate method. Doppler ultrasound is an alternative in patients without an a-line.[54]
- Patients with pulsatile devices should have a BP goal of SBP of < 130 mmHg and a DBP of < 85 mmHg[55]
- MAP > 90 mmHg is associated with stroke and pump thrombosis[54]

Heart Rate and Rhythm

- There is either no palpable pulse or a weak pulse with a continuous or non-pulsatile device. Gold standard for measuring HR and rhythm is ECG. Device does not affect ECG.[56]

Oxygen Saturation

- Measuring SpO_2 with pulse oximetry is unreliable with continuous or non-pulsatile devices
- Arterial blood gas measurement is the gold standard but only gives one snapshot in time
- Monitor for signs and symptoms of hypoxia: changes in skin color; confusion; cough; ↑ HR; ↑ RR; shortness of breath; or sweating[57]

Flow Rate

- VAD flow rate = CO
- LVAD flow rates should remain > 3 - 4 liters/minute[58]

Parameters regarding safe and effective exercise include:[58]

- Borg RPE Scale of no > 13/20 without onset of signs and symptoms of angina
- Electrocardiogram (ECG) changes including ST shifts no > 1 mm and/or no ↑ ventricular arrhythmias
- Dyspnea no > 5/10
- MAP maintained between 70 - 90 mmHg
- LVAD flow remains above 3 L/min

Sepsis - Pathophysiology/Background[59]

- Defined as a life-threatening organ dysfunction due to a dysregulated host response to an infection
- Risk factors: age, frailty, multiple comorbidities, indwelling lines or catheters, invasive procedures, breach in skin integrity, and immunosuppression
- Prompt recognition and treatment of sepsis improves survival
    - Quick Sequential (sepsis-related) Organ Failure Assessment (qSOFA) is a quick screening tool[60]
        - An individual with at least two of the following indicates strong consideration for ICU admission due to organ dysfunction
            - RR > 22 breaths/minute
            - Change in mental status
            - SBP < 100 mmHg

Sepsis - Vital Sign Recommendations[59]
• MAP is the primary clinical target during medical treatment for sepsis   • MAP Goal: > 65 mmHg • ECG, temperature, oxygenation (PaO_2/ FiO_2 ratio), electrolytes, glucose, and arterial blood gas (ABGs) are closely monitored • Older adults as well as individuals undergoing cancer treatments are less likely to develop an ↑ temperature with sepsis
Sepsis - Clinical Considerations
• Early activity and minimization of sedatives can help prevent critical Illness acquired weakness/ myopathy and critical illness polyneuropathy[61] • Warrants close monitoring of all VS with special attention to MAP. ECG, ABG, and lab values (electrolytes, glucose, CBC) should also be followed.

Special Population Considerations

Acute Coronary Syndrome/Myocardial Infarction - Background/Physiology

Acute Coronary Syndrome (ACS):[62,63]
• Unstable angina (UA) - absence of cardiac myocyte death
• Myocardial infarction (MI) (myocardial cell necrosis):
  • STEMI: ST-elevated MI resulted from total occlusion thrombus
  • NSTEMI: non-ST elevated MI resulted from partial occlusion with/without collateral circulation
Physiology:
• Dilation of ventricular chamber (infarcted wall thins) = ↓ systolic function
  • Blood pressure: ↓ CO may result in hypotension with exercise
  • ↑ Vasoconstriction + ↑ Afterload = ↑ Ischemia
• Reduction of angina with nitroglycerin which acts as a vasodilator
• Tachycardia: vasoconstriction and ↓ CO, HR may ↑ at an abnormal rate in response to exercise
• ECG[64]
  • STEMI: ST elevation ≥ 1mm
  • NSTEMI or UA : transient ST changes > 0.5 mm with possible;
  • Bundle Branch Block (BBB)
  • Sustained Ventricular Tachycardia (SVT)
• Cardiac Markers[64]
  • Elevation of troponin I (TnI), troponin T (TnT), or creatine kinase-MB (CK-MB) indicate necrosis

Acute Coronary Syndrome/Myocardial Infarction - Vital Sign Recommendations[13,65-67]	
Stable angina, stable and/or down trending troponins, stable ECG; **Initiation of PT intervention is likely to be appropriate**: • RR < 30 breaths/min; able to speak comfortably • Resting HR < 120 beats/min • CI ≥ 2.0 L/min/m • CVP < 12 mmHg • MAP of a minimum of 60 mmHg • SpO_2 > 90% • SBP < 110 mmHg	**Reasons to stop PT intervention** • Unable to comfortably speak • RR > 40 breaths/min • Onset of S3 heart sound • HR ↓ > 10 beats/min • SBP ↓ > 10 mmHg • MAP ↑ > 10 mmHg • CVP ↑ or ↓ > 6 mmHg • SpO_2 < 90% or a ↓ ≥ 4% • New onset or worsening of cardiac dysrhythmia • Return of pre-MI angina like pain

Heart Failure - Background/Physiology

- Heart Failure with Preserved Ejection Fraction (HFpEF): diastolic dysfunction with EF between 55% and 75%
- Heart Failure with Reduced Ejection Fraction (HFrEF): systolic dysfunction with EF < 40%

Physiology:

- SV is ↓ in both HFpEF and HFrEF therefore tachycardia (HR ≥ 100 beats/min) commonly occurs to help maintain or lessen the reduction of CO
- BP = CO X Total Peripheral Resistance (TPR)
- Given the ↓ CO that frequently occurs, hypotension at rest (< 90/60) and a ↓ SBP with exercise are common (↓ SBP > 10 mmHg)
- RR may be ↑ especially in HFrEF due to pulmonary edema
- Dyspnea may be a limiting factor during exercise

Heart Failure - Vital Sign Recommendations[68-70]

Stable HF: **Initiation of PT intervention is appropriate**:

- RR < 30 breaths/min; able to speak comfortably
- Crackles below rib 5 posteriorly
- Resting HR < 120 beats/min
- CI ≥ 2.0 L/min/m2
- CVP < 12 mmHg
- MAP > 60 mmHg
- Minimal to no weight gain in 24 hours

Reasons to stop PT intervention:

- Unable to comfortably speak
- RR > 40 breaths/min
- Onset of S3 heart sound
- Pulmonary crackles above 5th rib posteriorly
- HR ↓ > 10 beats/min
- SBP ↓ > 10 mmHg
- MAP ↑ > 10 mmHg
- CVP ↑ or ↓ > 6 mmHg
- New onset or worsening of cardiac dysrhythmia

Heart Failure - Clinical Considerations

- Important to monitor signs and symptoms of HF during every visit especially in patients with low EFs
- Worsening of signs and symptoms suggests decompensation and a medication adjustment may be needed (Refer to Pharmacology Section for more details)
- Important to monitor for signs and symptoms of hypotension
- Monitor for jugular vein distention and peripheral edema with right heart failure
- Monitor RR, PR, and rhythm (ECG analysis e.g. atrial fibrillation, PVCs)
- Auscultate for S3, pulmonary crackles before and after exercise and rib level where heard, and ↑ cough
- Document level of Borg RPE Scale or a Breathlessness Scale with vitals

Peripheral Arterial Disease - Background/Physiology

- Atherosclerotic disease impeding blood flow in arteries of extremities (> lower extremity)
- If O_2 demand exceeds O_2 supply to the periphery, claudication may occur
- As disease progresses, more severe symptoms e.g. resting pain and skin changes
- Complete obstruction to blood flow leads to limb loss[71]
- Ankle-brachial index (ABI) (ankle SBP/arm SBP) of ≤ 0.90 suggests PAD
  - Normal is 0.9 to 1.3 except in patients with diabetes
    - The lower this value, the patient may experience more pain[72]

Peripheral Arterial Disease - Vital Sign Recommendations

- Prevalence of other Cardiovascular Disease (CVD) such as coronary and carotid atherosclerosis is found in ≥ 50% in PAD patients[73]
  - With more severe disease, steep ↑ in BP may occur due to atherosclerosis and a diminished vascular bed
- VS assessment imperative at rest and with activity such as: HR/ECG, RR, Borg RPE Scale, signs or symptoms of cardiac compromise (chest discomfort, dizziness)
- BP: If upper extremity PAD (e.g. subclavian arterial stenosis), SBP values can be ≥ 15-20 mmHg ↓ in that arm[74]

- Use BP in the arm with the higher value
- Pulse oximetry: take in lesser involved extremity
- Assess for signs and symptoms of intermittent claudication

Peripheral Arterial Disease - Clinical Considerations

- Obstruction of blood flow leads to ↓ pulses, ↓ endurance, impaired sensation, and muscle atrophy in extremities
  - Assess for fall risk and integumentary changes
- Screen for other signs and symptoms of CVD such as angina or stroke
- Structured supervised exercise training improves exercise tolerance and walking distance[75-78]
  - Patient to walk through some pain to moderate pain, rest and repeat as tolerated with appropriate VS response

Aortic Aneurysm - Background/Physiology

Atherosclerosis and systolic HTN are common causes of the two main types of aortic aneurysms; thoracic and abdominal. An aortic aneurysm is a pathologic dilation of the aorta that is ≥ 50% than normal or ≥ 3 cm in size. Surgery is considered once the diameter of the abdominal aortic aneurysm (AAA) is ≥ 5.5 cm to avoid rupture of the aneurysm.[79] In patients with a thoracic aortic aneurysm (TAA), acute dissection, a tear of the inner lining of the thoracic aorta, is more common than rupture. In those with TAA, once symptoms occur, surgery is indicated.[80]

Aortic Aneurysm - Vital Sign Recommendations

- BP: Important to assess during activity to avoid excessive stress on the weakened area. Often SBP of ≤ 140 mmHg is suggested for those with AAA[81]
- Tachycardia and ↓ BP especially with patient complaints of sudden abdominal pain could be a sign of a ruptured aneurysm[82]

Aortic Aneurysm - Clinical Considerations

- Research suggests moderate activity such as treadmill and stair climbing in patients with small AAAs does not ↑ the risk of rupture. Therefore, moderate exercise should be promoted if the PT provider monitors VS, especially BP.[83]
- Signs and symptoms of an aortic aneurysm are often vague if there are any symptoms[79]
  - ↑ low back/abdominal pain or non-tender abdominal pulsating mass near the umbilical area may indicate an AAA
  - These are more prevalent in men, smokers and individuals > 60 years old
  - Aortic murmur and chest/upper back pain (complaints of ripping/tearing) may be seen in individuals with a thoracic aneurysm

Venous Thromboembolic (VTE) Disease - Background/Physiology

- Venous thrombosis is a clot obstructing venous blood flow
- Deep venous thrombosis (DVT) and pulmonary embolism (PE) are both manifestations of this disease
  - Distal DVTs: below the knee; more common; and less likely to become a PE than proximal DVT
  - PE: clot reaching the lungs[84]

Venous Thromboembolic Disease - Vital Sign Recommendation

- All vital signs, including RR, should be assessed before and with activity in any patient at risk for or diagnosed with venous thrombosis

Venous Thromboembolic Disease - Clinical Considerations

- Many patients in the acute care setting are at risk for VTE disease (DVT and PE)
- Mechanical compression, early activity and anticoagulation are necessary for prevention[85]
- Use Padua Prediction Score to assess global risk of VTE in hospitalized patients (medical team uses score to assess need for thromboprophylaxis)[86]
- DVT signs and symptoms: pain, ipsilateral swelling, warmth or redness

- Primary risk factors for hospitalized patients are age > 75 years-old, active cancer, reduced activity, previous VTE, major surgery including total hip or knee arthroplasty[87,88]
  - Use the Wells Clinical Decision Tool to assess for lower extremity DVT risk[89]
  - If results indicate a possible DVT, immediately inform the patient's physician
  - See American Physical Therapy Association Clinical Practice Guidelines for the Management of Patients at Risk for or Diagnosed with DVT[90]
- PE signs and symptoms may be vague
  - Unexplained shortness of breath (most common), ↓ in SpO_2, anxiety, pleuritic chest pain, cough, and tachycardia[84]
  - Use the Padua prediction tool for global VTE risk assessment[86]
  - Use the Geneva prediction tool to assess for PE likelihood[91]
  - Use Khorana VTE risk assessment for those with history of cancer or cancer treatments[92]

Lung Disease[93,94]

- Restrictive dysfunction and obstructive lung diseases (below) are both marked by progressive dyspnea, hypoxia and decline in FEV1 (forced expiratory volume in one second)
- In advanced stages, both restrictive dysfunction and obstructive diseases are predispositions for cor pulmonale (right ventricular failure with pulmonary hypertension and right ventricular strain)
- Potential signs and symptoms of heart failure include: jugular venous distention; peripheral edema; ascites and rapid decline in SpO_2 with activity

Restrictive Lung Disease and Dysfunction - Background/Physiology[93-95]	**Obstructive Lung Disease - Background/ Physiology**[93,94,96]

• Defined as impaired ability to get air in, with a FEV1/FVC ratio > 85% as a diagnostic threshold
• Restrictive lung dysfunction can be primary (lung pathology) or secondary (extrapulmonary pathology); and can be acute or chronic
  • Both primary and secondary pathologies typically have low lung volumes and ↓ diffusing capacity for carbon monoxide
• Secondary restrictive dysfunction includes any condition that impairs thoracic expansion: advanced pregnancy; neuromuscular weakness; thoracic integumentary restriction (e.g. major burn injury); thoracic musculoskeletal restriction (e.g. severe kyphoscoliosis, multiple rib fractures); major surgery; obesity; etc.
  • Paired with immobility, can lead to ↑ risk of pneumonia and/or atelectasis
• Primary (pulmonary) restrictive lung diseases include pneumonia, interstitial lung diseases, as well as acute lung injury, interstitial lung diseases and to acute respiratory distress syndrome (ARDS)
• Respiratory infection risk ↑ (e.g. colds, flu, pneumonia)
• Malnutrition: individuals appear emaciated due to ↑ work of breathing and inability to take in appropriate amounts of nutrition
	• Defined as impaired ability to get air out, with FEV1/FVC ratio < 70% as a diagnostic threshold
	• Chronic obstructive pulmonary disease (COPD), which includes chronic bronchitis, emphysema, bronchiectasis, asthma, and cystic fibrosis
	• Hyperinflation and ↑ residual volume are common with moderate to severe disease with a flat and weak diaphragm especially seen in emphysema and cystic fibrosis
	• Inspiratory to expiratory ratios approach 1:3 to 1:5
	• Moderate to severe obstructed expiratory flow can predispose CO_2 retention
	• Headaches, especially upon waking in the morning, flush skin, disorientation, and dizziness are potential signs and symptoms of hypercapnia
	• CO_2 can be assessed by end-tidal CO_2 or arterial blood gas
	• With chronic CO_2 retention, patient may depend on hypoxia to drive breathing thus the clinician needs to carefully titrate the supplemental O_2 and assess for signs and symptoms of hypercapnia. For patients with CO_2 retention, the target SpO_2 range might be below 90%.

Chronic, Restrictive Lung Diseases - Vital Sign Recommendations[93,94,97]	**Chronic, Obstructive Lung Diseases - Vital Sign Recommendations**[98-100]

• Often need ↑ amounts of supplemental O_2 during activity
• SpO_2 may drop precipitously with advanced disease; O_2 delivery dose and method/ device may need to be adapted
• Rapid, shallow breathing volumes with possible ↓ residual volume
  • Minute ventilation (RR x tidal volume) driven proportionally more by RR than tidal volume
  • Inspiratory to expiratory ratios approach 1:1 (normal 1:2)
• Note: secondary (extrapulmonary) lung dysfunction, such as severe kyphoscoliosis or obesity, may present with tachypnea and/or tachycardia and ↑ work of breathing; though O_2 desaturations are uncommon unless accompanied by a pulmonary infection, e.g. aspiration pneumonia[25]
Acceptable Parameters for Initiation of PT Intervention:
• RR < 40 breaths/min; able to speak comfortably
• HR: 60 - 120 beats/min (caution if > 120)
• Pulse oximetry: > 90%
• Need for supplemental O_2: generally, keep SpO_2 > 90%
Reasons to Stop or Modify PT Intervention:
• Unable to comfortably speak
• ↓ SpO_2 < 85%, especially if titration of supplemental O_2 is ineffective
• ↓ HR > 10 beats/min
• ↓ SBP > 10 mmHg
	• ↑ resting HR may occur due to an ↑ work of breathing as well as chronic, frequent bronchodilator use
	  • Therefore, the use of breathlessness scales and the talk test along with HR response to activity is needed
	• Supplemental O_2 use is often needed with moderate to advanced disease, but use should be judicious. Over-oxygenation may ↓ the hypoxic drive.
	  • O_2 titration with PT intervention (with MD order) is generally beneficial
	  • SpO_2 target with activity in the acute setting is generally 88-92%
	  • Except for those who retain CO_2, where their goal may be upper to mid 80's based on documented blood gas (consult with healthcare providers)
	Acceptable Parameters for Initiation of PT Intervention:
	• RR < 30 breaths/min; able to speak comfortably
	• Pulse oximetry: > 90% at rest (+/- supplemental O_2)
	• HR: 60 - 120 beats/min (caution if > 120)
	Reasons to Stop or Modify PT Intervention:
	• Unable to comfortably speak
	• ↓ SpO_2 < 85% especially if titration of supplemental O_2 is ineffective
	• ↓ HR > 10 beats/min
	• ↓ SBP > 10 mmHg

Chronic, Restrictive Lung Diseases - Clinical Considerations:[93,94,97]	**Chronic, Obstructive Lung Diseases - Clinical Considerations**[93,94,97-100]
• Difficulty pacing breath and ↑ accessory muscle use is common • Patients may need ↑ RR to get sufficient ventilation, so slow deep breaths are not encouraged • In early phases of restrictive lung disease: may only present with tachypnea with activity: will progress to tachypnea at rest • Hypoxemia will occur sooner in disease process and be more pronounced than obstructive dysfunction • Document level of Borg RPE Scale • Goal 11 - 13 on 6 - 20 Borg RPE Scale • Inspiratory muscle training can be helpful early in the disease process	Two central drivers of respiratory drive: • Patients with COPD can be chronically hypercarbic and have limited O_2 drive (hypoxemia) Supplemental O_2 should be titrated to meet the SpO_2 orders from the medical provider Be sure to return the supplemental O_2 back to the pre-intervention levels after PT intervention. If patient is unable to tolerate weaning to pre-intervention levels, notify the medical team. Document level of dyspnea and/or Borg RPE Scale • Goal 3 - 5 on 0 - 10 modified Borg RPE Scale • Goal 11 - 13 on 6 - 20 Borg RPE Scale • (Borg RPE Scale of 12 - 13 generally corresponds with 60% peak VO_2)

Diabetes Mellitus - Physiology/Background

Diabetes Mellitus (DM) is a prime risk factor for cardiovascular disease and can lead to multi-system impairments. A common complication of DM is autonomic neuropathy which can lead to orthostatic hypotension, silent ischemia, and impaired HR and BP responses during PT intervention.

Diabetes Mellitus - Vital Sign Recommendation

- **Heart Rate**
  - Monitor for dysrhythmias, especially atrial fibrillation[101]
  - Monitor for tachycardia or bradycardia, especially during position changes
  - Monitor HR recovery response (HR should ↓ > 12 beats within one-minute post-PT intervention)[102]
- **Blood Pressure**
  - Monitor for orthostatic hypotension (↓ SBP > 20 mmHg or ↓ DBP > 10 mmHg on standing within three minutes)[103,104]
- **Respiratory Rate**
  - Monitor level of dyspnea using Breathlessness Scale
- **Pulse Oximetry**
  - Pulse oximetry may overestimate blood O_2 saturation in those patients with poorly controlled type 2 diabetes who have ↑ HbA1c levels, suggesting that arterial blood gas analysis may be needed to determine accurate blood O_2 saturation levels[105]

Diabetes Mellitus - Clinical Considerations

- Monitor for symptoms of silent ischemia that may include fatigue, nausea/vomiting, sweating, arrhythmia, and dyspnea[106]
  - Use Borg RPE or a Breathlessness Scale with vitals
  - It is important to know your patient's blood glucose levels as well as vital signs[107,108]
    - Pre-exercise blood glucose should be between 90 - 250 mg/dL
    - For patients with a pre-exercise blood glucose < 90 mg/dL, they should ingest 15 - 30 grams of carbohydrates prior to activity
    - If glucose is 250 - 350 mg/dL test for ketones, collaborate with the healthcare team. Exercise should be avoided if moderate-to-large amounts of ketones are present. If ketones are negative or low mild-to-moderate intensity exercise may be done.
    - If glucose is ≥ 350 mg/dL no exercise should be done if moderate-to-large amounts of ketones are present. If ketones are negative or low insulin may be adjusted prior to beginning mild-to-moderated exercise.
- If the patient is receiving insulin, it is important to know the timing of the administration of insulin and timing of the last meal
- Autonomic neuropathy can lead to ↑ resting HR in early stages of the disease, but in the later stages, HR may become fixed and unresponsive with exercise[106,109]
- Patients may exhibit slow HR recovery post-PT intervention[102]

Oncologic Conditions - Physiology/Background

Due to the variations in cancers and cancer-related treatments (surgery, radiation, chemotherapy, and hormone), adaptations to exercise may be required with changes in lab values (anemia). Some side-effects may be acute such as radiation to the trunk, which can cause inflammation of the lung tissue and impair oxygen diffusion. Radiation also can lead to delayed-onset lung tissue scarring that can occur months to years post-radiation. Some chemotherapeutic agents can cause pulmonary fibrosis, cardiomyopathy, and/or accelerated atherosclerosis. Cancer and the related side effects from treatment warrant careful monitoring of VS and symptoms during interventions. Active cancer and chemotherapy increase risk of VTE events (Refer to Venous Thromboembolic Disease Section for more details)

Oncologic Conditions - Vital Sign Recommendations

- Exercise should be terminated for the following: ↓ HR and BP with ↑ workload; new onset of dysrhythmia; SpO_2 <88%; RR <5 breaths/minute or > 40 breaths/minute[110,111]
- Monitor for dizziness, nausea, chest pain, pallor, diaphoresis, or shortness of breath during activity[111]
- Should avoid exercise if body temperature > 38.3°C (101°F)[112]

Oncologic Conditions - Clinical Considerations

- Physical therapists should collaborate with the medical team to determine safe exercise limits based on the individual's trends (lab values and VS) to avoid serious adverse events
- Radiation to the neck can result in increased HR and variability in BP due to dysfunction of the arterial baroreceptors[113]
- Since oncologic treatments may affect HR, the physical therapist should consider using a Borg Breathlessness Scale, Borg, or Modified Borg RPE Scale to monitor appropriate progression of intervention[111]
- The American College of Sports Medicine Roundtable Consensus Statement recommended the need to adapt exercise programs for the individual per health status, adjuvant treatments, and anticipated disease trajectory[114]
- Individuals undergoing cancer treatments are at a higher risk of injurious falls. Multifactorial causes of falls may include but are not limited to anemia, hypovolemia, hypotension, altered cognition, pain medication, and altered pedal sensation[115]

Neurologic Conditions - Physiology/Background

Acute neurologic episodes such as stroke (cerebral vascular accident), traumatic brain injury (TBI), and spinal cord injuries (SCI) can cause abnormalities in VS that warrant careful monitoring. Assessment and interpretation should continue across continuum of care as abnormalities may persist beyond hospital discharge. For example, approximately 40% of patients with a stroke remain hypertensive beyond one week after initial event.[116,117]

In patients with chronic or progressive conditions such as Parkinson's disease (PD), multiple sclerosis (MS), Guillain-Barre syndrome (GBS), amyotrophic lateral sclerosis (ALS), and myasthenia gravis, VS should be closely monitored. These patients are at ↑ risk for orthostatic hypotension, ↓ exercise tolerance, impaired HR and rhythm responses, and respiratory insufficiency.[65]

Acute Stroke - Vital Sign Recommendations

Blood Pressure

Blood pressure needs to be managed carefully after an acute stroke. Persistent ↑ SBP can ↑ the risk of hemorrhagic transformation of ischemic stroke and lead to ↑ed bleeding area in hemorrhagic stroke. Aggressive ↓ of BP can induce cerebral hypoperfusion.[118]

Acute Ischemic Stroke BP parameters per 2019 AHA Guidelines[116]

- Thrombolytic agent (i.e., tPA) administered: Permissive hypertension up to 180/105 mmHg
- Thrombolytic agent not administered: In absence of comorbid conditions requiring rapid ↓, permissive hypertension up to 220/120 mmHg
  - If > 220/210 mmHg, ↓ by 15% in initial 24 hours post-stroke may be indicated
- Mechanical thrombectomy performed: Moderate BP control of < 180/105 mmHg is currently recommended. Some support for ↓ target ranges based on degree of recanalization

Intracerebral Hemorrhage[119]

- Maintain SBP < 140 mmHg

Subarachnoid Hemorrhage (Aneurysmal)

- Target SBP < 160 mmHg may ↓ risk of rebleeding
  - Exception: induced hypertension indicated in the presence of vasospasm or delayed cerebral ischemia. Verify target BP for individual patient[120,121]

Heart Rate and Rhythm

- Continuous ECG monitoring for at least 24 - 48 hours post-stroke is common. Risk for cardiac complications is ↑ed and abnormal findings may contribute to future neurologic events.[116,119]

Oxygen Saturation

- Per the AHA Guidelines, titrate O_2 to keep $SpO_2 \geq 94\%$ for patients in the acute phase of stroke recovery. ↓ SpO_2 levels within the initial hours post-stroke have been reported to be associated with ↑ mortality. Consult with medical team to provide supplemental O_2 and follow state practice act guidelines to provide and titrate supplemental O_2.[116,122]
- In patients with acute stroke, respiratory muscle weakness, aspiration risk, pneumonia, and sleep apnea may all contribute to hypoxia[123]

Traumatic Brain Injury (TBI) - Vital Sign Recommendations

Recommendations for patients with moderate to severe TBI defined by modified Glasgow Coma Scale (GCS) score < 12

- When feasible, SBP, CPP, and ICP should be continuously monitored. Even brief periods of hypotension, hypoxemia, and cerebral HTN have been associated with worse outcomes.[124]

Blood Pressure

- SBP recommendations associated with ↓ mortality and improved outcomes:[125]
- Patients 50 - 69 years old: SBP ≥ 100 mmHg
- Patients 15 - 49 years old or > 70 years old: SBP ≥ 110 mmHg
- Without capacity for invasive monitoring target SBP of 120 mmHg is recommended to prevent secondary injury[124]

Heart Rate

- HR > 100 bpm without obvious stimulus may suggest paroxysmal sympathetic hyperactivity and warrant review of BP, HR, and temperature[126]

Intracranial pressure (ICP) and Cerebral perfusion pressure (CPP)

- Maintain ICP < 22 mmHg and CPP between 60 - 70 mmHg[125]

Spinal Cord Injury (SCI) - Vitals Sign Recommendations

Blood Pressure

- Collaborate with medical team to address hypotension (SBP < 90 mmHg) prior to PT intervention. MAP goal of 85 - 90 mmHg is recommended for at least 1 week following injury for adequate spinal cord perfusion.[127]

Oxygen Saturation

- Patients with spinal cord injuries typically present with impaired pulmonary function secondary to a restrictive dysfunction (Refer to Lung Disease Section for more details) depending on type and level of injury. Clinicians should monitor SpO_2 levels within normal range, especially if these individuals have ineffective cough or excessive mucus retention.[128]

Neurologic Conditions - Clinical Considerations

The initiation of early mobilization (8 - 24 hours post-event) in patients s/p ischemic stroke, including those who receive pharmacologic or surgical interventions, is considered safe and associated with improved outcomes if vital signs and neurologic stability are monitored.[129-131]

The management of patients with acute and subacute TBI focuses on preventing systemic and intracranial secondary injuries cascading from the original insult. Best practice includes multimodal monitoring to prevent common VS alterations (e.g.: ↑ICP, ↓CPP, ↓CBF, ↓BP, ↓SpO2), associated ↑ mortality, and inferior neurologic outcomes.[125]

- Interventions including decompressive craniectomy or drain placement may be indicated to maintain threshold values
- Paroxysmal sympathetic hyperactivity (aka neurological storming): Abnormal response to afferent stimulation including movement resulting in transient ↑ in sympathetic and motor activity including ↑ of BP, PR, RR, temperature, sweating, muscle tone, and posturing. May not manifest until after patients are weaned from sedation.[126]

BP should be monitored in individuals with SCI due to possible disruption of the sympathetic nervous system. This disruption can result in ↓ vascular tone and/or orthostatic hypotension. Autonomic dysreflexia (AD) also may occur, causing an acute, unregulated elevation of SBP, which is often associated with baroreflex-mediated bradycardia[132]

- Patients exhibiting AD with HTN should be positioned upright for postural reduction of SBP. PT providers should seek to immediately identify and remove noxious stimulus.
- ↓ sympathetic stimulation may blunt cardiovascular response to exercise.

Patients meeting one or more of the following criteria should be screened for orthostatic hypotension, and blood pressure should be monitored during and after exercise. Exercise may exacerbate neurogenic orthostatic hypotension[133]

- Neurodegenerative disorder associated with autonomic dysfunction (PD, MS, Multiple System Atrophy, Dementia with Lewy Bodies)
  - Over 1/3 of patients with PD met criteria for orthostatic hypotension and may be asymptomatic[134]
- Unexplained fall or syncopal event
- Peripheral neuropathies are associated with autonomic dysfunction (DM, Amyloidosis, HIV)
- > 70 years of age and meets frailty criteria or takes multiple medications
- Postural dizziness or non-specific symptoms when standing

In patients with neuromuscular or neurodegenerative diseases that impact the brainstem, it is critical to monitor pulmonary status and VS[135-137]

- Patients with MS-associated brainstem demyelination have ↑ risk of dysrhythmia, requiring close ECG and vital sign monitoring[138-140]
- Patients with MS may have blunted vascular response and ↓ ability to maintain BP, resulting in ↑ prevalence of postural orthostatic tachycardia syndrome (POTS), orthostatic hypotension, orthostatic intolerance, and postural dizziness[141]
- Patients with GBS-associated disturbance of baroreceptor regulation may have ↑ BP lability and require close monitoring[142]
- Patients with some neurodegenerative conditions may exhibit blunted or variable chronotropic response to exercise. Use Borg RPE Scale in addition to PR to monitor exercise intensity and tolerance[65]
- Patients with neuromuscular and neurodegenerative conditions should be screened for impairments of inspiratory and expiratory muscle function (shortness of breath, orthopnea, weak cough, and poor secretion clearance). Risk for compromise is ↑ and additional respiratory support may be needed.[143]

Pharmacologic Considerations for Vital Signs[13,144-146]

In this section, we highlight certain classes of medications and their associated VS implications. This is not an all-inclusive list, and specific drugs listed under each drug medication class are examples. Additional resources should be consulted for increased depth of information regarding other aspects about the medications and other medication classes not listed here. While it is not in a physical therapist's scope to prescribe medications, it is within a physical therapist's scope to consider the impact on health, function, movement, and disability. Per APTA, "it is within the physical therapist's professional scope of practice to administer and store medication to facilitate outcomes of physical therapist patient and client management."[147]

The influences of other factors such as timing, dosing, patient population, absorption, distribution, metabolism, elimination, pharmacodynamics, and polypharmacy are not included in this table. Adverse reactions are more likely to occur with the first dose or when a dose is increased. Medications given as IV drips generally have a short half-life and are dosed in mcg/kg/min. Dose titration up or down can result in physiologic fluctuations that necessitate closer monitoring of VS as well as other signs and symptoms. The first table contains medications that primarily treat cardiovascular and/or pulmonary dysfunctions and can have a direct effect on VS. The second table contains additional medications that also require close monitoring due to their effects on VS.

Medication Class	Common Indications	Effects on VS	Common and/or Dangerous Adverse Reactions	Clinical Considerations
Angiotensin Converting Enzymes (ACE) Inhibitors • Lisinopril (Zestril, Prinivil) • Ramipril (Altace)	• HTN • Heart failure • Coronary artery disease • Renal disease	• ↓ BP (SBP > DBP) at rest and with exercise • ↑ Exercise tolerance in patients with HF	• Dry, hacking cough • Angioedema • Hypotension • Dizziness	• Closely monitor BP • If patient has dry, hacking cough, consider consult to prescribing practitioner; many patients can switch to angiotensin II receptor blocker (same clinical outcome with less frequency of cough)
Adrenergic Agonists (Combined Alpha/Beta) • Levophed (norepinephrine bitartrate)	• Shock (septic, cardiogenic, anaphylactic) • Heart failure	• ↑ BP via ↑ in peripheral vascular resistance • ↑ HR • ↑MAP	• Peripheral tissue necrosis • Extravasation • Dysrhythmias • Myocardial ischemia • Hyperglycemia	• Classified as vasopressors and often referred to as "pressors" • Closely monitor BP • Monitor for impairment in peripheral tissue perfusion • Extremely short acting (½-life ~ 3 minutes) necessitates continuous intravenous drip

Medication Class	Common Indications	Effects on VS	Common and/or Dangerous Adverse Reactions	Clinical Considerations
Alpha Blockers • Alfuzosin (Uroxatral) • Silodosin (Rapaflo) • Tamsulosin (Flomax) • Doxazosin (Cardura) • Terazosin (Hytrin) • Prazosin (Minipress)	• HTN • Benign prostatic hyperplasia	• ↓ BP	• Dizziness • Headache • Hypotension (exacerbated by • postural changes	• Hypotension, dizziness, and syncope are most likely to occur with first doses and when ↑ dosage or switching between forms • Assess orthostatic VS regularly • If positive for orthostatic hypotension: discuss with medical team; consider modifying treatment plan, e.g. perform activities in sitting
ACE Inhibitor/ARB • Sacubitril and Valsartan (Entresto)	• Heart failure with ↓ ejection fraction	• ↓ BP	• Hypotension • Fatigue • Hyperkalemia • Renal failure • Dizziness • Cough	• Monitor BP, HR, and ECG
Angiotensin II receptor blocker (ARB) • Losartan (Cozaar) • Valsartan (Diovan)	• HTN • Heart failure • Renal disease/ failure	• ↓ BP	• Dizziness • Hyperkalemia • Hypotension • Dry cough • Angioedema • Diarrhea • Weight loss	• ARBs may be preferred if patients are unable to tolerate the side effects of ACE Inhibitors, such as coughing
Anticoagulants • Apixaban (Eliquis) • Warfarin (Coumadin)	• Prevention and treatment of VTE and other blood clots, including atrial fibrillation and artificial heart valves	• No change, unless major bleeding event	• Bleeding (risk higher for anticoagulants) • Spinal/Epidural Hematoma	• Watch for signs of bleeding that could include dizziness, as well tachycardia and hypotension
Antiplatelet Agents • Clopidogrel (Plavix) • Ticagrelor (Brilinta)	• Secondary prevention of MI or ischemic stroke • Peripheral artery disease	• No change, unless major bleeding event • Bradyarrhyth-mias and dyspnea (15-20% of patients on Brilinta)	• Bleeding • Dyspnea • Bradycardia/ Bradyarrhyth-mias (Brilinta)	• Watch for signs of bleeding that could include dizziness, as well tachycardia and hypotension. • Monitor HR and ECG

Medication Class	Common Indications	Effects on VS	Common and/or Dangerous Adverse Reactions	Clinical Considerations
Beta Blockers • Metoprolol (Toprol XL, Lopressor) • Atenolol (Tenormin) • Carvedilol (Coreg)	• Acute MI • HTN • Heart failure with systolic dysfunction • Dysrhythmia • Migraine prophylaxis	• ↓ BP (SBP > DBP) • ↓ resting HR • ↓ HR with exercise	• Bronchospasm • Heart block • Masks signs and symptoms of hypoglycemia	• Use RPE scale in addition to HR to monitor exercise intensity • ↑ risk of developing or worsening heart block; monitor ECG • Auscultate to monitor for bronchospasm
Calcium Channel Blockers • Diltiazem (Cardizem) • Verapamil (Calan)	• HTN • Dysrhythmias • Ischemic heart disease • Vasospastic angina • Peripheral vasospasm (e.g. Raynaud's, Buerger's)	• ↓ BP • ↓ HR	• Bradycardia • Orthostatic hypotension • Syncope • Dizziness • Lightheaded-ness • Headache	• Hypotension, dizziness and syncope are most likely to occur with first doses and when ↑ dosage or switching between forms • May contribute to ↑ fall risk • ↑ risk of developing or worsening heart block; monitor ECG • Assess orthostatic VS regularly. If positive for orthostatic hypotension: discuss with medical team; consider modifying treatment plan, e.g. perform activities in sitting

Medication Class	Common Indications	Effects on VS	Common and/or Dangerous Adverse Reactions	Clinical Considerations
Potassium (K+) Sparing Diuretics/ Aldosterone Antagonists • Amiloride (Midamor) • Spironolactone (Aldactone)	• Heart failure • Hypokalemia • HTN	• ↓ BP	• Fluid/electrolyte imbalance • Dizziness • Headache • Dysrhythmia • Hyperuricemia/ gout flare	• Monitor for signs and symptoms of fluid-electrolyte imbalance e.g. hyperkalemia, fatigue, confusion, nausea, and altered heart rate; discuss abnormal findings with the medical team
Loop and Thiazide Diuretics • Furosemide (Lasix) • Hydrochlorothiazide (HydroDiuril)	• Certain renal disorders • HTN • ↓ edema resulting from: • Heart failure • Cirrhosis • Meniere's	• ↓ BP • (SBP > DBP)	• Hypotension (exacerbated by postural changes) • Dehydration • Ventricular dysrhythmias (due to potassium imbalances) • Hyperglycemia in patients with DM • Hyperuricemia/ gout flare	• Assess orthostatic VS regularly • If positive for orthostatic hypotension: discuss with medical team; consider modifying treatment plan, e.g. perform activities in sitting; consider discussing fluid status with healthcare team • Monitor ECG
Anticholinergics (Inhaled) • Ipratropium (Atrovent) • Tiotropium (Spiriva)	• Bronchoconstriction/ bronchospasm • Asthma • COPD	• ↑ temperature • ↑ ECG changes	• Bronchitis • Headache	• Monitor for CNS effects such as dizziness and blurred vision • Monitor for signs and symptoms of anticholinergic poisoning i.e. tachycardia, flushing, anhidrosis (inability to perspire), hyperthermia, mydriasis (dilated pupils), agitated delirium, and diminished bowel sounds; discuss abnormal findings with the medical team

Medication Class	Common Indications	Effects on VS	Common and/or Dangerous Adverse Reactions	Clinical Considerations
Beta$_2$ Agonists (Inhaled) · Albuterol (Ventolin; Proventil)	· Bronchoconstriction/ bronchospasm · Asthma · COPD	· Acute ↑ HR with administration	· Tremor · Nervousness · Bronchospasm · Tachycardia	· Monitor for immediate hypersensitivity reactions i.e. urticaria, angioedema, rash, bronchospasm, oropharyngeal edema, including anaphylaxis; discuss abnormal findings with the medical team
Beta$_1$ Agonists (Positive Inotrope) · Dopamine (Alpha and Beta$_1$ agonist activity)	· Shock (cardiogenic, hypovolemic, septic, anaphylactic, etc.) · Heart failure	· ↑ BP via ↑in SV and vasoconstriction resulting in ↑CO · + Chronotropic effects · ↑ HR	· Dysrhythmias (↑ incidence of tachydysrhythmias in patients with shock)	· Use RPE scale in addition to HR to monitor · exercise intensity · Monitor ECG
Cardiac Glycosides (Positive Inotrope) · Primacor (Milrinone)	· Acute decompensated heart failure · Dysrhythmia	· ↑ BP via ↑ in SV · ↓ Peripheral vascular resistance	· Dysrhythmias (tachycardia, ventricular, supraventricular) · Hypotension · Headache · Bronchospasm	· Administered intravenously · Short half-life (~2 hrs) · Use RPE scale in addition to HR to monitor exercise intensity · Monitor ECG
Other Positive Inotropes · Dobutamine	· Shock (cardiogenic, hypovolemic, septic, anaphylactic, etc.)	· ↑ BP via ↑in SV and significant vasoconstriction (pressor effect)	· Headache · Anxiety · Dyspnea · Severe HTN · Asthma exacerbation · Dysrhythmias (bradycardia, irregular)	· Closely monitor BP · Use RPE scale in addition to HR to monitor exercise intensity
Nitrates and Nitrites · Nitroglycerin (Rectiv, Nitrolingual, Nitrostat) · Isosorbide dinitrate (Isordil) · Amyl nitrite - inhaled	· Angina pectoris · Hypertensive crisis · Hypertensive pulmonary edema · Heart failure · Low CO syndromes · Acute MI	· ↓ BP via systemic vasodilation · ↑ HR at rest and with exercise	· Headache · Dizziness · Orthostatic hypotension · Nausea	· Closely monitor BP · Nitroglycerin requires special handling and storage to avoid skin contact with the medication

Additional Non-Cardiovascular and Pulmonary Medication Classes	Common and/or Dangerous Adverse Reactions Affecting VS and PT Intervention	Clinical Considerations
Neuromuscular Blocking Agents • Nimbex (Cisatracurium) • Rocuronium (Zemuron)	• Dysrhythmia • Hypotension • ICU-acquired muscle weakness	• Closely monitor BP, PR, and ECG • Monitor for impairment of muscle weakness including diaphragm • Requires mechanical ventilation

Sedative-Hypnotics
• Benzodiazepines
  • Alprazolam (Xanax)
  • Diazepam (Valium)
  • Lorazepam (Ativan)
  • Midazolam (Versed)
• Nonbenzodiazepines
  • Eszopiclone (Lunesta)
  • Zaleplon (Sonata)
  • Zolpidem (Ambien)
	• CNS depression
	• Drowsiness
	• Amnesia
	• Muscle incoordination
	• Impaired cognition/delirium
		• Monitor for fall risk (especially in older adults)
		• Monitor for neuromusculo-skeletal impairments
		• Monitor for changes in mental status/cognition
		• Any abrupt or overly rapid reduction in benzodiazepine dose among chronic users can produce withdrawal
		• Monitor for withdrawal symptoms i.e. tremor, anxiety, perceptual disturbances, dysphoria, psychosis, and seizures; discuss symptoms with medical team

General Anesthetics • Propofol (Diprivan) • Ketamine (Ketalar)	• Delirium • Dysrhythmia (bradycardia or tachycardia) • Hypotension or hypertension • Apnea/Respiratory depression • Diplopia • Hypertonia • Hyperlipidemia (Propofol) • ↓ CO (Propofol) • ↑ cardiac contractility and vasoconstriction (Ketamine)	• Long term use can lead to dependency so monitor for withdrawal symptoms i.e. tremor, anxiety, perceptual disturbances, dysphoria, psychosis, and seizures; discuss abnormal findings with medical team • Monitor for changes in mental status/cognition • Patients with obesity may take longer to recover from Propofol sedation • Closely monitor RR, SpO_2, BP, PR, and ECG
Opioids • Oxycodone (OxyContin)	• Hypotension • Respiratory depression/apnea • CNS depression • ↑ ICP • Dizziness • Confusion	• Monitor closely for respiratory depression, especially during initiation or dose escalation. CO_2 retention from opioid - induced respiratory depression can exacerbate the sedating effects of opioids. • Monitor for fall risk (especially in older adults) • Monitor for changes in mental status/cognition • Long term use can lead to dependency so monitor for withdrawal symptoms, i.e. tremor, anxiety, perceptual disturbances, dysphoria, psychosis, and seizures; discuss symptoms with medical team

Additional Non-Cardiovascular and Pulmonary Medication Classes	Common and/or Dangerous Adverse Reactions Affecting VS and PT Intervention	Clinical Considerations
Skeletal Muscle Relaxants • Baclofen-oral (Lioresal) • Cyclobenzaprine (Flexeril) • Metaxalone (Skelaxin)	• Hypotension • Bradycardia • CNS depression	• Monitor for signs of toxicity including dysrhythmias • Closely monitor BP for orthostatic hypotension • Monitor for fall risk (especially in older adults) • Monitor for neuromusculo-skeletal impairments • Monitor for changes in mental status/cognition
Agents for Bipolar Disorder • Lithium (Lithobid) • Tegretol (Carbamazepine) • Depakote (Divalproex)	• Tardive dyskinesia • Potential for cardiovascular instability as a sign of toxicity i.e. syncope, bradycardia, AV block, other atrial/ventricular dysrhythmias	• Any acute changes in cognition, neuromuscular system, or VS should warrant an urgent discussion with the medical team, due to possibility of toxicity
Tricyclic Antidepressants • Amitriptyline (Amitriptyline) • Clomipramine (Anafranil) • Imipramine (Tofranil)	• Orthostatic hypotension • Dysrhythmia • CNS depression • Headache • Syncope • Tardive dyskinesia	• Monitor for suicidal thinking and behavior in children, adolescents, and young adults (18 - 24 years of age) with major depressive disorder and other psychiatric disorders; discuss abnormal findings with medical team • Closely monitor BP for orthostatic hypotension • Monitor for fall risk due to ataxia and impaired coordination • Monitor for neuromusculo-skeletal impairments • Monitor for changes in mental status/cognition • Monitor for anticholinergic effects i.e. constipation, xerostomia, blurred vision, urinary retention
Anti-Parkinsonian agents • Carbidopa/Levodopa (Sinemet, Duopa) • Dopamine agonist (Requip, Mirapex)	• Dysrhythmia • Hypotension (exacerbated by postural changes) • Dizziness • Syncope • Neuroleptic malignant syndrome (tachycardia, fever, confusion, BP instability) is a rare but potentially fatal adverse reaction associated with abrupt withdrawal	• Monitor for signs of toxicity including dysrhythmias i.e. tachycardia • Closely monitor BP for orthostatic hypotension • Monitor for fall risk • Monitor for neuromusculo-skeletal impairments • Medications may be stopped due to medical procedures; discuss with medical team • Closely monitor VS especially BP in advanced stages of Parkinson's Disease due to autonomic instability[148] • Monitor for neuroleptic malignant syndrome and discuss abnormal findings with medical team

Additional Non-Cardiovascular and Pulmonary Medication Classes	Common and/or Dangerous Adverse Reactions Affecting VS and PT Intervention	Clinical Considerations
Corticosteroids (oral) • Prednisone (Rayos) • Dexamethasone (Decadron)	• Impairs tissue healing and immune response (can inhibit ability to generate fever) High-dose or prolonged use effects: • Adrenal atrophy/ crisis • Cushing's syndrome • Hyperglycemia • Dyslipidemia • HTN • Hypokalemia • Dysrhythmia • Osteopenia/ osteoporosis • Proximal myopathy • Peptic ulcers/ GI bleeds • Mood changes to psychosis	• Monitor for other signs and symptoms of fever • Monitor BP, HR, and ECG • Monitor for fall risk (especially in older adult) • Monitor for neuromusculo-skeletal impairments
Angiogenesis Inhibitors • Avastin (Bevacizumab)	• HTN	• Monitor VS frequently especially BP
Insulin[149]	• Hypoglycemia leads to ↑ BP and ↑ HR	• Monitor VS closely • Monitor for signs and symptoms of hypoglycemia

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