



*Unmasking the Patient who Survived COVID-19:
A Cardiopulmonary Perspective*

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*By the End of this Presentation,
You Should:*

» Understand the pathophysiology of SARS-CoV-2, including direct and indirect changes to the cardiovascular & pulmonary systems.

» Identify signs and symptoms of post-intensive care unit syndrome during clinical examination.

» Discuss basic cardiovascular and pulmonary examination and treatment techniques.

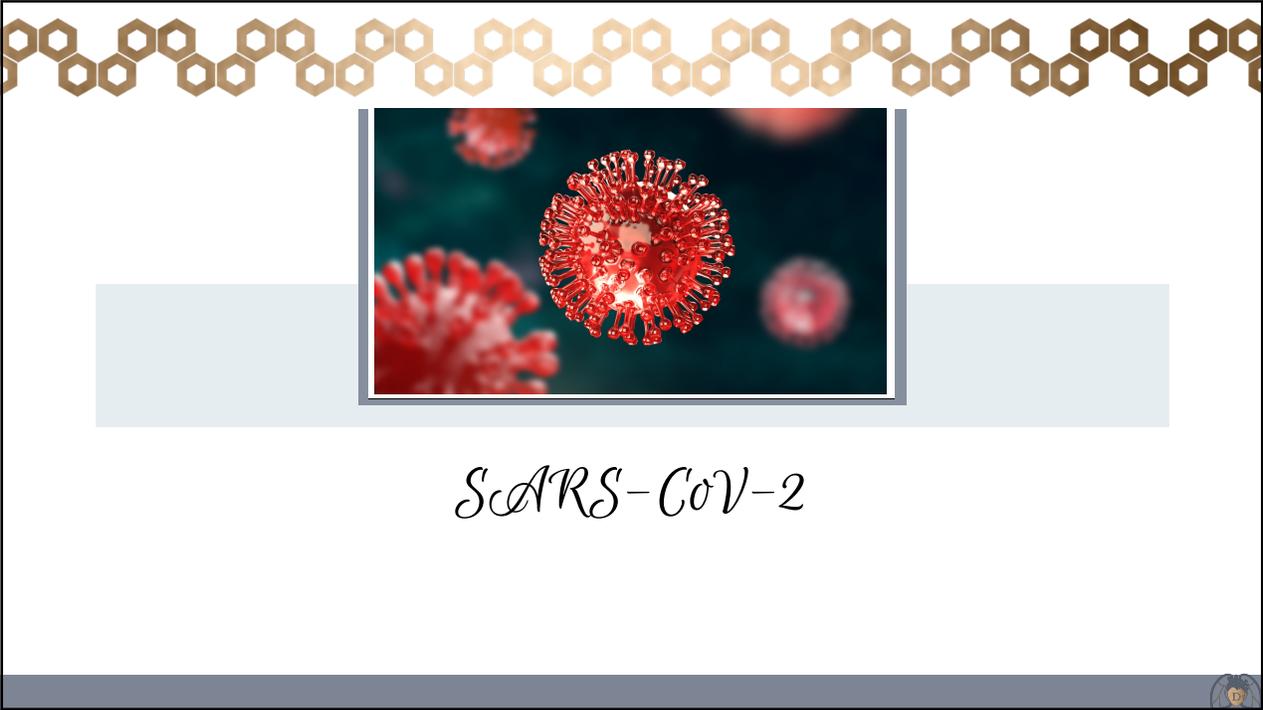


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Lecture Overview

One	Two	Three	Four	Five
SARS-CoV-2	Medical Management of SARS-CoV-2	Physical Therapy Implications of Medical Management	Cardiovascular & Pulmonary Examination	Cardiovascular & Pulmonary Treatment

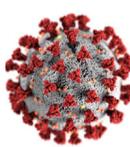
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SARS-CoV-2

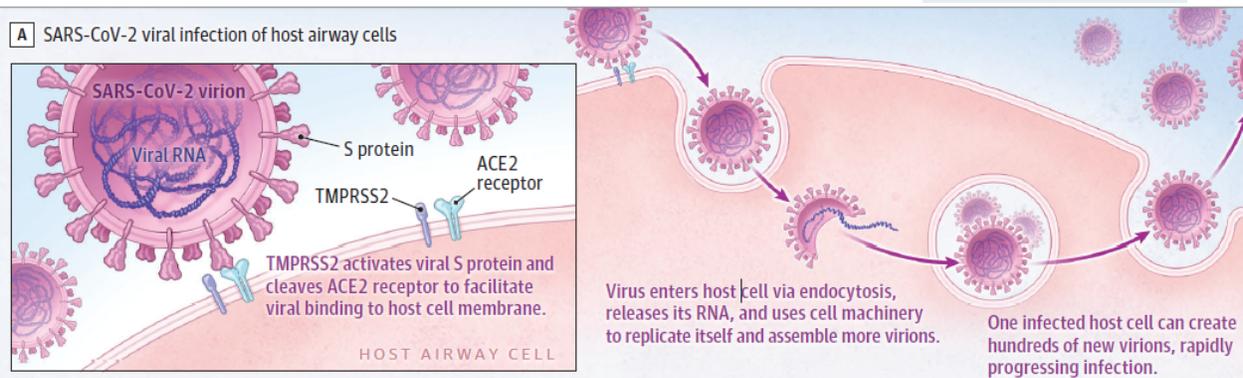
- Positive stranded RNA viruses
- Betacoronavirus, which is in the same subgenus that causes severe acute respiratory syndrome (SARS)
- The Coronavirus Study Group of the International Committee on Taxonomy of Viruses has proposed that this virus be designated *severe acute respiratory syndrome coronavirus 2* (SARS-CoV-2).



<https://www.uptodate.com/contents/coronavirus-disease-2019-covid-19-epidemiology-virology-and-prevention>
Image: <https://www.cdc.gov/coronavirus/2019-ncov/downloads/2019-ncov-factsheet.pdf>

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A SARS-CoV-2 viral infection of host airway cells



SARS-CoV-2 virion
Viral RNA
S protein
ACE2 receptor
TMPRSS2

TMPRSS2 activates viral S protein and cleaves ACE2 receptor to facilitate viral binding to host cell membrane.

HOST AIRWAY CELL

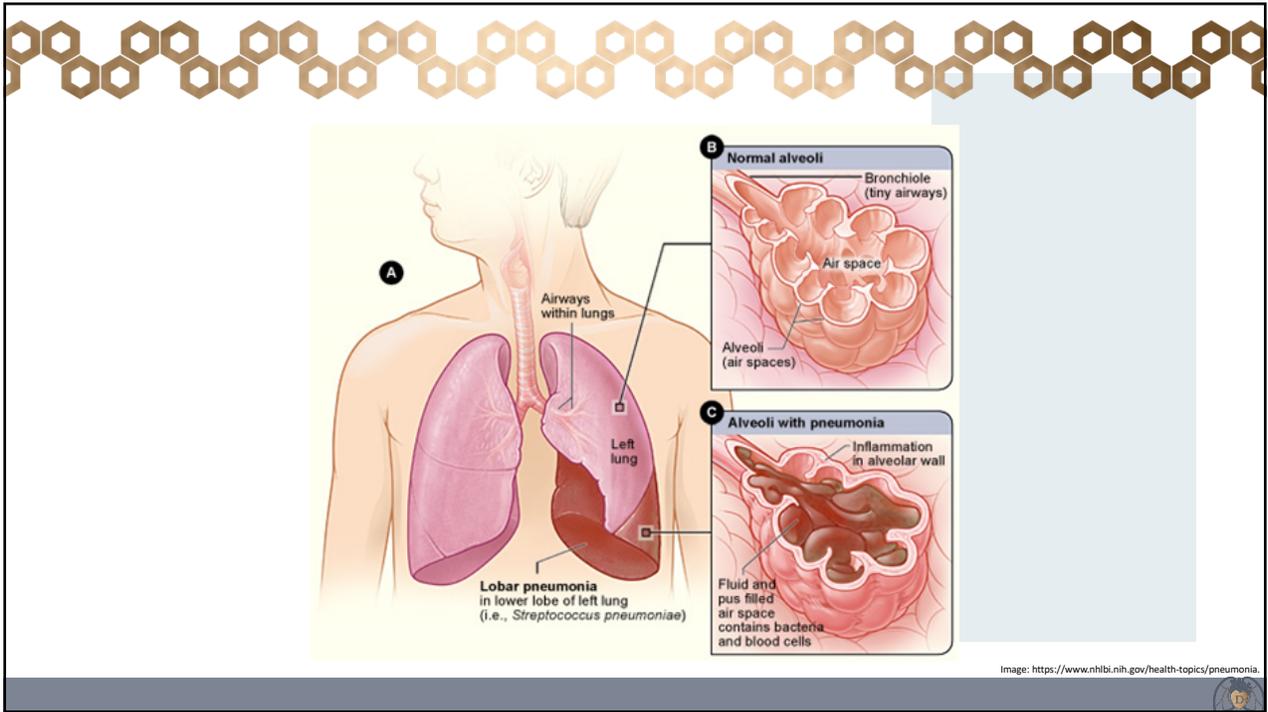
Virus enters host cell via endocytosis, releases its RNA, and uses cell machinery to replicate itself and assemble more virions.

One infected host cell can create hundreds of new virions, rapidly progressing infection.

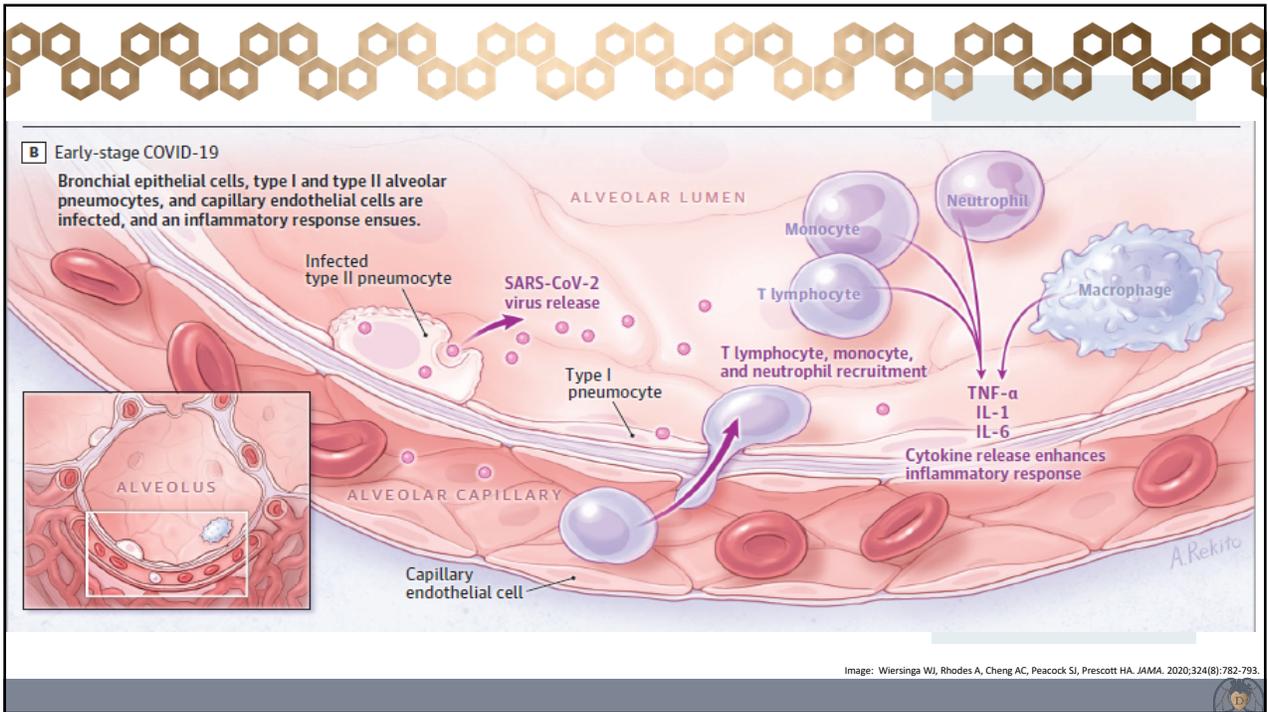
- Angiotensin-converting enzyme 2 (ACE2) is the host receptor for SARS-COV-2.
- SARS-COV-2 binds to ACE2 through the receptor-binding gene region of its spike protein.
- SARS-COV-2 enters the host cell through endocytosis or membrane fusion (penetration).
- Viral contents are released inside the host cell and viral RNA enters the nucleus for replication.

Image: Wiersinga WJ, Rhodes A, Cheng AC, Peacock SJ, Prescott HA. JAMA. 2020;324(8):782-793. <https://www.uptodate.com/contents/coronavirus-disease-2019-covid-19-epidemiology-virology-and-prevention>.
Yuki K, Fujiogi M, Koutsogiannaki S. Clin Immunol. 2020;215:108427.
Guzik TJ, Mohiddin SA, Dimarco A, et al. Cardiovascular Research. 2020.

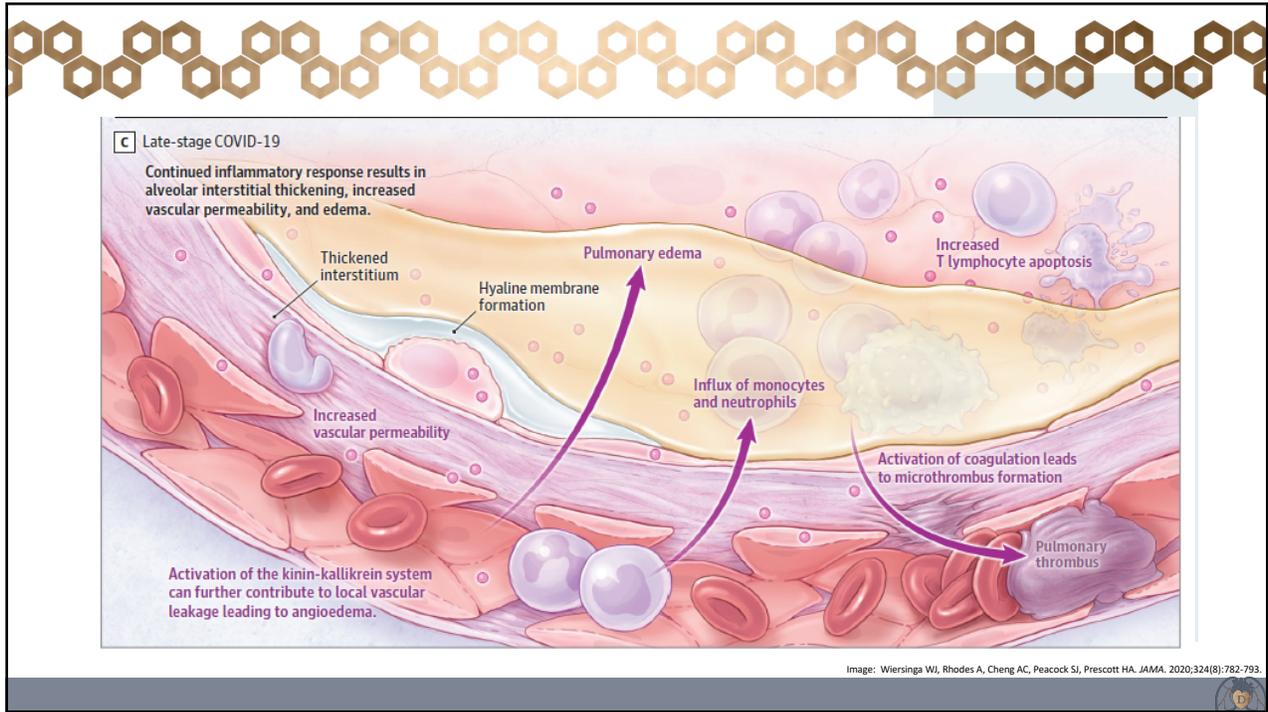
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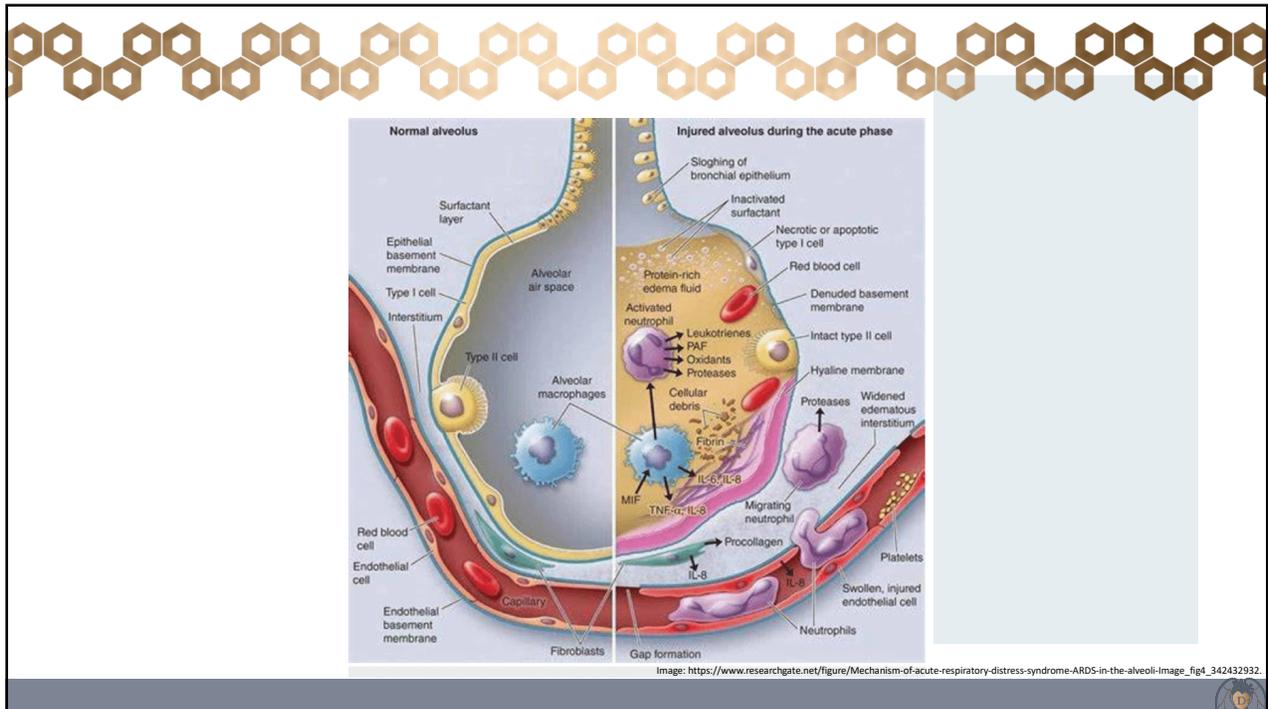
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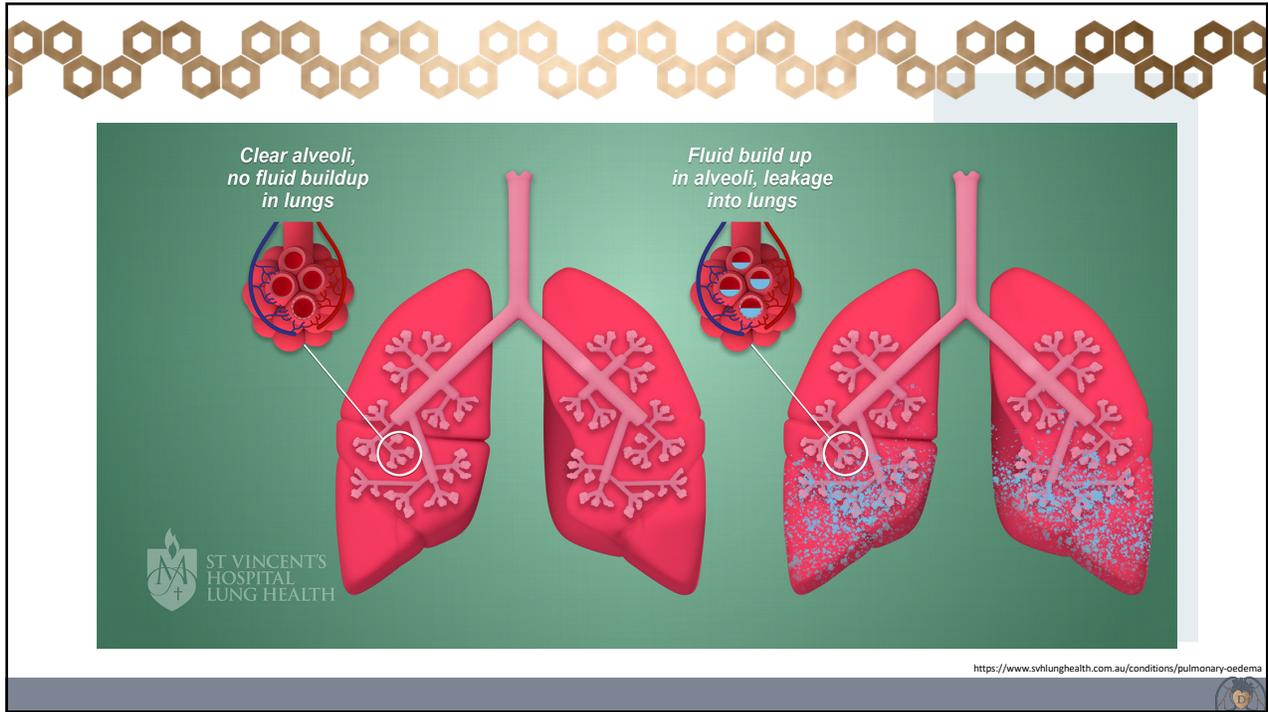
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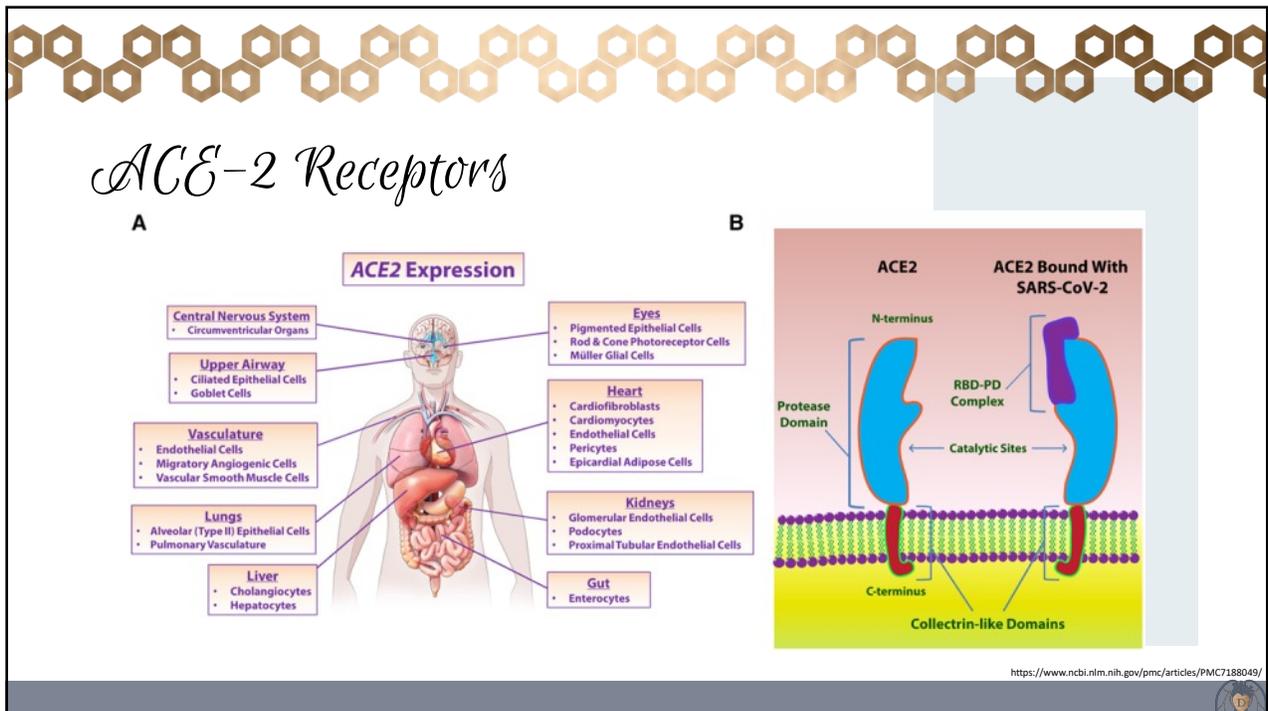
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Both direct and indirect involvement of other organs is common, with the CV system being particularly affected.

Image: <https://khn.org/news/mysterious-heart-damage-not-just-lung-troubles-befalling-covid-19-patients/>

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Figure 3 Cardiovascular involvement in COVID-19 – key manifestations and hypothetical mechanisms

Contractility Preload Afterload

Heart rate

Stroke volume

CARDIAC OUTPUT

Guzik TJ, Mohiddin SA, Dimarco A, et al. *Cardiovascular Research*. 2020. Images: <https://www.escardio.org/Education/COVID-19-and-Cardiology>. <https://step1.medbullets.com/cardiovascular/108003/cardiac-output-and-variables>

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Medical Management of SARS-CoV-2

Medications
Prone Positioning
Supplemental Oxygen
Extracorporeal Membrane Oxygenation

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Figure 1. Pharmacologic Management of Patients with COVID-19 Based on Disease Severity
Doses and durations are listed in the footnote.



DISEASE SEVERITY	PANEL'S RECOMMENDATIONS
Not Hospitalized, Mild to Moderate COVID-19	There are insufficient data to recommend either for or against any specific antiviral or antibody therapy. SARS-CoV-2 neutralizing antibodies (bamlanivimab or casirivimab plus imdevimab) are available through EUAs for outpatients who are at high risk of disease progression. ⁴ The Panel recommends against the use of dexamethasone or other corticosteroids (AIII). ⁵
Hospitalized but Does Not Require Supplemental Oxygen	The Panel recommends against the use of dexamethasone (AIIa) or other corticosteroids (AIII). ⁵ There are insufficient data to recommend either for or against the routine use of remdesivir. For patients at high risk of disease progression, the use of remdesivir may be appropriate.
Hospitalized and Requires Supplemental Oxygen (But Does Not Require Oxygen Delivery Through a High-Flow Device, Noninvasive Ventilation, Invasive Mechanical Ventilation, or ECMO)	Use one of the following options: • Remdesivir ^{6,d} (e.g., for patients who require minimal supplemental oxygen) (BIIa) • Dexamethasone ⁷ plus remdesivir ^{6,d} (e.g., for patients who require increasing amounts of supplemental oxygen) (BIII) ⁹ • Dexamethasone ⁷ (e.g., when combination therapy with remdesivir cannot be used or is not available) (BI)
Hospitalized and Requires Oxygen Delivery Through a High-Flow Device or Noninvasive Ventilation	Use one of the following options: • Dexamethasone ⁷ (AII) • Dexamethasone ⁷ plus remdesivir ^{6,d} (BIII) ⁹
Hospitalized and Requires Invasive Mechanical Ventilation or ECMO	Dexamethasone ⁷ (AII) ⁸

Remdesivir (Veklury):

- It is the first FDA approved treatment for COVID-19.
- It is an anti-viral and must be administered in a hospital or healthcare setting.

Dexamethasone (Decadron, Dexamethasone Intensol, Dexpak Taperpak):

- It is a corticosteroid, with anti-inflammatory and immunosuppressant effects.
- For patients with severe and critical COVID-19, a 7-10 day course of corticosteroid therapy is recommended.

<https://www.covid19treatmentguidelines.nih.gov/therapeutic-management/>
<https://www.fda.gov/news-events/press-announcements/fda-approves-first-treatment-covid-19>
<https://www.ema.europa.eu/en/medicines/human/EPAR/veklury>
<https://jamanetwork.com/journals/jama/fullarticle/2770275>
<https://www.who.int/publications/item/WHO-2019-nCoV-Corticosteroids-2020.1>

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Prone Positioning

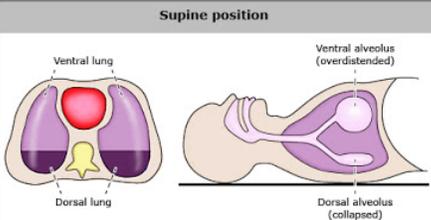
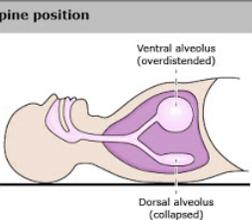
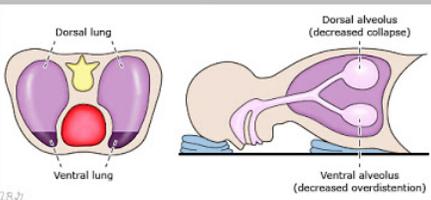
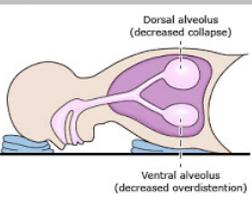
<https://jamanetwork.com/journals/jama/fullarticle/2769872>
<https://jamanetwork.com/journals/jamainternalmedicine/fullarticle/2767575>
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7304963/>
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7304954/>
 Images: Faculty of Intensive Care Medicine. Guidance for: Prone positioning in adult critical care. 2019.

- The technique of placing a patient on the stomach to optimize ventilation
- For management of SARS-CoV-2, prone positioning is occurring in patients with and without mechanical ventilation.




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Benefits of Prone Positioning

		PTP	Blood flow
Supine position			
		+++ ---	
Prone position			
		+ -	

- Improves ventral-dorsal transpulmonary pressure difference
- Reduces dorsal lung compression
- Improves lung perfusion

<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7188049/>

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Noninvasive Ventilation

Delivered by a nasal or facial mask that attaches to a positive airway pressure machine

Continuous Positive Airway Pressure (CPAP) BiLevel Positive Airway Pressure (BiPap)




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Noninvasive Ventilation

Patients who use NIMV may experience

- Headaches
- Eye irritation
- Sinus pain
- Sinus congestion
- Skin irritation
- Stomach bloating



If patient fails to improve or stabilize within a reasonable period on NIMV, the patient may need to be intubated.

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Mechanical Ventilation

➤ Purpose: to meet the physiological needs in acute respiratory failure



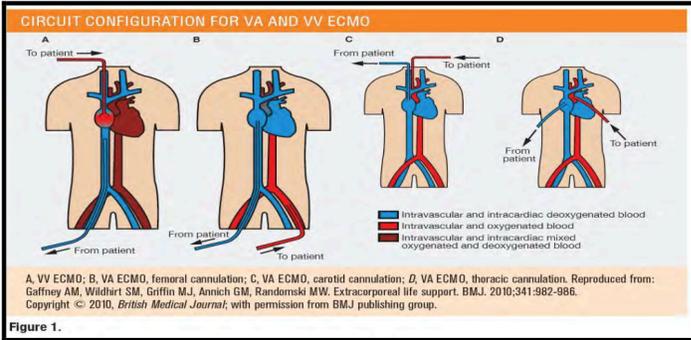
In patients who are mechanically ventilated, consider influence of additional associated medical interventions - such as sedatives, paralytics, vasopressors, bed rest, etc. - on body systems.

Image: <https://www.infectiousdiseasadvisor.com/home/topics/respiratory/pneumonia/updated-guidelines-for-management-of-hospital-acquired-ventilator-associated-pneumonia/>

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Extracorporeal Membrane Oxygenation

➤ Purpose: to provide life support that replaces the function of the patient's heart and/or lungs



CIRCUIT CONFIGURATION FOR VA AND VV ECMO

A. VV ECMO; B. VA ECMO, femoral cannulation; C. VA ECMO, carotid cannulation; D. VA ECMO, thoracic cannulation. Reproduced from: Gaffney AM, Widhert SM, Griffin MJ, Annich GM, Randemski MW. Extracorporeal life support. BMJ. 2010;341:982-986. Copyright © 2010, British Medical Journal; with permission from BMJ publishing group.

Figure 1.

Image: https://www.aci.health.nsw.gov.au/_data/assets/pdf_file/0007/306583/ECMO_Learning_package.pdf

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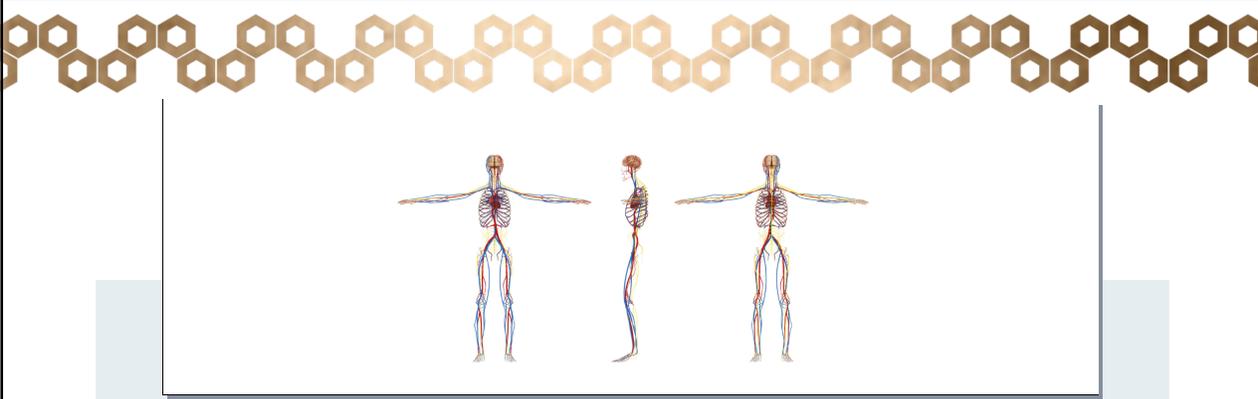
ECMO Cannulation



5 Fr Antegrade Cannula
15 Fr ECMO Venous Cannula
14 Fr ECMO Arterial Cannula
Triple Lumen Venous Access

Images:
https://www.researchgate.net/figure/Central-cannulation-for-V-A-ECMO_fig3_258207487
<http://www.cumc.columbia.edu/pulmonary/clinical-centers/center-acute-respiratory-failure>
<https://www.sciencedirect.com/science/article/pii/S0022346810005609>

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Physical Therapy Implication of Medical Management

- Medications
- Prone Positioning
- Supplemental Oxygen
- Extracorporeal Membrane Oxygenation

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Figure 1. Pharmacologic Management of Patients with COVID-19 Based on Disease Severity

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Hospitalized and Requires Supplemental Oxygen (But Does Not Require Oxygen Delivery Through a High-Flow Device, Noninvasive Ventilation, Invasive Mechanical Ventilation, or ECMO)	<p>Use one of the following options:</p> <ul style="list-style-type: none"> • Remdesivir^{c,d} (e.g., for patients who require minimal supplemental oxygen) (BIIa) • Dexamethasone^e plus remdesivir^{c,d} (e.g., for patients who require increasing amounts of supplemental oxygen) (BIII)^g • Dexamethasone^e (e.g., when combination therapy with remdesivir cannot be used or is not available) (BI)
Hospitalized and Requires Oxygen Delivery Through a High-Flow Device or Noninvasive Ventilation	<p>Use one of the following options:</p> <ul style="list-style-type: none"> • Dexamethasone^{e,g} (AI) • Dexamethasone^e plus remdesivir^{c,d} (BIII)^g
Hospitalized and Requires Invasive Mechanical Ventilation or ECMO	Dexamethasone^e (AI)^h

Remdesivir (Veklury):

- The most common side effect in healthy people is elevated liver enzymes. Monitor for signs and symptoms of liver disease.
- The most common side effect in people with COVID-19 is nausea.

Dexamethasone (Decadron, Dexamethasone Intensol, Dexpak Taperpak):

- Common side effects of long-term corticosteroid use may include muscle wasting. Link to functional deficits.
- If a patient has diabetes, it may increase the blood sugar level. Monitor for signs and symptoms related to hyperglycemia.

<https://www.covid19treatmentguidelines.nih.gov/therapeutic-management/>
<https://www.ema.europa.eu/en/medicines/human/EPAR/veklury>
<https://www.who.int/news-room/q-a-detail/coronavirus-disease-covid-19-dexamethasone>

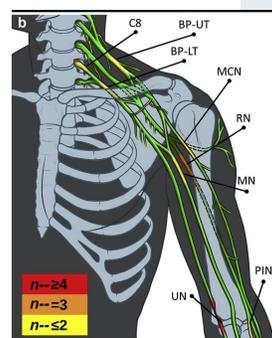
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Prone Positioning & Peripheral Nerve Injuries

➤➤ Of 83 patients s/p SARS-CoV-2 admitted to a single rehabilitation hospital, 12 were diagnosed with a peripheral nerve injury.

➤➤ 21 focal peripheral nerve injury sites across these 12 patients.

- 28.6%: ulnar nerve
- 14.3%: radial nerve
- 14.3%: sciatic nerve
- 9.5%: brachial plexus
- 9.5%: median nerve



Ask questions pertaining to medical management during hospitalization.
 Consider strength and sensation testing.
 Compare bilaterally.

Malik GR, Wolfe AR, Soriano R, et al. *BJA*. 2020.
 Other references:
 O'Sullivan J, Miller C, Jeffrey J, Power D. *PTJ*. 2020.
 Brugliera L, Filippi M, Del Carro U, et al. *Archives of Physical Medicine & Rehabilitation*. 2021;102:559-62.

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Prone Positioning & Pressure Injuries

Ask questions pertaining to medical management - including lines / tubes / drains - during hospitalization.
Perform an Integumentary screen.

Images: National Pressure Injury Advisory Panel. Pressure Injury Prevention - PIPS Tips for Prone Positioning.

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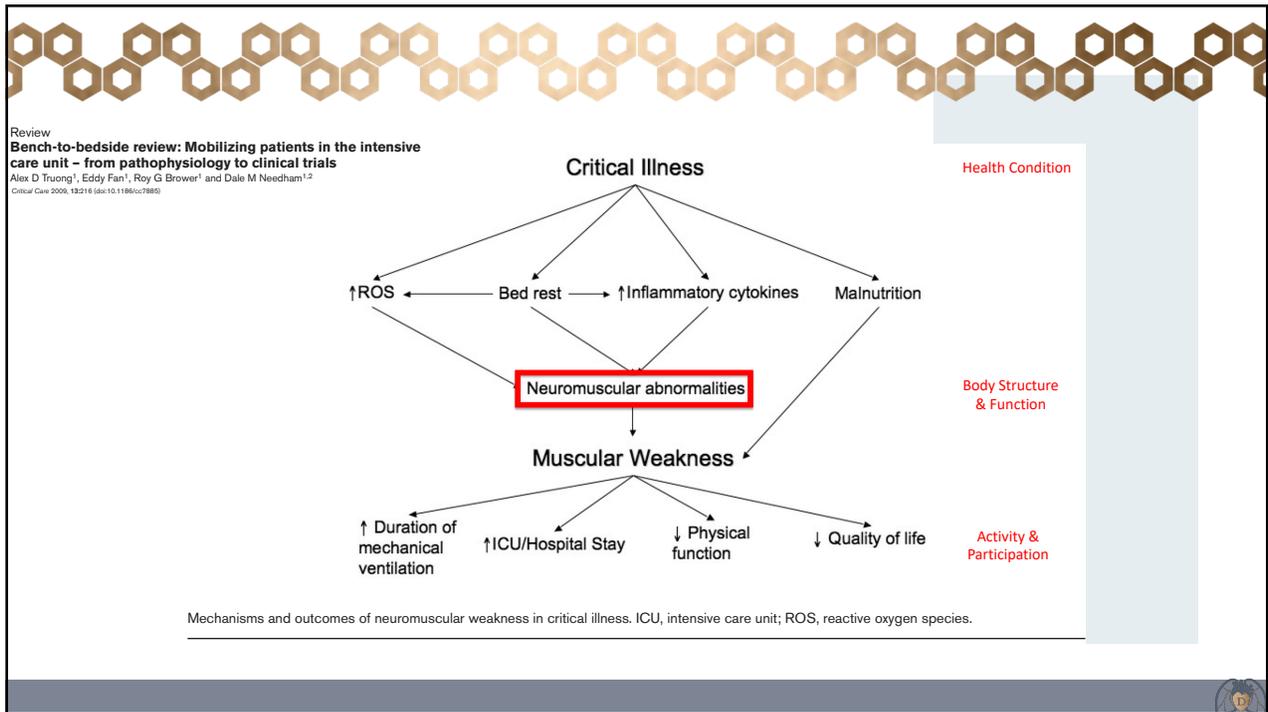
ICU Delirium

- 20% - 80% of ICU patients develop delirium at any points
- Typical onset in ICU patients: Day 2 +/- 2 days
- Typical duration in ICU patients: 4 +/- 2 days
- 50% and 10% of ARDS patients are delirious at ICU and hospital discharge.

Hypoactive delirium	Mixed delirium	Hyperactive delirium
44%	55%	1%
<ul style="list-style-type: none"> • Sleepy, inattentive • Decreased motor activity 		<ul style="list-style-type: none"> • Agitated • Increased motor activity

Ely et al. JAMA. 2001;286: 2703-10; Ely et al. CCM. 2001;9:1370-9; Paterson et al. JAGS. 2006;54:479-84; McNicoll et al. JAGS. 2003;51:591-98; Fan et al. CCM. 2008;94-9.

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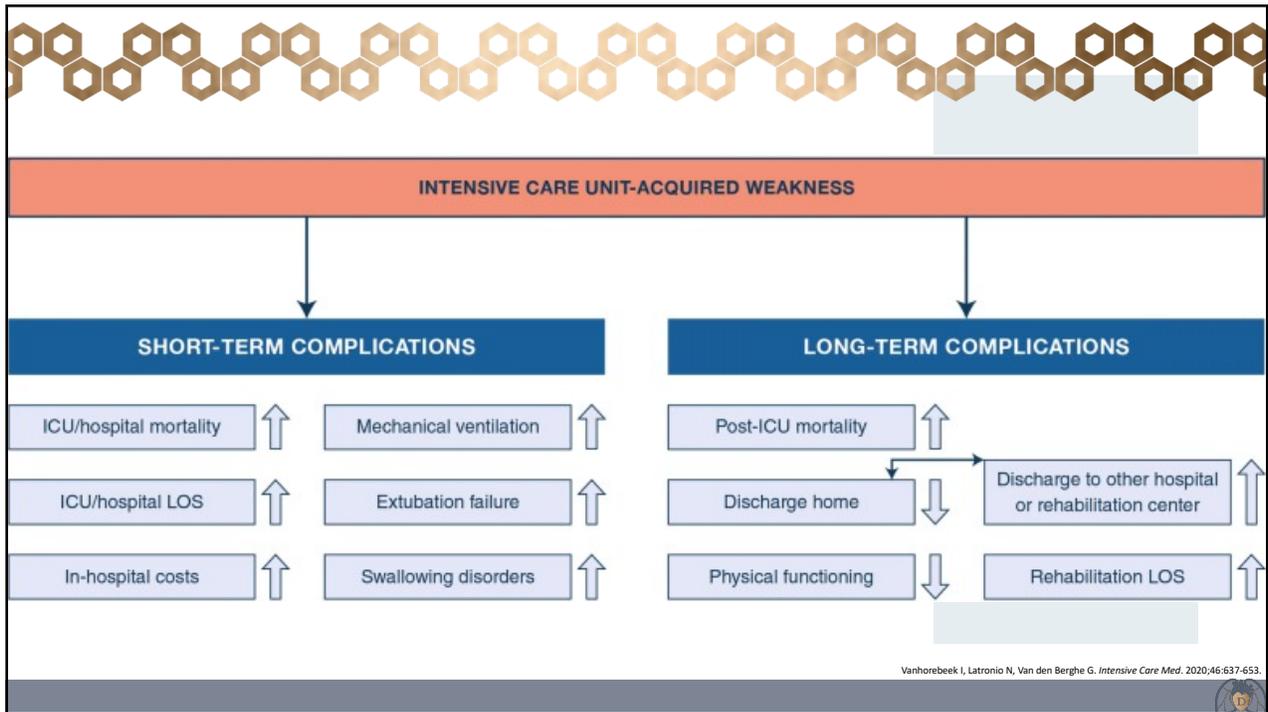
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ICU Acquired Weakness

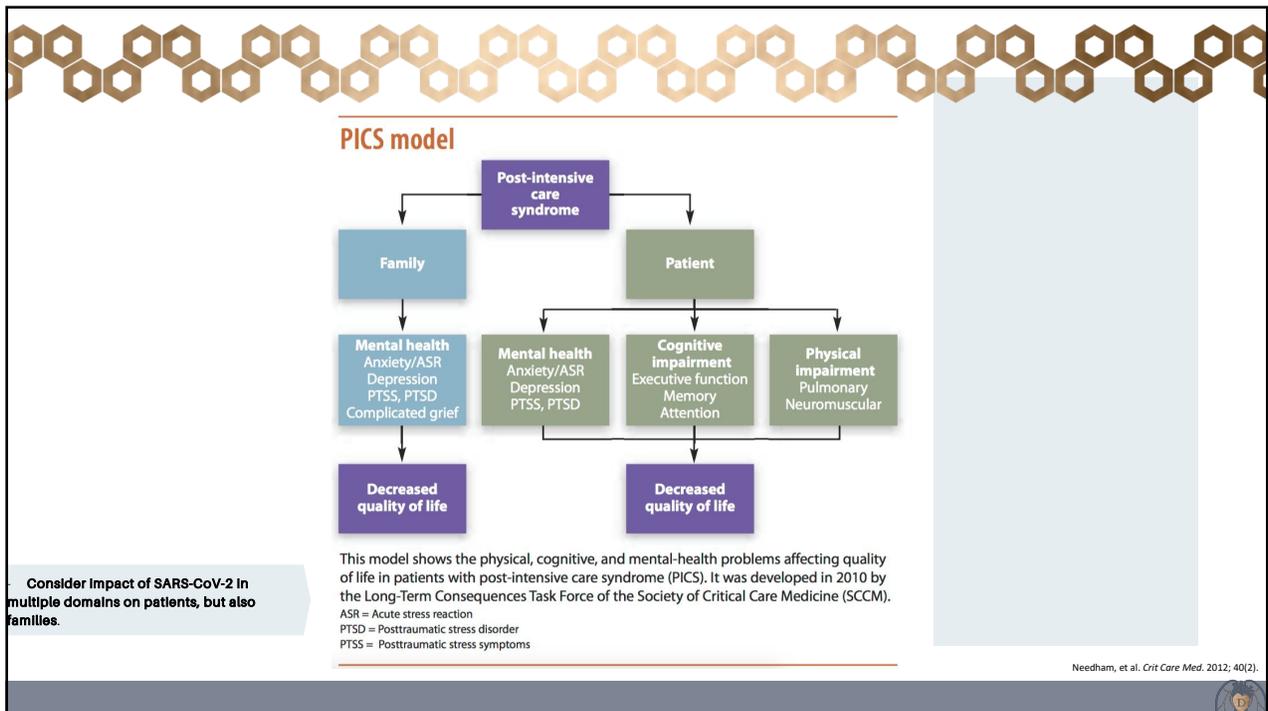
- Syndrome of generalized limb weakness that develops while the patient is critical ill and for which there is no alternative explanation other than the critical illness itself
- Critical Illness Polyneuropathy
- Critical Illness Myopathy
- Critical Illness Neuromyopathy

Stevens RD, et al. Crit Care Med 2009;37:299-308

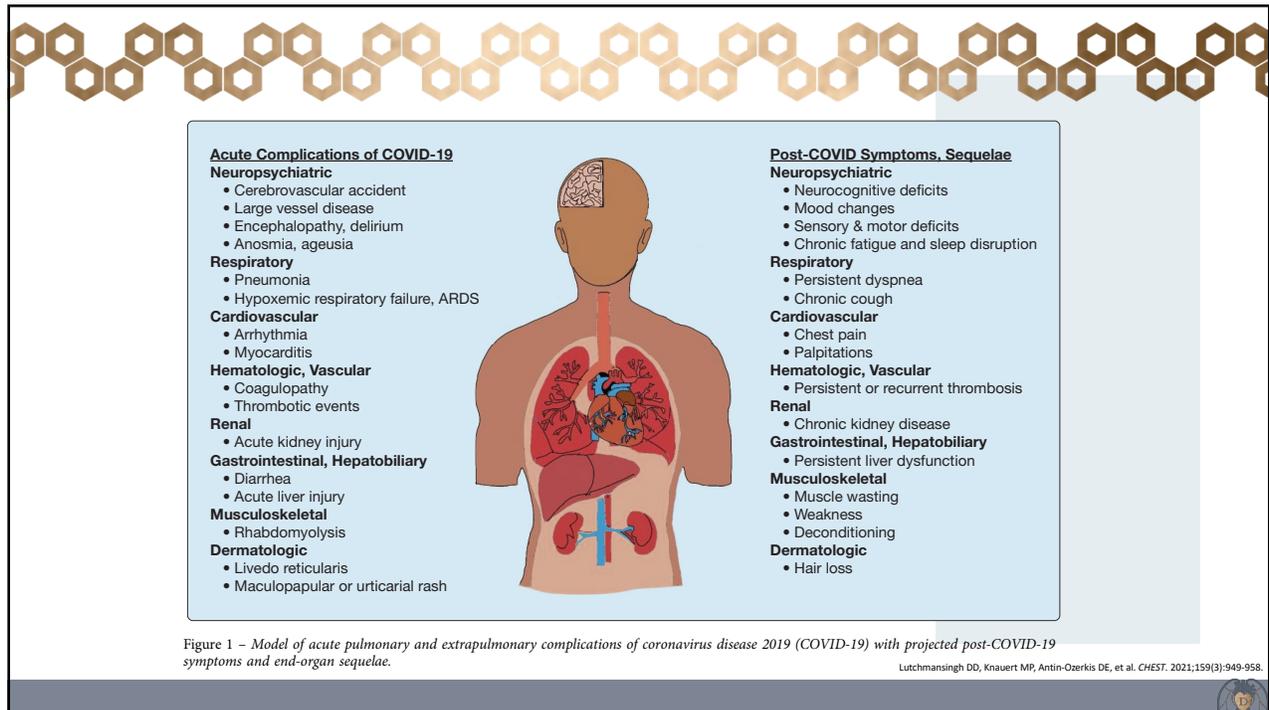
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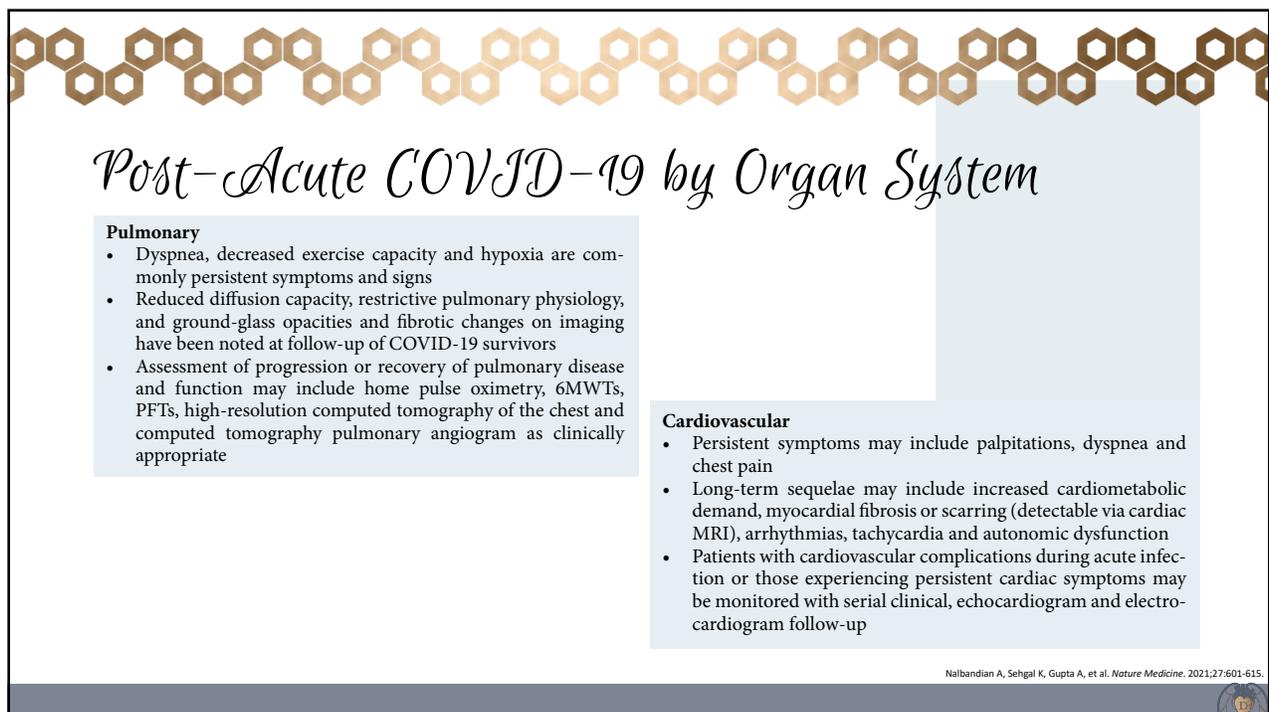
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Postural Orthostatic Tachycardia Syndrome

- Blood circulation disorder characterized by
 - A specific group of symptoms that frequently occur when standing upright
 - A heart rate increase from horizontal to standing of > 30 bpm (adults) OR > 40 bpm (adolescents)
 - Absence of orthostatic hypotension

- Pathophysiology
 - Neuropathic
 - Hypovolemic
 - Hyperadrenergic

Miglis MG, Prieto T, Shaik R, Muppidi S, Sinn D, Jaradeh S. *Clin Auton Res.* 2020;3:1-3.
 Postural Orthostatic Tachycardia Syndrome (POTS). <https://www.hopkinsmedicine.org/health/conditions-and-diseases/postural-orthostatic-tachycardia-syndrome-pots>.
 Coronavirus Information Page. <https://www.dysautonomiainternational.org/page.php?ID=227>.
 Safavi-Naeini P, Razavi M. *Texas Heart Inst J.* 2020;47(1):57-59.

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Postural Orthostatic Tachycardia Syndrome

Normal (3a)

Neuropathic POTS (3b)

Raj SR. *Indian Pacing Electrophysiol J.* 2006;6(2): 84-99.

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Postural Orthostatic Tachycardia Syndrome

➤ Signs and symptoms

- Severe and/or long-lasting fatigue
- Lightheadedness with prolonged sitting and/or standing (can leading to fainting)
- Brain fog
- Heart palpitations
- Nausea / vomiting
- Headaches
- Excessive sweating
- Shakiness
- Exercise intolerance
- Pale face and cyanosis

Miglis MG, Prieto T, Shaik R, Muppidi S, Sinn D, Jaradeh S. *Clin Auton Res.* 2020;3:1-3.
 Postural Orthostatic Tachycardia Syndrome (POTS). <https://www.hopkinsmedicine.org/health/conditions-and-diseases/postural-orthostatic-tachycardia-syndrome-pots>.
 Coronavirus Information Page. <https://www.dysautonomiainternational.org/page.php?ID=227>.
 Safavi-Naeini P, Razavi M. *Texas Heart Inst J.* 2020;47(1):57-59.

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Postural Orthostatic Tachycardia Syndrome

Table II.
 Recommendations for Treatment of Postural Orthostatic Tachycardia Syndrome

	Class	Level
A regular, structured, and progressive exercise program for patients with POTS can be effective.	IIa	B-R
It is reasonable to treat patients with POTS who have short-term clinical decompensations with an acute intravenous infusion of up to 2 L of saline.	IIa	C
Patients with POTS might be best managed with a multidisciplinary approach.	IIb	E
The consumption of up to 2-3 L of water and 10-12 g of NaCl daily by patients with POTS may be considered.	IIb	E
It seems reasonable to treat patients with POTS with fludrocortisone or pyridostigmine.	IIb	C
Treatment of patients with POTS with midodrine or low-dose propranolol may be considered.	IIb	B-R
It seems reasonable to treat patients with POTS who have prominent hyperadrenergic features with clonidine or alpha-methyl dopa.	IIb	E
Drugs that block the norepinephrine reuptake transporter can worsen symptoms in patients with POTS and should not be administered.	III	B-R
Regular intravenous infusions of saline in patients with POTS are not recommended in the absence of evidence, and chronic or repeated intravenous cannulation is potentially harmful.	III	E
Radiofrequency sinus node modification, surgical correction of a Chiari malformation type I, and balloon dilation or stenting of the jugular vein are not recommended for routine use in patients with POTS and are potentially harmful.	III	B-NR

Safavi-Naeini P, Razavi M. *Texas Heart Inst J.* 2020;47(1):57-59.

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Cardiovascular and Pulmonary Examination

Vital Signs
Auscultation
Special Tests



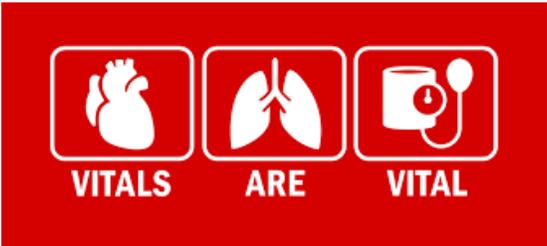
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Vital Signs

»» Why do we care about vital signs?

- Simplest, cheapest, and one of the most important pieces of data to collect
- Gives an indication of hemodynamic stability
- Can be a predictor of clinical deterioration



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7 SIMPLE TIPS TO GET AN ACCURATE BLOOD PRESSURE READING

- USE CORRECT CUFF SIZE**
Cuff too small adds 2-10 mm Hg
- PUT CUFF ON BARE ARM**
Cuff over clothing adds 5-50 mm Hg
- SUPPORT ARM AT HEART LEVEL**
Unsupported arm adds 10 mm Hg
- KEEP LEGS UNCROSSED**
Crossed legs add 2-8 mm Hg
- SUPPORT BACK/FEET**
Unsupported back and feet adds 6.5 mm Hg
- DON'T HAVE A CONVERSATION**
Talking or active listening adds 10 mm Hg
- EMPTY BLADDER FIRST**
Full bladder adds 10 mm Hg

The common positioning errors can result in inaccurate blood pressure measurement. Figures shown are estimates of how improper positioning can potentially impact blood pressure readings.
Sources:
1. Pickering, et al. Recommendations for Blood Pressure Measurement in Humans and Experimental Animals: Part 1: Blood Pressure Measurement in Humans. *Circulation*. 2005;116:897-916.
2. Bradley, J. The importance of accurate blood pressure measurement. *The Practitioner Journal*/Summer 2009/Vol. 18 No. 3: 51.
This 7 simple tips to get an accurate blood pressure reading was adapted with permission of the American Medical Association and The Johns Hopkins University. The original copyrighted content can be found at <https://www.ama-assn.org/ama-johns-hopkins-blood-pressure-resources>.
Revised December 2016
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AMA
AMERICAN MEDICAL ASSOCIATION

https://www.heart.org/-/media/files/professional/million-hearts/success-stories/7-simple-tips-to-get-accurate-blood-pressure-ucm_493556.pdf

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Blood Pressure

What is the AHA recommendation for healthy blood pressure?

This blood pressure chart reflects categories defined by the American Heart Association.

Blood Pressure Category	Systolic mm Hg (upper #)		Diastolic mm Hg (lower #)
Normal	less than 120	and	less than 80
Prehypertension	120 – 139	or	80 – 89
High Blood Pressure (Hypertension) Stage 1	140 – 159	or	90 – 99
High Blood Pressure (Hypertension) Stage 2	160 or higher	or	100 or higher
Hypertensive Crisis (Emergency care needed)	Higher than 180	or	Higher than 110

http://www.heart.org/HEARTORG/Conditions/HighBloodPressure/AboutHighBloodPressure/Understanding-Blood-Pressure-Readings_UCM_301764_Article.jsp#VpWkLTFnwv

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Blood Pressure, Mean Arterial Pressure

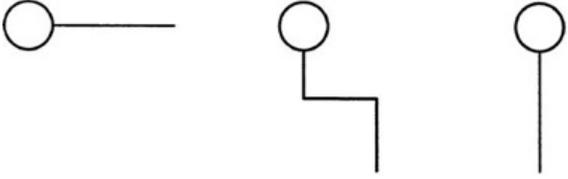
- Average arterial pressure throughout one cardiac cycle (systole and diastole)
- Influenced by cardiac output, systemic vascular resistance
- $MAP = DBP + 1/3 (SBP - DBP)$
- $MAP > 60 \text{ mmHg}$ to perfuse vital organs

If $MAP < 60 \text{ mmHg}$ for a prolonged period of time, end-organ manifestations such as ischemia and infarction can occur. Monitor for signs and symptoms of various end-organ failure.

<https://www.ncbi.nlm.nih.gov/books/NBK538226/>

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Blood Pressure, Orthostatic Hypotension



Supine Sitting Standing

SBP < 20 mmHg
DBP < 10 mmHg

http://www.heart.org/HEARTORG/Conditions/HighBloodPressure/AboutHighBloodPressure/Understanding-Blood-Pressure-Readings_UCM_301764_Article.jsp#VpVwKLTfnww

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Heart Rate

- # of heart beats / minute
- Adult Normal: 60 – 100 beats / min
 - Bradycardia: < 60 beats / min
 - Tachycardia: >100 beats / min
- - Stroke Volume: the amount of blood ejected / beat (~ 70 mL / beat)
 - Cardiac Output: the amount of blood ejected / minute (~ 5-6 L / minute)

CARDIAC OUTPUT

Cardiac Output (CO) = Heart Rate (HR) x Stroke Volume (SV)

Frownfelter & Dean.
<https://www.ncbi.nlm.nih.gov/books/NBK470455/>
http://www.heart.org/HEARTORG/Conditions/More/MyHeartandStrokeNews/All-About-Heart-Rate-Pulse_UCM_438850_Article.jsp#Vpo1T_krUK

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Respiratory Rate

- # of breaths / minute
- Adult Normal: 12 – 16 breaths / min
 - Apnea: lack of airflow to the lungs for > 15 seconds
 - Bradypnea: < 12 breaths / min
 - Tachypnea: > 20 breaths / min

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Oxygen Saturation

Measure of how much hemoglobin is current bound to oxygen compared to how much hemoglobin remains unbound

Hypoxia = deprivation of oxygen at the tissue level
 Hypoxemia = low arterial oxygen supply

The graph shows Oxyhaemoglobin (% Saturation) on the y-axis (0-100) and PO₂ (mmHg) on the x-axis (0-100). A sigmoidal curve represents the relationship. Annotations include:

- Bohr effect: ↑pH, ↓DPG, ↓Temp (left shift)
- Haldane effect: O₂ displaces CO₂ from Hb (right shift)
- Bohr effect: ↓CO₂, ↑pH (right shift)

Hafen B8, Sharma S. Oxygen Saturation. 2019. <https://www.ncbi.nlm.nih.gov/books/NBK525974/>, <https://nationalmaglab.org/about/around-the-lab/what-goes-in-the-magnet/hemoglobin>, https://en.wikipedia.org/wiki/Oxygen-hemoglobin_dissociation_curve

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Oxygen Saturation

Pulse ox: measures oxygen saturation

Ways to improve pulse ox signals

- Warm and rub the skin
- Apply a topical vasodilator
- Try a different probe site
- Try a different probe
- Use a different machine

Factors that may reduce the accuracy of the pulse ox

- Nail polish
- High-intensity ambient lighting
- Excessive patient movement
- Decreased perfusion
- Presence of abnormal Hgb
- Intravascular dyes
- Sats < 83%

The diagram shows a pulse oximeter probe with a light source (red and infrared) and a light detector. The probe is shown in cross-section, with light passing through the skin and being detected by the detector.

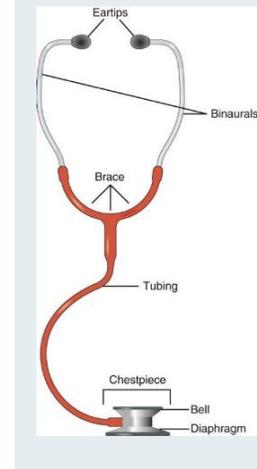
how equipment works .com

Hafen B8, Sharma S. Oxygen Saturation. 2019. <https://www.ncbi.nlm.nih.gov/books/NBK525974/>

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Auscultation

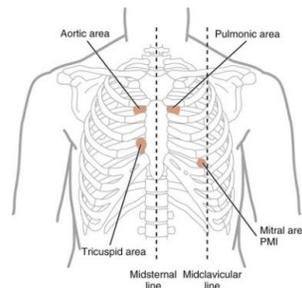
- Purpose: to listen to internal sounds
- Common errors
 - Listening to breath sounds through the patient's gown or clothes
 - Allowing tubing to rub against bed rails or patient's gown
 - Attempting to auscultate in a noisy room
 - Interpreting chest sounds as adventitious lung sounds
 - Auscultating only the "convenient" areas
- Correct technique
 - Placing bell or diaphragm directly against the chest wall
 - Keep tubing free from contact with any objects during auscultation
 - Turning television and/or radio off
 - Wetting chair hair before auscultation if thick
 - Asking alert patient to sit up; roll comatose patient onto side to auscultate posterior lobes



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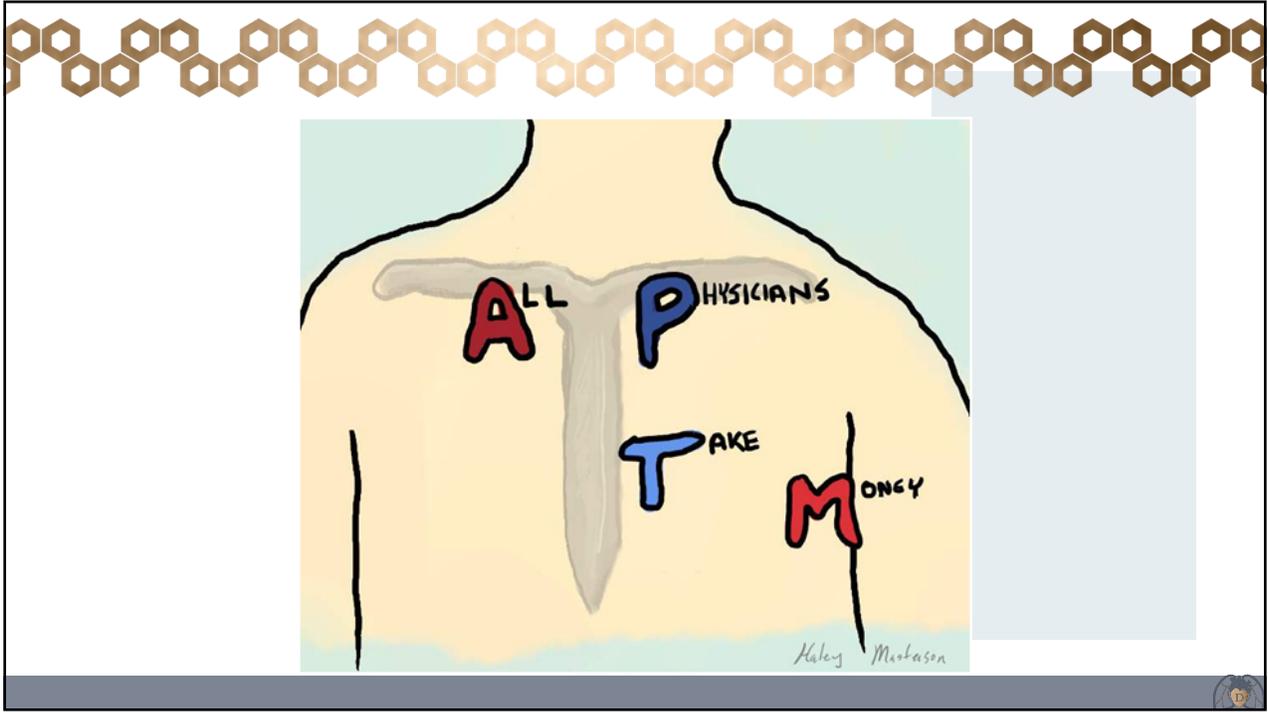
Heart Sounds

- S1: Closing of the atrioventricular valves
 - Tricuspid valve: left sternal border, 4th and 5th intercostal space
 - Bicuspid valve: left midclavicular line, 5th intercostal space
- S2: Closing of the semilunar valves
 - Aortic valve: right sternal border, 2nd intercostal space
 - Pulmonary valve: left sternal border, 2nd to 4th intercostal space

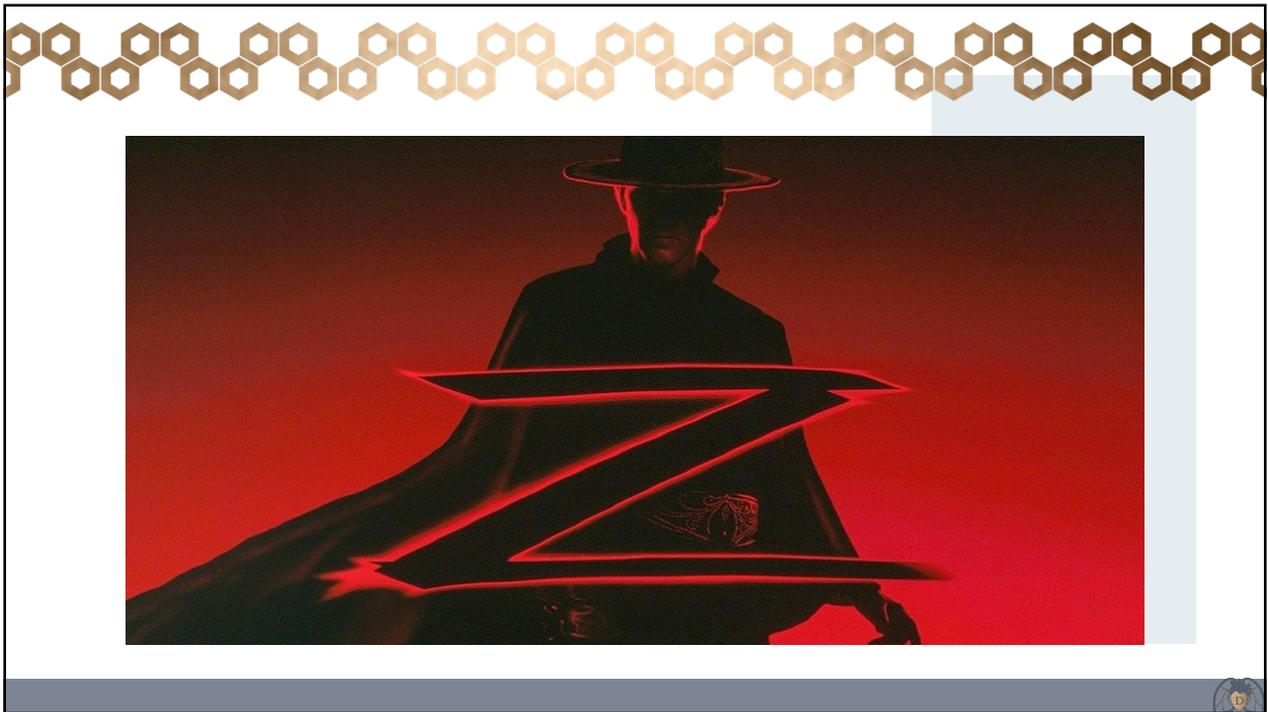


Frownfeiter & Dean.
Image: Figure 15-9 from Frownfeiter & Dean.

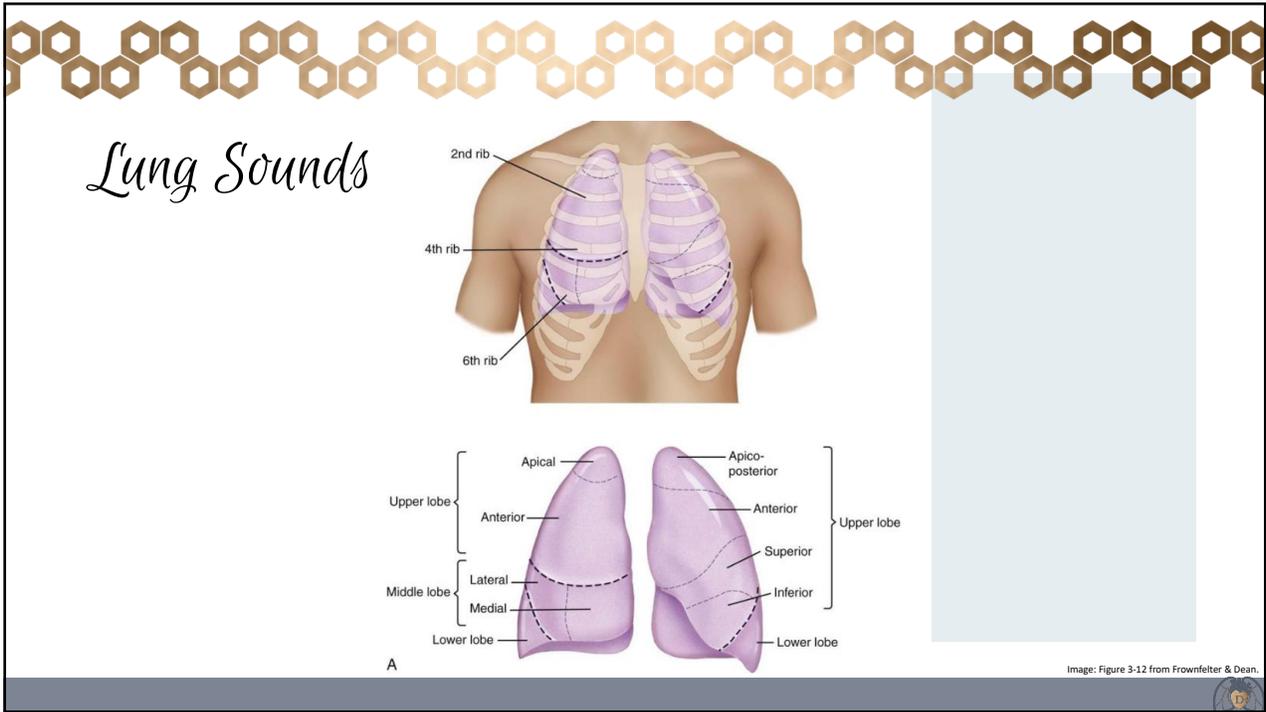
50



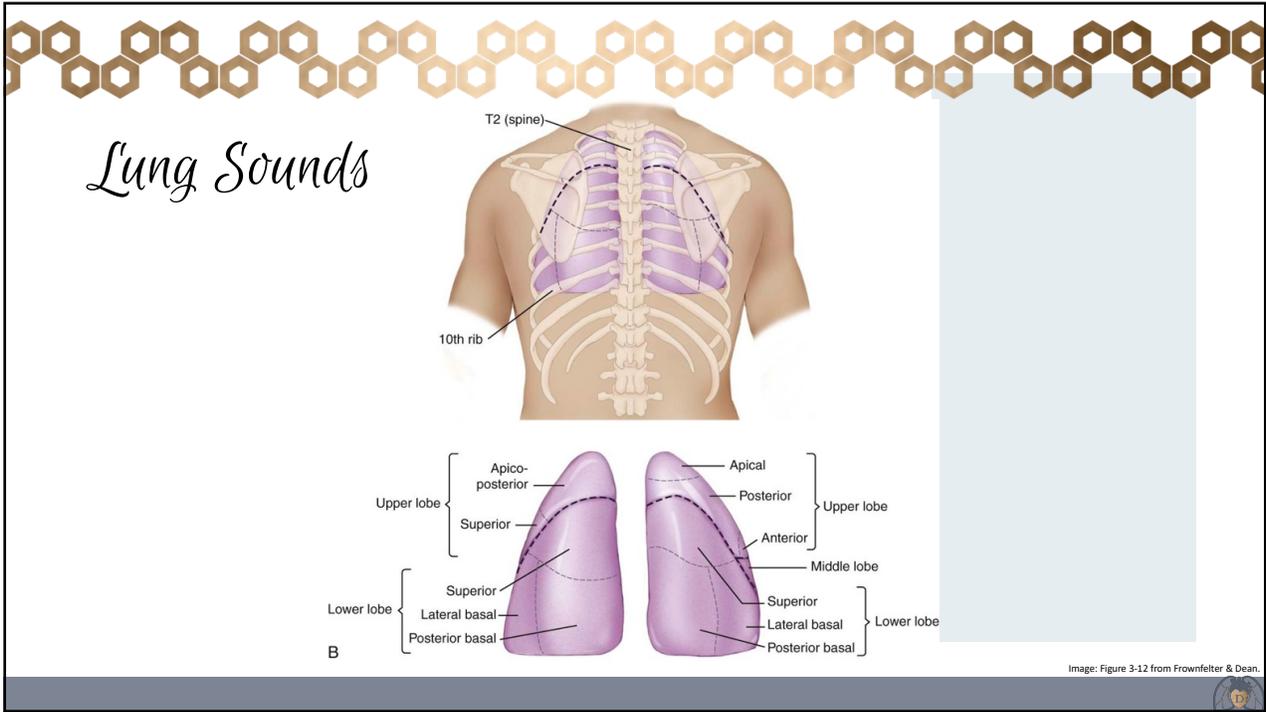
51



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Lung Sounds

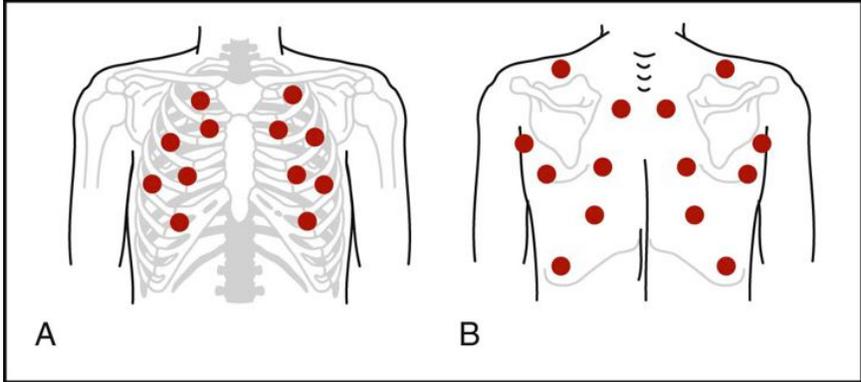


Image: Figure 15-7 from Frownfelter & Dean.

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Lung Sounds

	Sound	Phase	(+) pause between phases	Auscultation Location
Bronchial	High-pitched	Inspiratory / Expiratory	(+) pause between phases	- Heard over the trachea
Bronchovesicular	High-pitched	Inspiratory / Expiratory	No pause between phases	- Heard best whenever the bronchi, or central lung tissue, are close to the surface - Supraclavicular and suprascapular (the apices), as well as parasternal and interscapular (the bronchi)
Vesicular		Inspiratory, only the initial 1/3 of the expiratory phase audible		- Heard over the remaining peripheral lung fields

<https://www.youtube.com/watch?v=ON1r0Pxrk-g>

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Peripheral Pulses

➤ Purpose: to assess for circulation, heart rate, rhythm

Image: Acute Care Handbook for PT.

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Peripheral Pulses

Scale	Degree	Description
	0 Absent pulse	No pulse—no circulation
	1+ Diminished pulse	Reduced stroke volume and ejection fraction, increased vascular resistance 
	2+ Normal pulse	Normal resting conditions, no pathologies
	3+ Moderately increased	Slightly increased stroke volume and ejection fraction 
	4+ Markedly increased (bounding)	Increased stroke volume and ejection fraction, can be diminished with vasoconstriction

Acute Care Handbook for PT.
Table 1-5. Pulse Amplitude Classification.

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Peripheral Edema

SCALE	1+ Trace	2+ Mild	3+ Moderate	4+ Severe
DEGREE	Slight	0-0.6 cm	0.6-1.3 cm	1.3-2.5 cm
DESCRIPTION	Barely perceptible depression	EID (rebounds in <15 sec)	EID (rebounds in 15-30 sec)	EID (rebounds in > 30 sec)

Acute Care Handbook for PT, Table 1-6. Pitting Edema Scale. Image: <http://www.med-health.net/Edema-Grading.html>

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Risk of Deep Vein Thrombosis

Wells Score Criteria Description	Points
Active Cancer (treatment within last 6 months or palliative)	+1 point
Calf swelling ≥ 3 cm compared to asymptomatic calf (measured 10 cm below tibial tuberosity)	+1 point
Swollen unilateral superficial veins (non-varicose, in symptomatic leg)	+1 point
Unilateral pitting edema (in symptomatic leg)	+1 point
Previous documented DVT	+1 point
Swelling of entire leg	+1 point
Localized tenderness along the deep venous system	+1 point
Paralysis, paresis, or recent cast immobilization of lower extremities	+1 point
Recently bedridden ≥ 3 days, or major surgery requiring regional or general anesthetic in the past 12 weeks	+1 point
Alternative diagnosis at least as likely	-2 points

Interpretation:

- >2.0 : High (probability 53%)
- $1.0 - 2.0$: Moderate (probability 17%)
- < 2.0 : Low (probability 5%)

D-dimer may be used in either case to rule in/out DVT. Moderate to high risk warrants a vascular ultrasound.

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Shortness of Breath

MMRC Dyspnea Scale

<p>Grade 0 Not troubled by dyspnea unless on strenuous exercise</p>	<p>Grade 1 Dyspnea when hurrying or walking up hill</p>	<p>Grade 2 Dyspnea when walking on level (slower/stop for breath after 15 minutes)</p>	<p>Grade 3 Severe dyspnea when walking on level (need to stop after 100 m/a few minutes)</p>	<p>Grade 4 Very severe dyspnea till cannot leave the house</p>
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Image: <https://medicalrojak.wordpress.com/2015/09/30/modified-medical-research-council-mmrc-dyspnea-scale-illustrated/>

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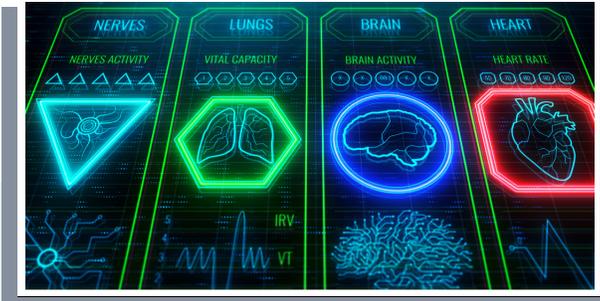
Risk of Pulmonary Embolism

Features	Score (points)
Clinical signs and symptoms of DVT	3.0
No alternative diagnosis	3.0
Heart rate >100 beats/min	1.5
Immobilization ≥ 3 days or surgery in the previous 4 weeks	1.5
Previous DVT or PE	1.5
Hemoptysis	1.0
Malignancy with active treatment in the past 6 months or under palliative care	1.0
Pretest clinical probability	
PE unlikely	≤ 4.0
PE likely	>4.0

PE = Pulmonary embolism, DVT = Deep vein thrombosis

https://www.researchgate.net/figure/Modified-Wells-criteria_tbl1_309719130

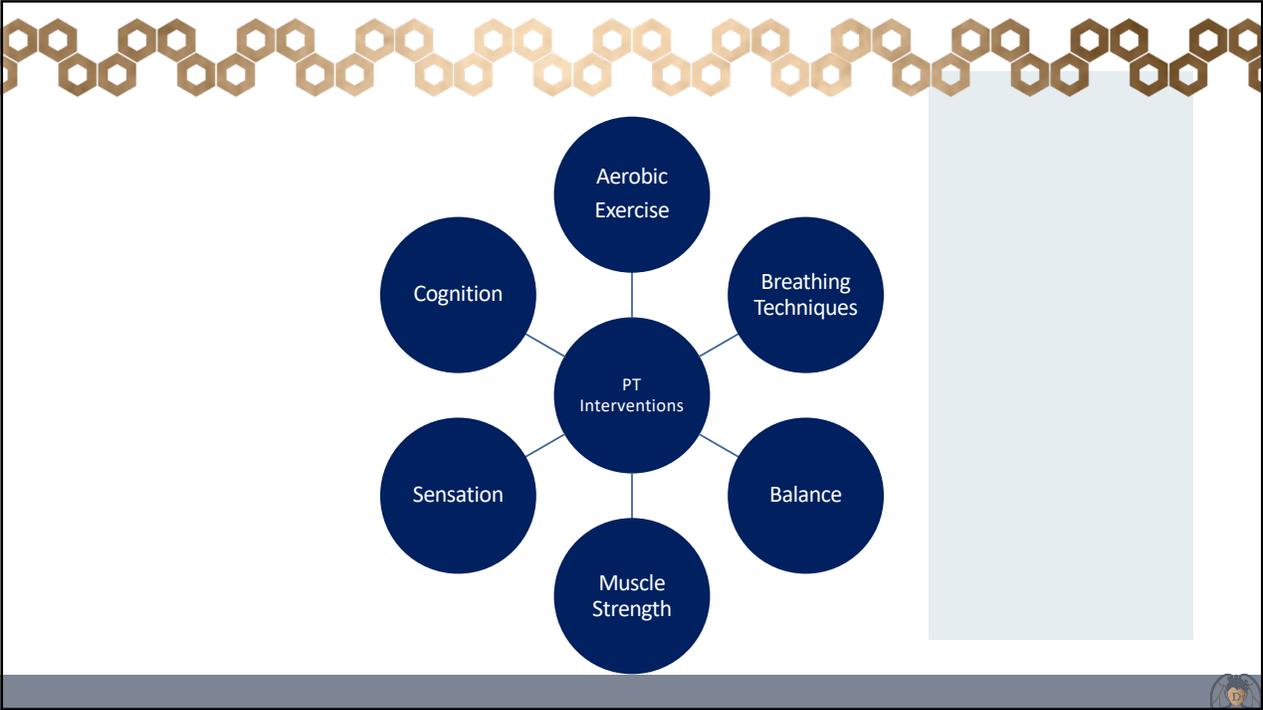
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Cardiovascular and Pulmonary Treatment

Aerobic Training
Breathing Techniques

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F.I.T.T. Principles for Aerobic Exercise – Inpatient



- F: 2-4x / day for the first 3 days
- I: RPE = 13/20
- T: begin with 3 – 5 minute bouts, increasing duration
- T: Walking

PresenterMedia

Strength training may need to precede aerobic training.
 When continuous exercise duration = 10-15 minutes, increase intensity as tolerated within recommended RPE and HR limits.

ACSM, 9th edition.
 Image: www.presentermedia.com.

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F.I.T.T. Principles for Aerobic Exercise – Outpatient



- F: 3-5x / wk
- I: 40 – 80% of heart rate reserve, RPE = 11-16/20
- T: 20 – 60 minutes / session
- T: Involvement of large muscle groups

PresenterMedia

After a cardiac related event, patients may begin with 5' - 10' of aerobic conditioning with a gradual increase of aerobic exercise time of 1' - 5' / session or an increase in time per session of 10% - 20% / week.

ACSM, 9th edition.
 Image: www.presentermedia.com.

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Diaphragmatic Breathing

- Main inspiratory muscle
- Core muscle
 - Pressure regulator between thoracic and abdominal cavities
 - Helps expel vomit, feces, urine
 - Prevents acid reflux



Image: https://en.wikipedia.org/wiki/Thoracic_diaphragm#/media/File:3D_Medical_Animation_Diaphragm_Structure.jpg

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Diaphragmatic Breathing

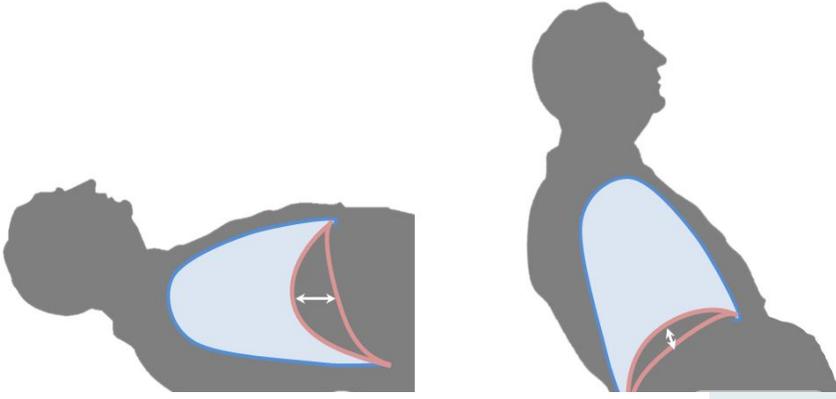


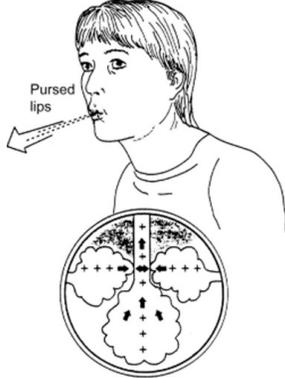
Image: <https://derangedphysiology.com/main/required-reading/neurology-and-neurosurgery/Chapter%20202.1.0/physiological-consequences-spinal-cord-transection>

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Pursed Lip Breathing

>> Improves SpO₂ by

- Increasing alveolar ventilation
- Increasing tidal volume
- Reducing respiratory rate
- Slowing expiratory flow
- Improves CO₂ removal



Hillebrand, 4th edition.
 Image: <https://basicmedicalkey.com/chest-inspection-palpation-and-percussion/>

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Take Home Points

- SARS-CoV-2 is a multi-system disease with the potential for extensive cardiovascular and pulmonary involvement.
- Medical management of SARS-CoV-2 can lead to cardiovascular, pulmonary, neurological, and musculoskeletal deficits.
- A thorough subjective intake and objective examination must be performed to accurately identify signs and symptoms of PICS.
- Physical therapy treatment should include aerobic training, as well as interventions to improve ventilation.



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See slides for additional references.



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