My Patient Is on a Ventilator! Now What?

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- [Calista] Our course title today is "My Patient is on a Ventilator. "Now what?" It is my pleasure to welcome Kreek't Rebano to physicaltherapy.com. Kreek't is primarily a hospital based physical therapist with a clinical focus on critical care, currently specializing in cardiopulmonary therapies. She received her bachelor's in physical therapy in 1998 and she's a foreign trained PT with overseas experience in the Philippines serving medically underserved communities in spinal cord injuries, cardiac rehab and pediatric oncology rehab. And also instructional experience in school settings for children with disabilities and special needs. She has developed ICU curriculum and competencies for training therapists at St. Mary's Medical Center in San Francisco, which include an introduction to the ICU setting, patients on life support devices and rhythm analysis to expand on developing early mobilization programs. Providing strategies for multiple interdisciplinary positions and follow up for the critical ill patient and the therapist involved in their care. Well, thank you so much for presenting for us today Kreek't and at this time I'm gonna turn the microphone and the classroom over to you.

- [Kreek't] Thank you Calista and welcome everyone. Thank you physicaltherapy.com for this opportunity to share with you all. My aim today is to make this session connecting, fun and immediately useful to you when you return to work. My email is listed at the bottom for any questions you have at the end of this seminar, and I'll do my best to get back to you. Some of the information like lab values, normal values I will mention along the way and they may not be printed on the slides, but you will have a chance to jot things down and kind of work it into your memory. So, the focus of this presentation is on the adult population and any other information you'll need you can study and look up if you work with more in the ped settings for the lab values and the normal values for that population. So, consider this very common scenario. So, you're working with a patient one day and then the next morning you find them not only admitted to the ICU because of an event that transpired the night before, but they are on a ventilator. So, our treatment doesn't just end because of that change. So, how do we go from there? This is the now what part of this series. So we are going to go over some of the learning outcomes. After this course, participants will be able to differentiate between non-invasive and invasive mechanical ventilation. Identify at least three ventilator modes in settings, list at least two mechanical ventilation parameters for monitoring oxygenation and hint, there's only two. List two mechanical ventilation parameters for monitoring ventilation, list at least five precautions when working with patients requiring mechanical ventilation. List at least five contraindications to mobilizing patients requiring mechanical ventilation and one to two exceptions. Accurately identify four elements or factors determining readiness for weaning, list at least three reasons why weaning failure occurs, describe the mechanics of respiration, respiratory control and respiratory distress, and list at least three ventilatory strategies for each. Restrictive support or obstructive support. So, I've grouped these learning outcomes into four main objectives for you guys. So, I want you to think of it in terms of what's in it for me? So, after this course, I want you to be able to explain the process and function of breathing, explain how mechanical ventilation works, decide on the best interventions for your patient, and assess your patient's potential to come off mechanical ventilation. I recommend that as you figure out some of the answers to these objectives, go ahead and write them down. It's a good review for you and it helps you kind of work what you can actually remember from the webinar. Now, this is an introductory class. So you're going to go over mechanical ventilation basics, which will include monitoring parameters to guide us in our interventions, as well as some basic anatomy and functional physiology. So this may be a review for a lot of you, but if you have never worked with a patient on a ventilator, I hope that you can take away points to use when you have your first patient. So, let's get to it. Here we have a set of patient vital signs. And because we are so familiar with these numbers, we know at first glance what these numbers represent. So we know that we have blood pressure, heart rate, respiratory rate and saturation levels. Inspecting further we can see that both these vitals are representing normal limits or functional limits or they're within normal parameters. Not too high, not too low. Just right for our patients. But what if I tell you that in order to maintain their vitals, the second patient, the patient on the right is on high dose pressors? They're on an external pacer, they are intubated and they are requiring an Fi02 of 80%. It doesn't seem so normal after all. On the one hand you'll have a patient that looks like this. The chances are our patient who's on the ICU requiring all the support is probably gonna look more like this. So, most of us know the therapy portion in our sessions, and we understand how these vitals represent the changes that are happening when we work with patients and we use these vital signs to help us decide on whether we're gonna terminate the session, or we're going to continue and progress with our patients. And though observing the patient is still the most important aspect in your session, regardless of what these numbers are showing, understanding the values presented by the monitoring systems can give us more information on how our patient is responding to the treatment. So, at the end of the webinar, on top of these vital signs I would like you to also be able to at a glance identify what you are looking at on a ventilator, and understand what those numbers you see mean and how to use those numbers in your treatment session. So just like learning a new sport, we want to understand the mechanics. We need to understand the language. So the language that we will use today is going to refer to important concepts and ideas for respiration and mechanical ventilation. So, write down the terms. Write down the calculation formulas. Write them down in your own words so you can grasp what they mean to you. So when you understand these terms, you'll have also just a better understanding of what's being described as far as the status of your patient is concerned when you're reading the chart, and before you even see the patient, you'll have an idea of what to expect as far as how they maybe are going to look like or how they are going to function. So let's talk about respiration. In pulmonary physiology, respiration refers to the body's ability to exchange gases. So, we use oxygen to provide sustenance to the tissues and we blow off carbon dioxide because it's a waste bi-product of that energy being used. We oxygenate by bringing oxygen to the tissues again, and we ventilate by releasing carbon dioxide. Under normal conditions the average adult takes about 12 to 15 breaths a minute to sustain both oxygenation and ventilation. In mechanical ventilation and in respiration in general, one breath is equal to one respiratory cycle. One respiratory cycle consists of one inspiration and one expiration. So these two have to occur to be considered one breath. Now how do we oxygenate? Oxygenation is a function of inspiration. Normal relaxed inspiration is an active process. Here we have a picture of a diaphragm and your lungs, schematic. But what happens is the diaphragm descends, generating negative pressure in the lungs, increasing the volume in the lungs, which then allows the oxygen to flow in. So what happens actually is when you increase volume in any object, the pressure inside it decreases. And atmospheric air has higher pressure then the pressure in our lungs, but because we reduce the pressure in the lungs, atmospheric air can now flow into the lungs. So that essentially is what is happening when we inspire. Ventilation is a function of expiration. So every time we exhale or every time we expire, we are ventilating. Normal relaxed expiration as you already know is a passive process. What happens is the diaphragm relaxes, and this relaxation places positive pressure around the lungs. So not inside the lungs but outside the lungs but this allows the lungs to recoil, and push out the carbon dioxide. Now the reason I make an emphasis on normal respiration mechanics is because in mechanical ventilation, we are not providing negative pressure. We used to in the form of the iron lungs back in the 60's, at the polio epidemic but those iron lungs, they just did not allow patients to move or mobilize and they were too bulky and very difficult to assess the patients when using them. So, modern day mechanical ventilation actually provides positive pressure to the lungs and this interferes with the physiological principles of breathing. So, you can imagine if you normally inhale by providing negative pressure with your diaphragm working, and now you are on positive pressure or they're pushing air into your lungs, it doesn't really allow your diaphragm to work. So, prolonged mechanical ventilation can lead to deficits in the diaphragm and other systems that function differently from the way you're being provided support. The ability of the lung to stretch is called compliance. So when you inhale, you wanna make sure that your lung tissues can't stretch enough to allow the oxygen to come in. Compliance so you can remember, can the lungs follow what you're asking them to do? Can they comply with the breathing requirement? Excuse me. So low compliance means that the lungs cannot stretch well. So think of like when you were blowing into a thick balloon, it can sometimes be very difficult to inflate it. In the lungs, this happens when you have fibrosis or scarring. The lung condition is restrictive. It doesn't allow the lungs to stretch. So, it's thick and stiff. So that's what we call low compliance, it doesn't stretch enough. On the other hand, high compliance means that the lungs stretch out so much, like when you're blowing into a grocery bag. You blow into a grocery bag very easy but it kind of stays open more than you'd like it to. So, although it may seem good that you can oxygenate better, considering that you can expand the lungs better, it's not elastic enough to recoil. So the lungs stay open and then what happens is you run into problems with pushing that air out or ventilating and this is a common issue that you see when you have patients with emphysema. So thy can get the air in, but they can't really push the air out. That's that, okay. Let's move on. The function of respiration is controlled by a number of systems. You have your nervous system which essentially is programmed to dictate and mandate your breathing. It contains receptors and effectors to communicate with your body. The ability of your body to transmit information to and from your muscles is a function of your muscular system and then your musculoskeletal integrity is the ability of your skeleton and muscles to both protect and allow movement of your lungs within your thorax. Moving gases in and out of your environment also requires clear airways. And then the lung tissues must be viable to be able to collect these gas products. And because the heart and lungs are so closely intertwined, you need a patent vessel system to facilitate the gas exchange from the actual lungs to your tissues. So, your cardiovascular system, your heart and your vessels, they are your transportation system. So your lungs take the air in, the gases in, and your blood transports this oxygen and carbon dioxide. Excuse me. Okay, let's... So, what happens when one or more of these systems fail? And it cannot be corrected. It will eventually lead into system failure. Or organ failure and even death.

Even though mechanical ventilation is life support, it is generally meant to be temporary. Usually it's a bridge to allow the systems, the body systems to heal and recover, but it is not a guarantee that the patient can or will survive. So we're gonna go over the control centers which we discussed earlier. Your neural system, musculoskeletal integrity, your cardiovascular system. Go over them so we understand a little bit more of the way these function to bring oxygenation and ventilation into our bodies. Here is the sagittal section of your brain, and I've highlighted the parts of the brain that influence breathing. We're gonna work our way from the bottom up. The medulla is in the teal, oh, I don't have an arrow. The medulla in the green is, actually, number three, is actually your primary respiratory control center. It is here where the signals for breathing occurs, so you automatically breathe and you breathe in a rhythmic pattern because your medulla is intact. And the way to remember this is you have that drum and you have that clap. Think about your patients that have brain stem strokes or injuries where their automatic, involuntary and continuous control of breathing is impaired. So, there is a drive issue that is involved with these patients that have these injuries. The pons, number two, the yellow one, it smooths out the pattern of your breathing. This is actually your pneumotaxic center. So what it does is it has the receptors from your lungs that communicate with this part of your brain stem and this pons sends impulses to maintain the repository of your breathing. So, inspiration, expiration. It controls that portion of the breathing. We will talk about some of these refluxes in a bit but I placed a ballon there because, the inflation of the lung and how the body protects itself from over inflating is a function of your pons. Your pons is also responsible for adjusting your respiratory rate and your depth of breathing via metabolic control. What that means is it responds to changes in the amount of chemicals in your body such as specifically your carbon dioxide and oxygen in your blood. And then the cortex, the number one, the very top which is in gray, it is responsible for voluntary ventilation changes. So your breathing can generally change in response to emotions, exercise or activity, sometimes even pain and body temperature. As therapists we can primarily influence this part of the breathing cycle by altering the breathing pattern through self awareness and exertion of will such as when we instruct our patients to do for instance, pursed lip breathing maneuvers or slowing down their breathing rate. Metabolic control occurs in response to the chemical changes in the tissues, excuse me, blood and CSF, cerebral spinal fluid. So, you have chemoreceptors in your body. These are specialized sensory cells which convert chemical substances and they make a signal to transmit information to the brain. A great example of this in your body are your taste buds. You detect a taste, it sends out that information to the brain, and it makes you decide if you're going to continue tasting this item or you have to spit it out. In the respiratory system you primarily have two centers. You have your central chemoreceptors, which are present in your brain, in your mid brain, and you have your peripheral chemoreceptors which are present in your vessel system. It's around your aortic arch and in your corroded arteries. So these chemoreceptors are responsible for detecting toxins or hazardous chemicals and they tell the nervous system, hey, hey, you gotta get rid of this stuff, right? For example, when you exercise your body generally demands more oxygen, produces carbon dioxide as a waste. The increase in the carbon dioxide levels are picked up by your central chemoreceptors which are in your mid brain, and your peripheral chemoreceptors which are in your arterial system. These receptors send messages to a respiratory center to enable the body to clear itself of carbon dioxide. But they do have slightly different mechanisms. Your central chemoreceptors on your left are located on the ventral surface on your medulla and marked with an X here on this image. They're sensitive to changes in your blood acidity and increased carbon dioxide. But these chemoreceptors in the brain, they desensitize over time. So when you have patients that have chronic conditions where they continually retain carbon dioxide, at some point it doesn't tell the body to increase the rate of breathing or increase the depth of breathing which is essentially increasing your ventilation. Your peripheral chemoreceptors on the other side detect changes in blood oxygen again and carbon dioxide. So, your corroded bodies are very sensitive to hypoxemia. So this is when you have partial pressures of oxygen below 100 and to drops in pH or acidity level of your blood. These receptors, they don't desensitize, however their effect on the ventilation or again, the rate of breathing and the depth of breathing effect on changes in that aspect is a lot less then those with the central chemoreceptors. And then we have your reflexive responses. Most of these responses are protective such as coughing when an irritant enters your airways. Now if you remember the balloon in the pneumotaxic response, that is mitigated by your pons, we'll go over it a little bit so we can describe these Hering-Breuer reflexes over here. Et cetera. Okay. Your, let's see. So when you blow up a balloon, you blow and blow, at some point it's gonna have a resistive quality that lets you know that if you keep blowing, it's gonna burst and that makes you decide if you're gonna keep blowing anyway until it bursts or you're gonna stop because you've kind of filled the balloon to its limit. Your lungs has a mechanism called the Hering-Breuer reflex. What it does is when your lungs have inflated, it's gonna stretch to a point where these receptors are gonna let the brain know, oh, you're inflating a lot. We gotta stop now and then it's gonna trigger the pons to initiate deflation. On the other hand when you're not breathing enough, it tells the brain wait a minute, we've been deflated for a long time. I think it's time to stretch out and get some air in our lungs. So this Hering-Breuer reflex or the reflex of like preventing over inflation, it's not so much a problem on sea level because atmospheric pressure is usually higher. But scuba divers or people that work under water a lot that, or receive compressed air, if they have damage through their receptors, this can actually cause damage to the lungs because they'll over inflate and the lungs don't have the capacity to, or to tell the brain that hey, you're putting too much air in. So a little trivia for you. The absence of the Hering-Breuer reflex actually contributes to the diagnosis of brain death. So, there's another set of receptors in your lungs which are very close to your alveoli. They're called j-receptors because they're juxtaposed. They're just right beside them. And studies show that even low volumes of stretching these alveoli can actually facilitate an inspiratory response. So you stretch the alveoli a little bit and the lungs say, oh, oh, we gotta take a breath. And it facilitates inspiration, and this is especially true when people have apnea. It's also one of the basis for providing artificial air or probably pressured air in either a code situation or when people are, have sleep apnea. And here are some general conditions that can cause respiratory insult. From a functional standpoint, we characterize these diseases as being obstructive, or resistive in nature. So we'll go a little bit more in depth regarding this. On the left side of the screen we see asthma, bronchitis and emphysema. By looking at the pictures you can kind of already tell that there's going to be restrictive of the airways. The airways are smaller, the airways are tighter. In asthma you have your smooth muscles that constrict as a protective response, and then of course it tightens the airways, limits the influx and outflow of air. So with asthma you can have a problem with getting oxygen in and you'll definitely have a problem with getting the carbon dioxide out. In bronchitis again, you have the airways tight, but this time it's the inflammation of your airway linings that tightens the airways. And mucus glands, they over produce mucus and again this contributes to constricting the airway. And emphysema, you can see here are these two examples. The one on the left is like normal lungs, and the one on the right side is a patient with emphysema. You'll see that you have a break down of your alveolar walls. So imagine on the left each alveoli has a capacity to disperse gas around its perimeter. So that whole circle, blood can flow, gas can flow to the vessels throughout that entire circle. The pressure gets inside and allows the gases to push through. But on the right side, what happens is the walls are broken down so you have essentially just one big bubble, and imagine that the pressure inside it, because the volume is bigger, the pressure is less. So not only does it not push the gas into the vessels well, but it also has less surface to actually collect the gas to bring to the vessels. On medical exams, these are the patients who present with a lot of air trapping. So they probably have very large, round chests, they have enlarged lungs and chest x-ray, and they generally have higher levels of carbon dioxide in their system. Sometimes in fact, these lungs, they stretch out so much they form what's called a bulla which is kind of just a big bubble and these bullae, they can burst causing what they call spontaneous pneumothorax. Spontaneous pneumohemothorax. So, one of the ways that I do so I can remember this is it's called an obstructive disease because it obstructs the outflow of air. So, O and O. Obstructive outflows, make it easy to remember. Now on the right side of the screen, we look a little bit more at restrictive conditions. Now, restrictive is because the lungs can't stretch, they can't comply. There's low compliance. The lungs can't stretch enough to fill and as you can already tell, if you can't expand or inspire enough, chances are you can't oxygenate well. In pneumonia or pulmonary edema, or even pulmonary hemorrhage, what happens is you have fluid collection inside the alveoli. So oxygen can't get through to the vessels and carbon dioxide can't get out. And you can have problems with both oxygenation and ventilation. In pleural effusion, the lungs can't expand because there is pressure around the lungs within the thoracic cavity. So it's within your pleural cavity. Because there's only so much space that occupies that it puts pressure in the lungs and again you run into not being able to expand and get oxygen in. Okay, let's see. Okay. So pneumothorax is also, pneumothorax also occupies the pleural space as you can see. But usually it does so in the form of the air. So air, fluid or blood again, like anything occupies the pleural space will prevent expansion of the lung. So, the interesting thing about these two conditions, although they both have fluid restricting the expansion, in pleural effusion it kind of acts like water in a water bottle. If your water bottle is upright, the water stays at the bottom. Then if you tip the water bottle to the side, it occupies kind of halfway of the bottle up to where the water line fills it. So, when you're managing patients with pleural effusion, a lotta times positioning will be a key factor. So you can move the fluid around the cavity and then allow other parts of the lung to expand with your breathing recruitment strategies. When there's of course a lot of fluid in the cavity there's just no way to push that fluid out, they do a medical procedure called a thoracentesis. So they come in with a needle, they aspirate and they pull out all that extra fluid. But you can't do this with alveoli. If you go back to the pneumonia and pulmonary edema picture above. You can't just puncture that alveoli and try to pull out the fluid. So what happens is when there's gas inside this alveoli, or this alvelous, I guess singular, it's exerting continual pressure against the entire alveolar wall. So that fluid is not sitting down. Apologize for that one. The fluid is not sitting down just at the bottom of the alveoli like that. Just a second. I'm gonna turn off some of these. So, what happens is positioning may affect some change most likely to relieve breathlessness, but what you need to do instead is allow more air to come into that alveoli, to pop it open. So when you stretch that alveoli out, it's going to recoil and kinda stretch back and push the fluid out along with the exhaled gases and this is kind of an effect you get when you do all your deep breathing exercises, and follow them with a cough. And then another point to note. As far as the pneumothorax is concerned or hydrothorax or hemathorax, between fluids and gases, air always rises above. So when you have air in the lungs, chances are they're gonna be situated higher up towards the apex of the lung, and this is why you have chest tubes that are higher up on the chest versus water, blood or other fluids that tend to stay towards the bottom part of the lungs like when you have the pleural effusion. And positioning again will be important if you wanna manage the compliance or recruit compliance when you work with these patients. Other issues that can cause respiratory problems would be here on the left side. You have fibrosis where you have scars that form at that alveolar level. So what happens is the alveoli, a portion of the alveoli or the entire alveoli, they're not gonna stretch. So, not only can they not get oxygen in, but they also don't allow gas to push through from the alveoli to the blood vessels. And you're probably gonna see patients who are tachypneic. They're gonna be very short of breath and they will have low oxygen saturation levels. And the same thing occurs with anything that causes an infectious or inflammatory response that thickens the lung tissues such as an interstitial lung disease here at the bottom left side of your screen. And then you also have the circulatory transportation standpoint where you have a clot like in pulmonary embolism there on the left side. So what happens when you have the clot there, blood doesn't flow to the rest of the tiny vessels, the arterials, and it doesn't allow to pick up the gases from the lungs. So, you could have a well functioning lung, but the transportation system is whack so it's, you're gonna get oxygen in but you're not gonna get it into the tissue. So there's no diffusion that's going to occur. You can also have respiratory issues from circulation deficits related to pulmonary hypertension where your pulmonary artery has thick vessel walls. It's very tight. It doesn't just allow the blood flow to flow smoothly into the alveoli. So again, blood flow is very slow to come around to the alveoli or not at all. And then from other issues that can cause respiratory insults would be maybe neuromuscular disease where you actually have muscles that don't function. There is a little picture of a diaphragm at the bottom there. So, the diaphragm doesn't work so you can't expand properly. You're gonna use all your other muscles which contribute to your work of breathing and fatigue for your patients. You can have tumors taking up space or trauma like burns or vehicle accidents puncturing the lung. You can have chemical inhalation injuries like smoke, carbon monoxide, even drowning. And sometimes also your lungs can get effected by medications that impair your respiratory drive such as your patients that are on heavy sedatives or they're on a lot of opioids or anesthetics or they've overdosed on other medications or they do substance abuse. So, all these conditions can cause respiratory distress and if that's not corrected, ultimately it's going to lead to respiratory failure. So what's the difference between each? So, respiratory distress is when your patient is maintaining respiration only by increased work of breathing. So what happens is they either maintain oxygenation, or they maintain ventilation or both only because they're working really hard to breathe. So, it's compensatory, right? And the body attempts to correct the problem. But what happened is when the work of breathing is sustained only to meet like the minimum level for balance, it's not gonna be sustainable right? It's only gonna be awhile before something fails or something corrects. So again, that's called respiratory distress. If compensatory efforts don't correct anything, it's not sufficient, the patients, they go into respiratory failure. So on the left side here is a picture of a patient in distress. This is mostly the signs, kind of classic signs you would see. They would maybe look pale. They can be agitated or have mental status changes. Their noses are flaring. They're maybe pursed lip breathing or wheezing, they're definitely tachypneic, definitely tachycardic, and they could have delayed cap re-fall. That's the CR down there. In respiratory failure they may not even be responding anymore or they would like they're just hungry for air. Their respiratory rates could be like extremely high or extremely low and they're probably gonna start looking blue. Mottling is a condition you see on the skin where you kind of see patches of discoloration and that's a sign that ischemia is developing in the tissues. And mechanical ventilation can actually occur at any point along this pathway. So, they can jump in and provide support either when a patient is in distress to prevent the failure, or when the patient has already gone into respiratory failure. In clinical trials, respiratory failure is generally triad of tachypnea, abnormal gases and increased work of breathing. So, those three coming together like all at once, chances are your patient is gonna go into respiratory failure or they are in respiratory failure. And mechanical ventilation management is usually related to one of two things or both. Is the patient hypoxemic? And do we need to provide oxygenation? Is the patient hypercarbic and do we need to provide ventilation? So in the pictures up there you see oxygen's not really coming in or oxygen is flowing in but it's not going into the tissues. And on the other hand you can see that carbon dioxide is not blowing off or exiting the body or carbon dioxide is just in the tissues and it can get to the lungs to be released into the environment. So there are a number of tests that are done to kind of identify if your patient is more hypoxemic or more hypercarbic. Most of these tests are done rapidly in the emergency department or upon admission to the ICU. Particularly your blood gases and we'll go over them a little more. So if your patient is a frequent flyer or a repeat offender, you see them, excuse me, showing up at your hospital every other week, chances are they've already had a pulmonary function test and it's generally a test to see how well your lungs are working. They measure your lung volumes, capacity, flow rates and general ability to get fast in and out of your environment. It'll also give you a history if your patient has a restrictive or an obstructive lung disease. A V/Q scan which stands for ventilation or profusion, examines the airflow from your lungs, in and out of your lungs and the blood flow in and out of your lungs to the vessels. So what happens is this used to be the way they would rule out or diagnose a pulmonary embolism, but it's not as frequently used because the chest is CT scanned is a more accurate diagnostic test. And then, let's see. Okay. And then of course your arterial blood gases. So this essentially tests how well your lungs are actually moving oxygen and carbon dioxide in your blood. It's a measure of how your lungs are oxygenating your tissues and how they're ventilating your tissues essentially, okay? So, always going back to those terms because it's very important concepts. 02 or partial pressure of arterial oxygen is a measure of the oxygen content in your arterial blood. And C02 or partial pressure of arterial aid for arterial. Carbon dioxide is a measure of carbon dioxide in your arterial blood. Excuse me a second. Okay, so gases exert pressure against your alveolar wall, so that it has a capacity to push through the lungs and into your vessels, okay? So from the lungs it pushes from the alveoli to the vessels, and from the vessels it pushes from the vessel back to the alveoli. And this process is called diffusion. So moving those gases to and from the lung walls to your vessels, okay? Your transportation system. And generally whichever of the gas has the higher pressure, is the one that's gonna allow the diffusion in the direction of that gas. So, there are standard values for partial pressures of oxygen and carbon dioxide, but a good rule of thumb is to remember 50/50. So we want oxygen pressures to be above 50 millimeters mercury, and you want carbon dioxide measures to be less than 50. So, if your oxygen levels, if your oxygen measures are less than 50, generally you are hypoxemic, and if your carbon dioxide measures are above 50, then you are hypercarbic. So normal 02 is about 90 to 100 millimeters mercury. An oxygen saturation level which we measure with our pulse ox's of about 90% corresponds to a 02 of about 60 millimeters mercury which is the minimum oxygen concentration required to prevent ischemia to the tissues. So, mechanical ventilation also, diseases are categorized into either an airway or an alveolar disease. So we're gonna go over the respiratory unit and it's function. The respiratory unit is where your actual gas exchange takes place. Before getting there the gas needs to be transported by your conducting zones. So you have your trachea breaks down into your bronchi and then the bronchi break down into small bronchiales up to like 24th generation. So they're really, really tiny. And then what happens is the end of these bronchiales has a little conversion. So you have the conducting zone, which is your terminal bronchiales, your smooth muscles around the bronchiales, and then your ciliated epithelium. So, this area that has cilia is also the area that has mucus and this is the part of your airway that you manage so that you can push out secretions. But after this what happens is that terminal bronchial kind of converts itself into a respiratory portion. So, the lining of your respiratory bronchiales already starts with surfactant and I'll explain what surfactant is later. And what happens is these respiratory or terminal bronchiales, they expand, they kinda evaginate and they open up and then these are the ones that form your alveoli. So, each of your alveoli are surrounded by very dense capillary beds. So you have your transportation system. Let's take a closer look at this alveolus. So here you have a picture of an alveolus. You have your capillary bed which consists of your arterials and your venules. And again, your arterials carry oxygenated red blood cells, and your venules carry deoxygenated red blood cells. You see the lining of the alveoli with surfactant. Surfactant is a compound that alters the surface tension between gas and liquid. So, normally gas and liquid, they don't mix. That's why when you have a glass of water and you, or you have a balloon and you put a little bit of water in there and you blow into the balloon you can blow into the balloon and the water just kinda stays in there right? But in the lungs we have to kinda mix this gas into liquid so that it can be carried through the alveolar wall into the vessels. And the surfactant is what does that. It mixes it so to speak. So now you have your gas mixed with your blood so it goes into the tissues, 'kay? So the air that we inhale is a combination of a bunch of gases but what's important for our respiration is oxygen and nitrogen. At sea level, oxygen concentration is about 21%. So this is your room air oxygen level. It's less at higher altitudes. So the higher you are up in the mountains or when you're in, flying, it's lower. So 21% of oxygen concentration, and then while nitrogen concentration's about 78%. So that's a big amount of nitrogen in the air that we breathe in. When we breathe in, oxygen and nitrogen come in. Nitrogen exerts a force against the alveolar walls to keep them open. By keeping the alveolar walls open, it allows oxygen to diffuse into the capillary bed to be taken up by the tissues, at the same time allowing carbon dioxide to diffuse out. So, this opening of the alveoli is very important for oxygenation. And so we will go over that now. The process of oxygenating or increasing oxygen occurs in two ways. One, we can increase the percentage of pure oxygen that your patient is breathing in. So you have here on the left, this is your oxygen content, we increase it, right? Just provide more pure oxygen. And then the other way to do it is to increase the pressure against the alveolar walls to keep the alveoli open. So more pressure keeps that alveoli popped open more or longer. And this allows oxygen to diffuse into the tissues. Now in mechanical ventilation, we know more oxygen concentration as increased fraction of inspired oxygen, and keeping our alveoli open for longer is also called your increased positive end-expiratory pressure. Okay? Or increased PEEP. That's how we provide oxygenation. Of course like with anything, oxygen is also considered a drug. And like with many drugs you can have adverse effects if this is given in excess. Sometimes when there is too much oxygen, what happens is it washes out the nitrogen. Remember oxygen's exert gases, right? And so just more oxygen there is gonna pop that alveoli really open and it's gonna push the nitrogen out. Now what happens is the alveoli can collapse, and this is actually a condition we know as absorption atelectasis if you've heard this before. And then also excessive oxygen can be very harmful to the organs. You can have tissue destruction from what we call oxygen toxicity. So, oxygen molecules, a lot of them as you know they, electrons come in pairs in your molecules, right? But what happens is when you have so much oxygen, sometimes these oxygen molecules, they split, and when they split they don't have a twin, they don't have a pair. So what they're gonna do is they're gonna try and find other molecules and try to bond with those molecules and what happens is they stress out those other cells and then they damage them. So, think of oxygen destruction in this way. So, if you have a potato sack race, which requires a pair to play, so you got two people per sack to play, and you have an extra person who doesn't have a partner, but they're pushing themselves to join in the race so they jump in with someone in someone else's pair and they put their leg in and they start hoppin' around, of course that's gonna cause problems for the initial players. But that extra person, think of that as an oxygen as a free radical. So it's very harmful to the game. Too much oxygen also has a lotta pressure, right? So it can exert, when your lungs are expanding so much, it can exert pressure on your vessels and cause your vessels to collapse. So you can see some patients that maybe have blood pressure issues, their blood pressures are so low they can't, blood doesn't push out well into their body 'cause there's just so much pressure in their lungs. Also a lot of oxygen in the body can produce a lot of carbon dioxide which causes a build up of CO2 and then you go into what's called an indirect carbon dioxide narcosis. So your patient starts having mental status changes, they can go again into respiratory distress trying to ventilate themselves, and eventually could get into respiratory failure.

So ventilation occurs in two ways. Every time, if you remember earlier I said, every time you exhale you ventilate, right? And there are two ways to ventilate. You either increase your depth of breathing , breathe deeper, get a bigger recoil and , push out more carbon dioxide. Or you inhale faster. So let's look at it the way it kind of works. So when you inhale, you expand the alveoli more, allow the recoil by increasing your depth of breathing, and then push out the carbon dioxide. The increase of that breathing and the expansion is actually called increasing your tidal volume, right? So if you're just breathing regular, like you're sitting there and you'll take a breath in and out, don't change anything. Just listen to my voice and breathe.

So that volume of air you just brought in is actually your tidal volume, okay? It's just your regular breathing in inspiration volume of air coming into your lungs. So, our lungs, they grow in proportion to our height. So the taller you are the bigger your lungs. The smaller you are, the shorter you are I mean, the smaller your lungs. In mechanical ventilation, they calculate tidal volume that they're giving to a patient based on the ideal body weight for their height and gender. So what happens, it doesn't matter if a five foot eight guy is 500 pounds, or a five foot eight guy is 100 pounds. They're gonna receive generally the same amount of tidal volume as a supplement when they're being taken care of. And generally they provide about six to eight milliliters, or six to eight mL of oxygen per kilogram of body weight. So, for a 65 kilogram male, on the lower end that may be about 319 mL of oxygen. And the higher end 520 mL of oxygen. So if they're not meeting these tidal volumes, they're probably not ventilating properly, okay?

So, let's go back. So again, ventilation is a function of your tidal volume or an increased depth of breathing, or you exhale, you release carbon dioxide, you exhale faster you exhale more carbon dioxide. Breathe faster, okay? Again, in mechanical ventilation, we call that as increasing your tidal volume or increasing your respiratory rate. So like with the dangers of too much oxygen, there are also dangers of too much carbon dioxide. We have to remember that carbon dioxide is a waste product. Too much waste accumulating in your body, it's not gonna allow your organs to function. So, there's more in depth physiology then I'd like to cover in the webinar, but we're gonna go through the basic concepts.

Too much carbon dioxide produces acidosis in your body. When you have a lot of acid in your blood, your cells, just they can't function, okay? The brain is sensitive to increases in carbon dioxide and what it's gonna do, carbon dioxide is gonna vasodilate your brain vessels and all that vasodilation increases blood flow, sometimes sudden blood flow, and that could put pressure on the brain, and you know what happens when you get pressure on the brain, right? Also, when you're hyperventilating you're blowing off a lotta carbon dioxide. Your body can kind of detect that as, oh, okay. We have a lotta carbon dioxide. Maybe if we're breathing in a lot of oxygen. So it's gonna slow down from the neural centers and it's going to exert kind of a depressed instruction for your breathing and that can slow down your breathing to a point where you're not even breathing enough to get oxygen. Okay, we finally get to this. So, key concepts in oxygen delivery. Mechanical ventilation is used to correct oxygenation, ventilation or both. Again, you know that there are many causes of oxygen or ventilation deficits, but the way to correct them is mechanical ventilation provides these things. So, one it provides positive pressure ventilation. So it pushes air into the system. There are two ways to do this. They do it by non-invasive methods versus invasive methods. So non-invasive, you're familiar with them. You have your bag-mask valve, artificial breaths when you're providing CPR. Oxygen delivery is a form of correcting oxygenation, right? So sometimes you have high flow nasal cannulas or nasal cannulas. In mechanical ventilation, high flow nasal cannula provides positive pressure by actually attempting to open up the alveoli by using a high flow or high push of air into your lungs. Your CPAP or your continuous positive airway pressure and your BPAP which is your bi-level, it's actually just, it's a closed circuit that allows six pressures to be delivered in and out of your patient, okay? It uses this through a mask. Now, invasive ventilation on the other hand, it follows the same thing. It's providing positive pressure ventilation, but it does so with airway adjuncts. So, they give artificial airway.

So that's really the basic thing. And there's two ways they do this. They generally provide it through intubation via endotracheal tube or ETT, or a tracheostomy tube by a TT, they put in a trach. So, aside from providing positive pressure ventilation, they use mechanical ventilation to provide either increased oxygen to the tissues, or deliver volume or pressure or even breaths to correct the problem. So, we're gonna focus on invasive mechanical ventilation in this webinar and managing your patients that are either on an ETT or a TT. Intubation is performed by a doctor to either open or maintain an airway.

So that medications, oxygen or breathing relief can be provided. Your patient is considered to be on prolonged intubation if they are intubated for more than seven days. So, if you look at the picture of the ETT on the left side, you see that the tube passes through the mouth in through the back of the throat and there's a little structure I labeled there called the epiglottis. The epiglottis is a very important structure that you use in the swallowing function. What it does is that structure drops and it seals off the airway while the vocal cords close so that you can have the food pass on to the stomach to the esophagus which is at the back, like posterior to the trachea. If you notice that the ETT tube, it actually passes through the larynx, okay? So it comes in through the voice box and then it gets what do you call it? Kind of planted there. A tracheostomy on the other hand is a surgical procedure. So what they do is they create a hole or a stoma just below the level of the larynx or the voice box, and they just hook in through your wind pipe. And sometimes they do this if intubation has been prolonged and they're not getting correction because they wanna minimize the damage to the throat structures and the airways. But sometimes also there could be so much damage in the oral and upper airway cavities. Maybe a bad accident or burns that close off everything and then they can't access with an ET tube. So, pay attention to these two airway adjuncts again.

Both of these tubes they terminate at the bifurcation of the trachea, which we call the carina. And if this is about that level of the angle of Louis. It's around the level of your fifth thoracic vertebrae. If you palpate your sternal notch, so find your clavicles, trace your clavicles over to the center when you get to the sternal notch. From your sternal notch about three finger breaths down, you're gonna find a bump which is where it connects to your breastbone, and that bump there is your angle of Louis. So, the end of your tracheal tube or your endotracheal tube, it actually, it stops there. This is the portion where your trachea splits into each bronchi to go to the lungs. So, one of the biggest precautions in working with patients that are on invasive mechanical ventilation, is it's the team's number one priority to prevent accidental extubation on a ETT or accidental decannulation if they're on a trach. You have to remember that when you're working with these patients you need a standby bag to provide ventilation if any of these come off, right? So that you can, provide emergency of resuscitative breathing. So, these two area adjuncts, they generally come with a cuff. The cuff is not so much to hold that tube in place, but it's really more to establish a closed system. So this way air doesn't travel around the tubes. It goes straight from the environment or from the machine into the lungs and back out. This way they can ensure that they can also provide direct measurements of volume and pressures when they are doing ventilator management. So, what are the advantages of a tracheal tube over a ETT? So, the biggest thing is that when patients are trached, they have the ability to perform speech and swallow functions. The trach allows for a protected airway, but it also opens up the rest of the orals and nasal structures for functional use. In fact, when patients are on an ET tube, there's really not a lot we can do in the area of swallowing, speech, maybe a little bit of breathing strategies, but we can't even do a cough because coughing requires a glottal closure and the ET tube just occupies that space. So the biggest thing we can do for patients that are on an ET tube is to actually get them mobilizing as soon as possible. Just get them to sit, get them to do some exercise.

Tell them to practice their breathing rates and just focusing on moving everything else. But with the trach, we can actually have a speech therapist work with your patients more and you can incorporate that into your sessions. So always good to identify the level of the voice box which is your larynx, right? Above the larynx is your upper airways, below the larynx are your lower airways. Your lower airways consist of your trachea, your bronchi your bronchiales and all the way down to your alveoli. Usually patients that are on a trach, if they're gonna be working on swallowing or speech functions, they place a Passy-Muir valve or a speaking valve. This has to occur with a deflated valve. So if this, the Passy-Muir valve is a one way valve.

It's going to allow air to come in, but it's gonna block any pressure or air coming out. So if that cuff is inflated, you're not gonna get any air up. It's just gonna come in and it's just gonna stay there. So here's an example of what happens when you breathe in, comes in through the valve, and when a patient exhales that gas, it passes through the voice box and then of course the voice box vibrating produces your speech. In a swallowing function, did you know that there are about 50 pairs of muscles required in swallowing? But don't ask me what they are 'cause I do not know. Do not know all of them, but again we have the larynx. Everything above the larynx is your upper airways. Your upper airways consist of your nasal cavity, your oral cavity, where they meet is called the pharynx, right? And again if you remember that picture initially of the epiglottis, I have a drawing of the epiglottis right there. So when you chew, yeah, when you chew, when you get food, you chew it. You create what's called a bolus. And this bolus is the structure that you swallow. When you swallow, this bolus comes in down through the pharynx and actually pushes down that epiglottis, which protects your airways and it allows that bolus to go on to the esophagus and into the stomach. If your epiglottis and your larynx are damaged during intubation, you can run into problems with swallowing. So, swallowing requires the epiglottis to close and also requires your larynx to close, so your voice box to close, right? So patient that have damage can have eventually recurring aspiration, and that's why they try to make sure that intubation is just, it's a very short time.

They generally try to intubate a patient for maybe no more than 48 to 72 hours and see if they can establish a correction through there. So, I also wanna talk about oxygen delivery. So, the oxygen that is released from the tank or the ventilator is always 100% oxygen. So, so you know, it's pure oxygen. Always 100% all the time. But the reason the percentage changes is relating to how much, number one, how much oxygen is required to maintain saturation? And then that oxygen concentration which is your Fi02 is determined by the flow. So how much oxygen is flowing to provide a tidal volume to inflate the lungs? And that's why you have different devices that provide different flow rates and different oxygen concentrations. So as you can see on this table, we have a sample of your sample devices, your nasal cannula, your simple mask, non re-breather mask, and those three on the top, if you notice they all have six liters per minute flow. Right? That means every minute six liters of oxygen is being pushed. But the corresponding fraction of inspired oxygen being delivered is different. So on an a nasal cannula six liters per minute is just about 40%. Simple mask 35 to 50%, and a non re-breather about 60%. So, what you want to remember in this, I'm gonna go to the next slide, is the more closed circuit your oxygen delivery system is, the more concentrated your oxygen delivery can occur, right? So you have your nasal cannula on the left, it pushes air through the cannula, but there's a lot of oxygen that kinda goes into the atmosphere too. Versus a non re-breather and versus a positive airway pressure device like your CPAP or BPAP. So, let's see. On the next slide here is an example of how oxygen's being delivered when your patient is on invasive mechanical ventilation.

So, when they're intubated they sometimes have what's called a T-piece. If they're breathing well and they just require airway support, either there's a lotta swelling there or they can't manage their secretions enough that they still need some support there, they have what's called a trach collar or a mist mask. And a trach collar is very similar to someone using a nasal cannula if they're not trached. And then of course, oops, sorry, and then of course you have the closed circuit on the right side when they're completely vented. The T-piece, sometimes it's used when your patients are intubated but they don't actually require ventilatory support just like your trach mask. So they just have the tube in place to help them breathe. But they're oxygenating or they're ventilating just fine.

No issues. A mist mask has humidified air because if you're directly inhaling through the trach, you actually bypass the nasal hairs that humidify the air that we breathe, and so if your airways are so dry it dries up your mucus lining and without mucus you can't push irritants out of your airway. So when you mobilize your patients, it is absolutely important that a respiratory therapist is present, or at least they are on standby and they are close to you, especially when you're gonna be moving these patients out of the room. The respiratory therapist will be responsible for performing any of your mechanical ventilator setting adjustments, to keep your patient comfortable and able to perform the tasks. They also will select appropriate O2 delivery devices and they can provide bronchodilator therapies to your patient. Communicate with your RT.

Chances are they're gonna be very willing to help you. They can also provide treatments before your session, and assist you with any needs in the event of a crisis. So, extra hands, always good. I'll talk about some points contraindications to mobilizing. This is a good list to start with. It's not complete but most of the times these are what you would see and just give you an idea if it's okay to work with your patient or not. Paralytics which are also called neuromuscular blocking agents usually have a drug name ending in ium, ium. So examples are atracurium, pancuronium, rocuronium. But they are a very potent muscle relaxants, and most of them are really used during surgery to prevent muscle movement or sudden reflexes. In mechanical ventilation they are sometimes used for your patients to allow patient ventilator synchrony.

So, sometimes if patients are so stressed or they're very sick and you're providing positive pressure ventilation and they're not breathing in tune with a ventilator, they're fighting the ventilator is what you would hear usually the team call this as. It doesn't allow the machine to do its work and the body doesn't allow the oxygenation or ventilation correction to occur. Sometimes they also use paralytics to allow damaged lungs to heal. So, when your muscles aren't demanding so much oxygen, there's no need for the lungs to kind of drive oxygen to the tissues.

So, paralytics are commonly used with very deep sedation, otherwise your patient is going to feel everything but they will not be able to move. Okay, so definitely you can't really work with patients that are like it's absolutely contraindication. Paralytics are also used in patients with acute respiratory distress syndrome but just for a short while. Usually about one to two days, and let's see. Oh here, so, nevermind. We'll keep going. So, here you can go ahead and read on the other contraindications to mobilizing, anything that I've marked with an asterisk, actually requires a team consult, okay? Some hospitals may allow for careful mobilization if you have an experienced therapist, even if your Fi02 requirements are beyond 60%. Even if your PEEP requirements are beyond 10 centimeters of water. Okay? So, generally at Fi02's of 60% or higher, you run the risk of having absorption atelectasis. And any PEEP requirements greater than 10 can run the risk of barotauma or your alveoli bursting because there's so much pressure. So, think about what high oxygenation requirements mean. Generally it means your patient is at risk for hypoxia. They don't have enough oxygen going to the tissues or the tissues are not accepting the oxygen that you are providing such as in the case of, circulatory insults. Sometimes though you might have patients who are on a pre-lung transplant program. They will definitely have oxygenation requirements way higher than these parameters, but it could be okay to work with them. So, again consult with your team. Another way to think about it is if you have a patient that's requiring high oxygen's to maintain saturation levels. So let's say their oxygen saturation is 90%, but to stay at 90% they are requiring 80% concentration. So if they de-saturate with activity, there's only 20% more oxygen you can provide to help them maintain sufficient oxygenation to their tissues.

So it's not a good thing. Okay, let's talk about modes. Mechanical ventilation has a lot of different modes and really this is the setting or the method of providing inspiration. So, a lotta times when someone's on mechanical ventilation it's because they're trying to get the inspiration to kick in. Again, remember inspiration, this is generally an active process but mechanical ventilation is trying to mimic that, however it's providing positive pressures. The terminology for classification of modes can vary based on the equipment but basic concepts really are this. Control means the ventilator does the work, right? A lotta times the breath is initiated by the machine. Assist is when your patient maybe tries to take a breath but it's not enough to meet a tidal volume or not enough to open the lungs. So, assist means the patient generally does some of the work and then the ventilator jumps in or takes over and usually it's done by one of two ways. It either delivers support by it providing more volume, or more pressure or it delivers a breath to maintain the set respiratory rate if the patient doesn't trigger the breath. In a spontaneous mode which we'll talk about in a bit, the ventilator is essentially on standby. So, it's just ready to jump in if the respiratory therapist switches it. So a spontaneous mode patient is doing all the work. Here's an example of which you can see when your patient is on a ventilator. Let's go over what you're looking at. The top bar where you see the green C, 30, 15, 10, 1.27, 18, this top bar represents actually what the patient is achieving or doing. The bottom area where you see this blue screen, AC, VC, it tells you what the ventilator settings are. Now the respiratory therapists together with the pulmonologist or your intensivist, they're gonna place the settings determined by the minimum requirements for the patient to achieve oxygenation and ventilation or both, right? The initial settings are based on the patient's blood gas status.

And what they're gonna do is they're gonna provide these settings and then wait 30 minutes and they repeat the blood draw to see if the settings are correcting the problem. The area with the big letter tells you if within a breathing cycle, inhalation, exhalation, again, inspiration is provided by the ventilator, and expiration is just allowed to recoil like normal. So, the C tells you that at that point in the breathing cycle, the ventilator took over for the breath. If you see an A usually the ventilator assists it. The patient's current respiratory rate is designated by the F which means frequency on the machine. F total is total respiratory rate, and it says it's currently set to 18. The currently delivered fraction of inspired oxygen is 50% and the current PEEP setting is 10 centimeters of water.

So, if you remember what increasing oxygenation and increasing alveolar opening are for, this is your oxygenation correction. When working with your patients, you'll wanna check that the settings are sufficient to have them maintain their oxygen saturation levels with activity. What that means is you monitor their oxygen saturation levels. Use the pulse ox. See if they're maintaining the saturation levels that are dictated by the team. Generally you want them to be saturating above 90%, unless they're oxygen retainers, right? So usually you'll have a cut off of 88 to 92 'cause anything above 92 again, more oxygen, more carbon dioxide, more retention. In this example, they're breathing within their range. At the bottom left of the screen you can see that the frequency's set to 18. They're breathing at around the same rate to maintain what they need. Let's go over a spontaneous breathing mode. So a lotta times when patients are in spontaneous mode, the patient triggers all the breaths. So they do everything. A pressure support is usually provided to augment the title volume in a spontaneous breathing setting. What happens is when they require more, they have to breathe deeper or they have to, yeah, they have to increase their tidal volume with exercise, their respiratory therapists can increase the pressure support so that the patient doesn't have to work so hard to achieve this.

They also provide positive and expiratory pressure which is the pressure applied at the end of the expiration to keep the alveoli open. The CPAP or the BPAP is actually a form of pressure support. Okay? Except it is a non-invasive way. So again, spontaneous means the patient is taking all the breaths and they regulate their own tidal volume and their own respiratory rate. So, acceptable pressure support values are between five to 15 centimeters of water. Acceptable PEEP values are between zero to eight, or five to eight. Generally less than eight. So, when you're looking at the screen of a patient on spontaneous mode, the higher these values are, the more support the patient needs to correct the problem.

This ventilator screen is showing a patient on a spontaneous breathing mode. It's designated by the big S right there on the left. Additionally you can see here that pressure support is indicated at 15 centimeters water. A bit high for the patient but looking at all the other parameters you know this patient is probably doing well. You look at the top. They have a respiratory rate of 13 normal values or between 12 to 20 breaths per minute. And tidal volume. At the bottom you see a preset of 550. So you wanna know that the patient will at least meet a tidal volume close to 550. If you look at the top again, the tidal volume is listed as 726, way more than what they need. So they're doing okay. They're only requiring 40% of Fi02, which if you think about it it's equivalent to about six liters per minute on a nasal cannular so they're doing well. And they're PEEP is five. Sometimes you're going to hear the respiratory therapists describe a patient on spontaneous breathing as oh yeah, they're on spontaneous at 15 over five, and that just indicates their pressure support and their PEEP values, okay? When patients are in a spontaneous mode, sometimes the ventilators can have quite a number of alarms. Never hit the alarm silence. Watch your patients for any signs of distress, and have their respiratory therapist or the nurse take a look at what could be causing the alarms to go off. I wanna highlight over here also the concept called RSBI or the Rapid Shallow Breathing Index, which is a well studied value as a weaning predictor.

So what they do here is the respiratory therapist during a spontaneous breathing trial is going to turn off ventilatory support for one full minute. Then they're gonna observe how the patient does. If the patient is breathing rapidly, they're tachypneic, and very shallowly which means a low tidal volume. So the breathing, instead of breathing , they're breathing like this. That already can tell you that they're working very hard to maintain that ventilation status, right? So again, they're breathing very rapidly, they're breathing very shallowly, low tidal volumes. It indicates that they cannot, or probably will not tolerate independent breathing.

And these are the patients that will have a high RSBI score, okay? For example, if you have a respiratory rate of 25, and you have a low tidal volume of 250, you divide 25, so RR over tidal volume. That's why I place it this way. 25 divided by 250 is gonna give you an RSBI of 100, which means the body is breathing at 100 breaths per minute per liter, all right? The magic number is 105. An RSBI greater than 105 accurately predicts weaning failure. So the top vitals over there in a spontaneous trial, this is what they're watching for. Are they having within normal parameters of respiratory rates and are they providing enough tidal volume to bring in the air, okay? And you monitor the oxygen saturation along with this. Now what the ventilator screens don't tell you is they don't tell you the method that oxygen is being provided. So, sometimes you have to do other assessments of your patient. Don't adjust any settings on the ventilator, but there is one button that we therapists can press anytime the patient requires. So you wanna look for a button that says 100% oxygen and like you know, there's already 100% oxygen being delivered but the flow dictates how much fraction of inspired oxygen is actually being given to the patient. Pressing this button is gonna adjust the flow to provide 100% oxygenation for two full minutes and then it's gonna stop. It's gonna go back to the baseline.

So this would come in handy if let's say you were going to perform suctioning on a patient, or maybe your patient is de-saturating with activity and they're taking more than a minute to recover, okay? Despite the rest. Let's do a little exercise. Go grab a pen and paper and I want you to write your answers down. This is a little bit of practice on documentation. Here is a picture of a portable ventilator. I want you to go over this screen, look at the buttons, see if you can identify the ventilator mode.

Are they in control mode, assist mode, assist control mode or are they spontaneous? What about your ventilation parameters? How much is tidal volume? How much is respiratory rate? What about their oxygen parameters? How much is your Fi02? How much is your PEEP? Can you identify any other information on the screen? Is there any information from the ventilator screen that is incomplete or that you can't tell just by looking at the screen that's maybe happening to your patient? Can you find 100% oxygen button? And don't go trigger happy with that one. If I tell you that this patient is a five foot 11 male, is he meeting the appropriate tidal volume to ventilate? If he was not, what can your respiratory therapist do to help to consider the setting? If this same patient is demonstrating saturation levels of 87% with ambulation, what settings can be adjusted to correct this? Overall, do you think this patient is doing well? As a hint you know that they're on a portable ventilator, which probably means they are out of the room, and likely they are walking, so that is a good sign. Now I'll give you a few minutes to answer this and we'll go over to the next slide. So let's go over this patient's mechanical ventilation parameters. So in the previous slide, I asked if you can document the ventilator modes oxygenation and ventilation parameters. So, things that you don't see here is if your patient is intubated, you wanna document the position of their ETT, their endotracheal tube before and after treatment.

Initially there's gonna be a mark where that ETT escapes and if it says 25 centimeters at the teeth, you wanna ensure that at the end of your session it is still at 25 centimeter at teeth. 'Cause remember, where this tube ends, if it doesn't go to the area of the carina it's gonna be deficient in inflating both sides of the lungs, okay? So the documentation on the ventilator parameter. So this patient is on a spontaneous breathing mode. If you find it over there it says SPONT. See, they're on spontaneous mode. So breathing completely on their own. That's a good sign. They also are requiring a pressure supported 12 and on this ventilator it's designated as CPSF above PEEP. What that means is pressure support ventilation.

So really what it is is if they're receiving a PEEP of eight as you probably already know, they're receiving about 12 more above this PEEP. So, in total they're receiving about 20 centimeters of water pressure to maintain the ability to expand their lungs, okay? You wanna document their oxygenation parameters which is the Fi02 of 30%. If you see it over there it's beside the screen alarms. Their respiratory rate if you find it, their actual rate is pretty high. I think I put, sorry about that. I made a mistake on the slide here. It says a frequency of 20 but that's actually the settings that they had prior to being on spontaneous. Their actual respiratory rate is 42 if you caught that, 'kay? Then you wanna document the flow. They are receiving 30% of Fi02, but how much flow? Is it 50 liters per minute? Is it 10 liters per minute? So it's very important okay? That will help you determine when they come off the ventilator what flow settings they actually require to continue their breathing strategies okay? So again, this patient is on a spontaneous mode with a pressure support at 12. Their ventilation parameters are a tidal volume of 450 mL. Their respiratory rate is 42. Their oxygenation parameters are an Fi02 of 30%, and a PEEP of eight. So, the first question they had, one of the questions they had on the other slide, if the patient was five foot 11 male, is he meeting the appropriate tidal volume to ventilate and the correct answer is yes. So you multiply his ideal body weight. So, go find a chart. Five foot 11 male. Find their ideal body weight and multiply that by six to eight kilograms, okay? And then you'll have your answer. If he was not maintaining the tidal volume, what can your respiratory therapists do to help?

So, if they're breathing on their own, all they need is increased pressure. So your respiratory therapist is probably gonna adjust your pressure support settings, 'kay? If the same patient is demonstrating 87% saturation, it's low, it's below 90, what settings can be adjusted to correct this? You provide more oxygen and one of the ways to do that, the lesser invasive way is to just increase their oxygen concentration level. So they're gonna increase to 30%, maybe to 40% and sometimes I tell this to the RT. They're not really paying so much attention to tell them hey, can we support this patient with 50% right away and just start working? And that's fine. You just need to maintain their oxygen saturation levels, okay?

Overall, is the patient doing well? I don't know but I will tell you, yes, this patient did very well. We actually, it's was a female that we had transferred over to the long term acute hospital to continue her care. The respiratory rate, although it does say 42, you have to consider it could be compensatory. Maybe the respiratory rate is high but the tidal volume is sufficient. So they're not really increased work of breathing but it could be just a demand to the exercises right? So when patients have restrictive diseases, they're gonna breathe faster 'cause they gotta get more air in and a respiratory that's high doesn't always mean it's severe or it's horrible, okay? It's compensatory. So I always wanna look at those two things. High rate but tidal volume doing well. Okay. So how can we help? How can we as therapists help these patients succeed? So we have what we call your weaning trials, which is usually done by the team. It's your respiratory therapist and your team assuming that a lot of the oxygenation or ventilation issues have been corrected. And where we come in is in both ways. The weaning trials and the pulmonary toilet. So, pulmonary toilet which we now know as pulmonary hygiene is a manner of, it's a set of interventions that we have to help the patient clear their airways, and provide oxygenation and ventilation. So this is kind of the functional way to ventilate the patient. So instead of the machine, we're doing activities.

How do we know that your patient is ready for weaning? So we wanna look at your patient's status during the therapies, right? We wanna see their oxygenation status. Are they maintaining saturation levels above 90% on an Fi02 of 40% or less? Are their PEEP levels less than five centimeters of water? Right? If you answered yes to both of those, chances are they are oxygenating well. Let's take a look at their ventilation status. Are they, it's not listed here but you can add it in your handout. Are they achieving sufficient tidal volumes, right? And are their respiratory rates less than 35 breaths per minute? If your answer is yes to both, chances are they're ventilating well. They're getting the carbon dioxide out of their system. Then we take a look at their hemodynamic status.

Hopefully there's no active myocardial infarction, there's no active cardiopulmonary process. There haven't been any vasopressor changes or they're just on a low infusion rate. Maybe just one pressor support. You wanna check that they have within normal limits of hemoglobin levels. It's above seven. There are a lot of patients above eight from the APTA guidelines, right? Because as you know, your red blood cells carry a protein called hemoglobin and oxygen binds to this hemoglobin so it can be transported to your tissues. So you obviously wanna check that there haven't been any arrhythmias, or significant ECT changes, that their electrolytes are balanced, right?

They're not hypo or hypercalcemic. They're not hypo or hypernatremic. Or hypo or hypercalcemic 'cause, and their magnesium levels are within good limits. These electrolytes have a very strong impact on cardiac electricity and conductivity. So you wanna make sure the heart is doing well. Of course you run into situations where you just have a patient who has a bad heart. Maybe an exacerbation of CHF, so on top of the lung problem, they're also having problems managing their fluids. But these are things to look out for, watch, kind of assess of your patient when you're having your therapy session.

And of course one of the biggest things is you wanna check their sedation status. You wanna make sure number one, they're not on a paralytic, and number two, they can follow instructions. They usually have a rath score of zero to negative one. Maybe a little drowsy, maybe a little agitated plus one. But they can generally follow your commands. And then number three, with the sedation off gives you an idea of their respiratory drive. You can tell if they actually are just pretty much breathing on their own, 'kay?

So on the right side of the screen, is you have your parameters for weaning. You know your patient is ready to wean as a review on the oxygenation, Fi02 less than 40, PEEP less than five, pressure support less than 10, they're maintaining stats and their work of breathing. So it's not just the rate that these patients have, but what are they doing when they breathe? Are they dyspneic? Are they shallow breathers? The tidal volumes are low. That's where your RSBI comes in if you remember and you could certainly compute it if you have an incentive spirometer, have them take a breath, it's a little bit harder to measure 'cause, but just as an idea, right? And then if you have those values available to you, divide your respiratory rate by the tidal volume and see what their RSBI is. Are they using a lot of accessory muscles to breathe? If you have patients that have diaphragm paralysis, they are probably gonna use their accessory muscles to breathe and that's not a bad thing. That's just the way they compensate, but look at the quality of that breathing, right? Are they heaving? Are their chests retracting, right? Are they looking different? Do they look like they're having trouble when they're performing activities and they're breathing at this level? So not just the rates, not just the tidal volumes, but watch your patient. Observe how they are functioning and how they are compensating for the increased demands of the activity. And then the bottom part, again parameters for weaning. These two parts are related to the three and four over there. Neurologically are they awake, are they alert? They're not having any seizures, they can follow instructions. Psychologically you still wanna check. Is your patient very fearful? Are they anxious?

Are they in a lotta pain? Are they so stressed? And all of these factors, they still have to come into identifying if your patient will be ready to wean or be ready to extubate. Weaning trials, they are usually performed as soon as the patient meets all these criteria, okay? On this page. So, if you have one slide to take away from this presentation this would be a good slide to take with you. Weaning is progressively decreasing the mechanical ventilation support. So the patient can breathe on their own. You can assess if they're breathing more on their own, right? And they're ready to come off the assistance.

Unfortunately despite meeting all of these criteria, and even passing a weaning trial, patients can still fail extubation. And of those patients that fail, 25 to 50% have a, they die. The 25 to 50% mortality rate. And we'll go over a little bit of why this occurs. Now what can we do? On this next slide, I would like for you to write the normal values for each parameter in your handouts. See if you can do them by memory. What are your normal respiratory rates? How 'bout tidal volume? Tidal volume's gonna be variable because it's gonna be dependent on the ideal body weight of a patient based on their gender and height, right? But you gotta know the formula. Six to eight kilograms, six to eight mL of oxygen per kilogram of body weight, right? What are your normal PEEP values? So, when mechanical ventilation is being provided, the PEEP that is being provided is actually an extrinsic PEEP. It's just to allow some of the resistance of the tubes providing additional pressure to keep the alveoli open. But we also have our intrinsic PEEP which is from zero to five cm. So when we exhale on our own without mechanical ventilatory support, that is our PEEP, our normal PEEP values, right? Sometimes the alveoli completely exhales all the air and the alveoli closes in on itself, but it doesn't completely collapse because there's such surfactant there. So the next time we take a breath, it just fills up right away, okay? What are normal Fi02 values? And this one should be easy. Room air is 21%. So if your patient is saturating well on 21% of oxygen which is room air, that's kind of your normal values, okay?

So again, the top, number one and number two are your ventilation parameters. How do you exhale, bring out carbon dioxide? That's why I put an arrow up there. And then your bottom values, your PEEP and your Fi02 are your oxygenation parameters. How do we bring oxygen into the body. Now how do we effect this? There are a number of strategies that we do for what we call airway clearance and alveolar recruitment. So alveolar recruitment is when we try to pop these alveoli open, right? And then airway clearance techniques are clearing your airways. Trying to cough out, trying to get the airways open and allow us to ventilate.

So, these strategies that I'll list here, is an overview 'cause I wanted to really focus on mechanical ventilation. But I do encourage you guys to go over some of these techniques, study them, practice them, see how you can teach them to the patients. It's win win 'cause they're only gonna get better and you're gonna understand more about everything else that you do for your patients, okay? So how do we effect tidal volume? Tidal volume is how deep your breathe. You can increase this or facilitate this with your patients by using incentive spirometry, right? Deep breathing exercises, recruiting your diaphragm. So when your patient breathes in, you wanna kind of see that belly breathing. When they breathe through their belly , they're actually inflating the lungs by allowing the diaphragm to descend. Sometimes you can have them breath stack. So they take a breath in , close the glottis, breathe again , close the glottis, breathe again , until they can't breathe anymore. And then you can have them exhale. So you're just pulling some air in to go into the other parts of the alveoli that are not quite getting the air. So the trick with tidal volume is to do a slow but long breath, okay? So your airways, they have resistance, and any enlarged airway will allow the air to pass there faster. So if you're blowing into two balloons, whichever balloon has the bigger straw will inflate faster. But if you slow down that breath delivery, it's gonna also push that air into the smaller balloon to allow that balloon to inflate. Okay? With diaphragmatic recruitment you also wanna try and focus your patients from moving to an upper chest breathing into a lower chest breathing, okay? So you can do palpation's and there's a lot of strategies for this, and maybe in a later seminar we'll actually go over these strategies, okay?

Respiratory rate, paced breathing and dyspnea control, we wanna make sure that sometimes when they're walking they're just out of sync with their breath. You wanna make sure that you can do some pace breathing. One step inspiration, next step expiration. One step up the step, inspire, step off, expire, okay? And dyspnea control. So you'll wanna teach them some , dyspnea scales to help them manage how much activity they should be doing so that they can control for the rest periods they need. And will. You want to teach your patients how to control their respiratory rate by just thinking about controlling their respiratory rate, okay? Being alert and aware of their breathing cycles. PEEP or increasing PEEP is done by pursed lip breathing and the correct way to do this is when you inhale , you purse your lips like you're blowing through a small straw but you don't force the air out. So giving the instruction of blowing out a candle is actually not correct. You just want to let the air exhale, escape, sorry. So you inhale , purse your lips and . So the tighter those lips are, the more back pressure you have to push that air backwards into your lungs and keep the alveoli open. And people are asking well, how do I know how much pursed lip the patients should do? So, a normal respiratory cycle, a normal breath has a inspiratory expiratory ratio, an IE ratio of one is to two. So when you inhale if it takes you two seconds to inhale , it should take you four sends to exhale or recall. Okay? So you wanna follow that. When you have them pursed lip, if they're taking three seconds to inhale, you get them a pursed lip position that allows them six seconds to exhale that air, okay? We also use positive expiratory devices. Positive expiratory pressure devices like floater valves or acapella, and again it's adjusted to meet that IE ratio, okay? Don't forget that value of medications for our patients to get more oxygenation. We need their airways open. If they need bronchodilators or nebulizer treatments before we see them go for it. It's the same way we pre-medicate our patients for pain when we mobilize them after surgery. And lastly, you can provide oxygen in the form of your oxygen titration. So muscular support. Your upper airways are your pharyngeal laryngeal and smooth muscles.

A lotta times this is really the first part of your airways related to your speech and swallowing. Your inhalation and exhalation, your diaphragm is your primary inspiratory muscle along with your intercostals. It's active. Your exhalation is a passive recoil. Excuse me, and just allowing the diaphragm to relax. However, we can affect again, changes with our patients through kind of like a accessory inspiration or effortful inspiration. And forced exhalation which are functional exhalation which is, whoops, sorry. Oh, I don't have a thing there. Sorry about that. Well basically it's required for your coughing.

Effortful inspiration is also what you know as accessory muscle breathing. When your patient is accessory muscle breathing and they are primarily diaphragmatic breathers, a lotta times that's a sign of increased work of breathing okay? So most of the muscles that have attachment to your ribs can serve both postural or breathing functions. And the trick is to eliminate the postural control so that you can use those muscles for breathing. This is what happens when you have these breathlessness positions. Your patient leans forward, tripods on their elbow, starts breathing with their shoulders or with their neck. You have your sternocleidomastoid, your scalenes, your traps and your pectorals. Sometimes you'll see them, this is when you'll see the patients having these upper chest breathing patterns okay? Abdominals are the key to all the forced expiration including functional cough. So if I inhale , and I exhale , and I exhale more , it's all the function of your abdominals, okay? So think about your patients that have spinal cord injuries, right? Or injuries in the abdominal wall that have new surgeries in the abdomen. They will have trouble firing these muscles. But these are your key muscles. Your quadratus labrum to stabilize your spine while your diaphragm works. Your rectus abdominis. All your rectus muscles, right? All your abdominal muscles, sorry. Your rectus abdominis, your transversus abdominis. Your internal and external obliques are also forced expiratory muscles. They're required also for functional cough. Coughing is an airway clearance technique that requires you to take in your breath , close your glottis and expel the air, right?

So, there are phases of a cough and you wanna find out which phase your patient is having trouble with. Maybe they can't take a breath in enough to actually fill, increase the pressure in your intrathoracic cavity. Maybe they can't close their glottis, right? If they can't sound out their voice like that or phonate, they probably are gonna have trouble coughing. You cannot cough when you have an endotracheal tube because it passes through the vocal cords. You can't close it.

A cough is also, if you have your mucus ciliary transport you have little hairs in your airways that push irritants out of the body but they push it if there's mucus there. So, your function of your mucus is affected by hydration if your patient is dehydrated or they're positioned in such, the same position all the time then you're gonna have dry airways, right? These positions give you an example of what happens to your mucus, your airway system when your upright versus supine, airways collapse. Also upper sides or the upper side of the airway's gonna dry out. It's not gonna have a lot of mucus to push your irritants out. But the bottom part's gonna collect secretions and when you have more secretions it's gonna be hard to push that out. If there's too much secretion it's gonna be just tighter airways and harder to move, right? Profusion is just related to the vessel. So you wanna bring the liquids or the fluids closer to the base of the lungs when you're upright. Get more profusion to the lower bases of your lungs when you're in supine posteriorly, when you're in left side lying, the medial part of your right lung and then the lateral part of your left lung, right? To get the vessels that the gases and the fluids to flow to that area more to pick up by your vessels. And here are examples of breathlessness positions. Again, these are guidelines, and again you're eliminating the postural role of your chest and back muscles so you can use them to breathe. You patient will be the best person to figure out what actually helps them. If it can't find it for them help them find it. So it's not always about standing upright or having your patient have their chest puffed out because the breathlessness positions are compensatory.

They allow the oxygenation or the ventilation to occur, right? As therapists we always wanna encourage good postural control and over time we wanna work with our patients to achieve this. When are muscles are efficient, our patients can work with less effort and the muscles will demand less to get the oxygen that they need. So think about your goals when you work with these patients. What is the failing system, right? If the lungs are failing maybe just the lungs failing, but they still have their heart, their cardiovascular system, their musculoskeletal system. You wanna keep this intact so that they can survive and they can function and they can recover. You don't want a patient to come in the hospital, be in mechanical ventilation being supported entirely and but you don't work with them because you're like oh well, they need so much more life support, so much help, and in the mean time they're getting so weak that after their lungs are recovered, they're just so disabled they can't get back to their life. Right? Rest and recovery. These are examples how you can have strategies that you can give your patients, right? Ask them to adhere to their medications or encourage it. Tell your patients it's okay to ask for help. Sometimes we use mobility devices. Not just for the balance but to kinda help them conserve their energy. Don't forget also don't underestimate sleep. Now why do patients fail to wean? Primary causes of failure may not be corrected, or it cannot be corrected, right? There's just so much damage. Failed extubation really is when they can't sustain breathing or after they're extubated they're re-intubated within 24 to 72 hours. That's failed extubation, okay? And the primary, the most important reason for extubating a patient is the reversal of the cause of the failure to begin with, okay? A lot of these are, they're a lot of important things but if the cause is not reversed chances are they're gonna have to be on mechanical ventilation maybe even forever.

Sometimes they have diseases like cardiovascular insufficiency, heart failure, wasting, ICU acquired weakness and then they extubate and they fail because these are just, we get to take care of them, okay? 15% of patients that successfully pass weaning trials can fail when they get extubated. Maybe they can breathe okay but they can't cough. They have no coughing mechanism or reflex and they can't manage successive secretions. So they're gonna again not have a protective airway. Sometimes the lungs are just failing and they need to be replaced. There's just no way around that. And then sometimes just the patient that is to be weaned is really gonna need some kind of mechanic ventilatory support.

So they wean them not, they don't just extubate them, but they wean them to a positive airway pressure support or continuous non-invasive ventilatory system like patients with chronic respiratory failures, spinal cord injured patients or they have AMS or they're just anticipated to progressively lose respiratory muscle function, okay? So remember the whole point of life support is to promote function and we can help them. They're already being supported. So we should support them in the other ways. Have them move, get them upright, work on their breathing strategies, okay? As therapists we need to get these patients moving as fast as they can so they can survive the illness and they can reduce the chances of being disabled on discharge. And that ends the presentation. I'd like to thank you for your time and support. At this time I actually would like you to take, to look over the objectives and see if you can answer the questions that are listed in the learning outcomes and answer the four questions in the what's in it for me? Try to answer them without looking at the slides. I wish you the best with the exam and with your patients and I hope that you learned something that will be useful to you immediately. Thank you again Calista and Kathleen and everybody over at physicaltherapy.com and I wish you all a great day.

- [Calista] Well, thank you so much Kreek't for sharing your expertise with us today and thank you all for attending. Have a great day everyone.