



David F. Chang, MD

## Reviewing phaco fundamentals: How to optimize settings for routine and complex cases

by David F. Chang, MD

**O**ptimizing machine settings is an important factor in successful cataract surgery, but it is often overlooked or under-emphasized in phaco education. The 2013 ASCRS Clinical Survey confirmed strong educational interest in this topic for a majority of cataract surgeons, regardless of their experience.

Like the simplicity of a point-and-shoot camera, using the same phaco machine settings throughout every case might at first seem appealing. However, because the ultrasound power and fluidic objectives change between the different stages of nuclear emulsification, modifying

these settings can improve both surgical efficiency and safety. Thanks to multiple, preprogrammed memory settings, surgeons can now use the foot pedal to seamlessly alter these parameters intraoperatively. Much as cameras allow you to choose preconfigured settings for sports, portrait, or nighttime photography, we can preconfigure a package of settings for sculpting, chopping, fragment removal, or epinucleus aspiration.

Finally, understanding certain principles and objectives allows us to further alter and optimize our phaco machine parameters for more complicated cases, such as those with weak zonules, brun-

cent nuclei, or IFIS. This *EyeWorld* educational program highlights key principles for optimizing fluidics and power modulation for different stages of nuclear removal in both routine and complicated cases. Additional information, lectures, and my most recent textbook chapter on this subject can be found in the ASCRS Phaco Fundamentals Classroom at [phaco.ascrs.org](http://phaco.ascrs.org). You can access this online classroom for free.

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### Educational Objectives

Ophthalmologists who participate in this course will:

- Describe platform-specific phaco settings to establish a baseline to customize settings in practice;
- Discuss and integrate best practices and phaco techniques for routine cataract surgery, including nuclear disassembly, hydrodissection, efficient use of fluidics and phaco power; and
- Establish best practices for successfully navigating common phaco complications and surgical challenges.

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Bonnie An Henderson, MD

# Understanding peristaltic versus venturi pumps

by Bonnie An Henderson, MD

**W**hen differentiating between peristaltic and venturi pumps, it is important to review the goals of proper fluidic relationships. The objective is to have sufficient power to remove the cataract while maintaining a stable anterior chamber and minimizing corneal damage and heat production.

Another crucial concept when discussing phacoemulsification pumps is inflow and outflow. Usually inflow is defined by gravity and hence, bottle height. The higher the bottle, the greater the difference between the height of the bottle and the eye, leading to a higher inflow. Inflow is accompanied by a programmable pump. Some newer phacoemulsification machines have substituted an active pump system rather than relying on gravity. Outflow is defined by vacuum, aspiration, tubing size, and incision architecture.

Aspiration flow rate may seem like an amorphous factor, but it actually refers to how much and how fast fluid is removed. It is what causes nuclear pieces to be attracted to the phaco tip. In turn, vacuum is

the negative pressure that keeps the nuclear fragments on the phaco tip; the higher the vacuum, the greater the holding force.

A peristaltic pump uses flexible tubing compressed against a rigid rotor by a series of rollers on the pump head. This creates a relative vacuum when the aspiration port is occluded. There are several advantages to peristaltic pumps. The surgeon can set vacuum limits independent of flow and can allow a different amount of flow but a greater amount of vacuum. Peristaltic pumps allow for moderate flow with low vacuum to increase thermal safety during sculpting. However, with peristaltic pumps, you have to have a clear understanding of how flow and vacuum work, as they can be changed inappropriately in novice hands.

With the venturi pump, the flow and vacuum must work together so there is only one variable to change.

In a venturi system, the tip does not have to be occluded to create vacuum. The movement of the phaco port can be minimized and without needing to chase pieces. The disadvantage is that you have to be more cautious of what else is around your tip at the time. When the vacuum is engaged, not only will the nuclear fragment be attracted to the tip, the capsule will also be attracted. With today's efficient, advanced systems, you will notice the rapid movement of the pieces toward the tip.

## Preventing surge

Surge occurs when a fragment that is occluding the port is suddenly aspirated. When the fragment is occluding the phaco tip, the tubing collapses due to negative pressure. When the fragment clears, there is a sudden expansion of the tubing causing a rapid rush of fluid into the tubing and subsequent flattening of the anterior chamber. Surge is often associated with the rigidity of the tubing. The more pliant the tubing, the higher the likelihood of creating surge. To help control surge, the surgeon can increase the inflow into the eye with a higher bottle height, lower aspiration flow rate, and lower vacuum preset. Today's phaco technology often will have built-in aids to help avoid surge. These include digitally controlled and automated infusion systems, rigid tubing, and a bypass port to allow some flow even when the tip is occluded.

## Phaco device settings; avoiding wound burn

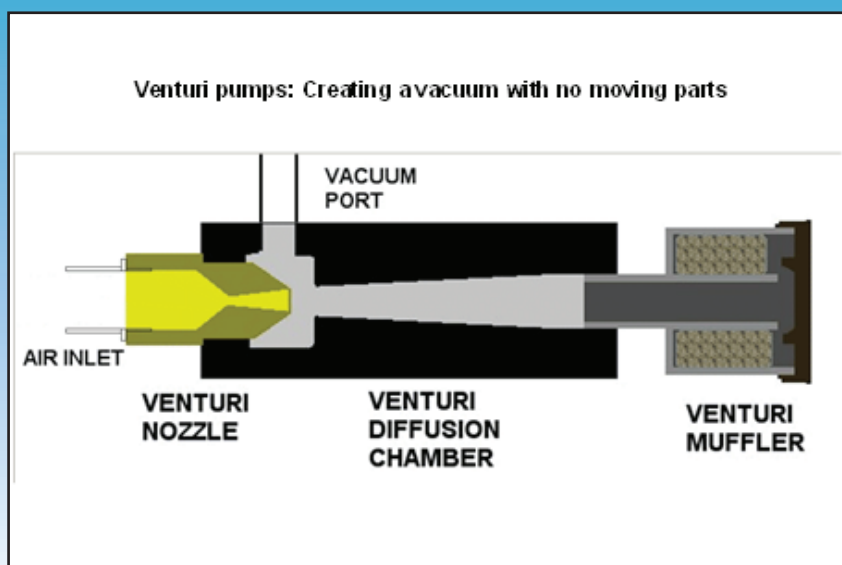
Altering the fluidics for the density of the cataract can be advantageous. For a venturi pump system, a typical setting for a moderate cataract is a bottle height of 135 cm, power of 40, vacuum of 275, duty cycle of 40%, and 30 pulses per second (pps). In contrast, with a dense lens, the bottle height remains at 135 cm, but the power can be increased to 60, vacuum increased to 290, duty cycle increased to 70%, with 70 pps. If the

patient has weak zonules, I adjust my settings to a bottle height of 50 to 75 cm, a power of 40, a vacuum of 35, 50 to 70 pps depending on density, and a duty cycle of 50%.

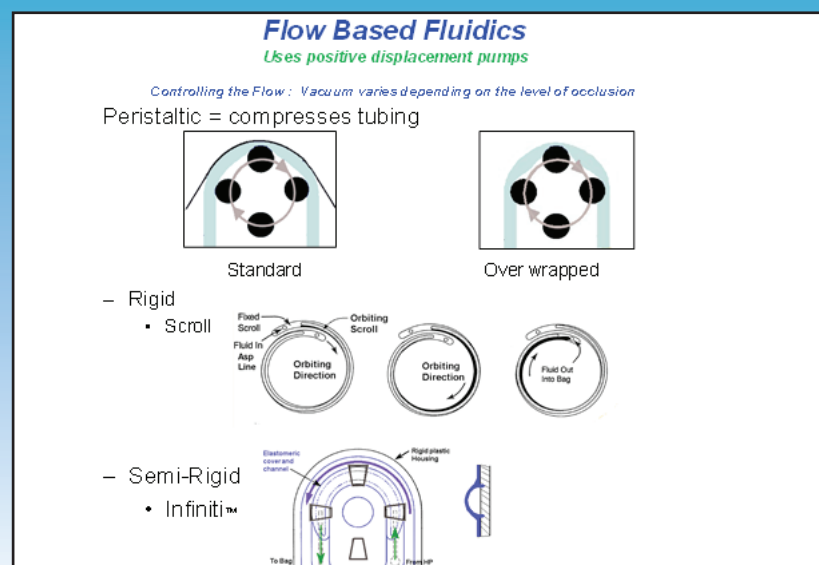
With weak zonules, the entire diaphragm of the capsular bag tends to trampoline up and down, so the goal is to stabilize the chamber. By doing so, this can prevent the vitreous from prolapsing anteriorly and hopefully prevent the need for a vitrectomy. As inflow decreases with a lower bottle height, I decrease the vacuum and decrease power to about 40.

Although wound burn is less common with today's advanced phaco technology, it still is something every surgeon tries to avoid. A few surgical pearls to prevent a wound burn are to aspirate some of the viscoelastic material before beginning to sculpt or vacuum the lens and to ensure proper incision architecture. Make sure the incision size is appropriate, the entry into the anterior chamber is square, and avoid torquing the wound when using the phaco handpiece. Paying close attention to these types of small details are the basics of phaco fundamentals.

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Venturi pump



Peristaltic pump



Lisa Park, MD

## Best practices for phaco device settings

by Lisa Park, MD

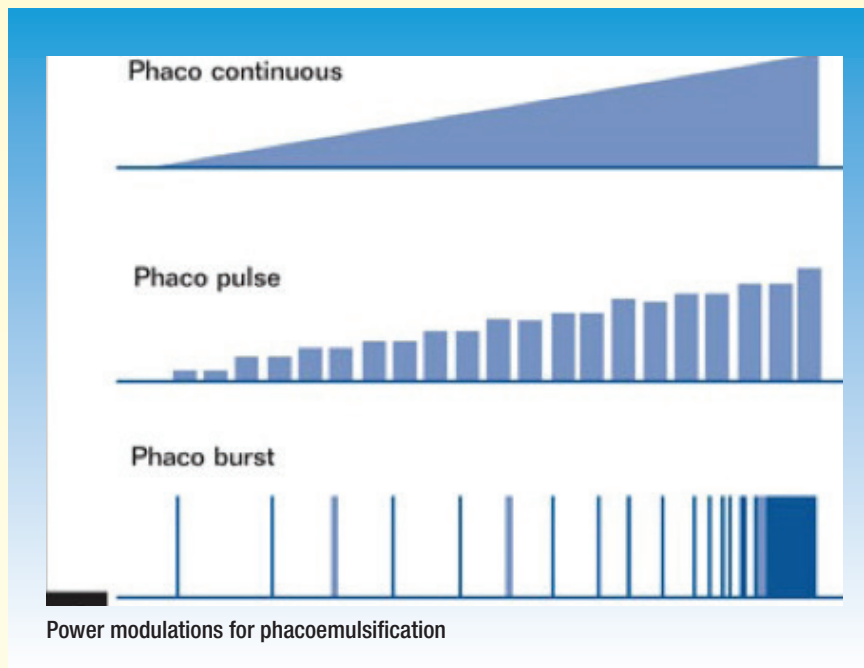
with a simultaneous side-to-side motion resulting in an elliptical motion to increase the efficiency of breaking up the lens. With torsional ultrasound, the phaco tip is angled and moves in a circular oscillating motion that also aims to maximize cutting efficiency. Both technologies decrease heat production and can result in clearer corneas postop.

### Pulse and burst modes

Traditional phaco is continuous, which means exactly what the name implies—energy is delivered the entire time the foot pedal is pressed. Pulse mode is a power modulation that allows for automated alternating of phaco-on and phaco-off time. The term “duty cycle” refers to the ratio of phaco-on time to total phaco-on and phaco-off time, expressed as a percentage. The concept to understand is that the number of pulses per second is independent of the duty cycle. Traditional pulse has a duty cycle of 50%, so that 500 ms of ultrasound energy is delivered per second, which cuts down to 50% of energy delivered compared to the continuous mode. The number of pulses is set to the surgeon’s preference.

Burst mode is a power modulation in which the time interval between each burst is dependent on depression of the foot pedal. The farther the foot pedal is pressed, the shorter the phaco-off time becomes, and maximum foot pedal depression is equivalent to continuous phaco.

Hyperpulse and hyperburst extend the range of programmable settings. Traditional pulse mode is



limited to 20 pulses per second, but hyperpulse can allow for greater than 100 pulses per second. Similarly, hyperburst can be programmed to a very short burst of 4 ms compared to regular burst mode of about 80 ms. Both options can be helpful in limiting phaco energy and heat delivered.

### Adjusting settings for surgical objectives

As surgeons, we must change our settings depending on the type of case. With a typical 2+ or 3+ nucleus, I use 100% torsional phaco on a linear setting. I have found that this mode generates very little heat and allows for very clear corneas on postop day 1, even with a supracapsular approach, which is what I favor for a soft lens. In contrast, with a very

dense lens, I will lower the torsional parameters and increase longitudinal phaco to a maximum of 40% and add pulse at a 35% duty cycle with 10 pulses per second. In all cases, the goal is to phaco only when there is complete occlusion at the phaco tip, to minimize unnecessary energy.

Understanding the options for power modulation allows a surgeon to decrease energy production, reduce endothelial cell loss, resulting in more efficient surgery, clearer corneas, and ultimately better patient outcomes.

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The evolution of modern cataract surgery is exciting because of rapid technological advances that now allow surgeons to modify phaco settings in order to increase patient safety and decrease healing time. The trend has been to minimize phaco energy in order to protect corneal endothelial cell loss, and an understanding of power modulation is an important step toward achieving this goal.

There are two basic principles to consider regarding power modulation: the direction of phacoemulsification—longitudinal, transversal or torsional—and timing—continuous, pulse, burst, as well as hyperpulse and hyperburst.

### Longitudinal, transversal, torsional phacoemulsification

Traditional longitudinal phaco uses a jackhammer-like motion, in which the tip moves forward and backward. However, it has been recognized that when the tip moves backward, energy is being produced but not breaking up the lens, resulting in unnecessary heat production. With transversal ultrasound, longitudinal phaco is combined



Kenneth L. Cohen, MD

## Using a phaco flow pump to your advantage

by Kenneth L. Cohen, MD

Flow with a peristaltic pump refers to how fast that wheel is turning, which in turn indicates how fast fluid is moving through the device. If you occlude the tip, the pump still turns. No fluid can enter, so the vacuum in the line starts building. Eventually you will hit a limit, and that’s when the pump stops turning. One question many people ask is if you do not have an occluded tip, do you get vacuum? Although there will never be a maximum vacuum in

this situation, you will still get some vacuum. You will see the vacuum go up by increasing the ramp speed, and your tip is a point of resistance. Although many cataract surgeons like peristaltic pumps, there is the concern that you will have uncontrolled vacuum pulling things forward. If this occurs, the flow is too high. You have to lower your flow rate or lower your vacuum.

I tend to think of flow and vacuum as working independently of each other, but they also work

together. Think of flow as speed. The faster that pump turns, the faster fluid has to go through. If the procedure seems to be taking too long, maybe you need to turn up the flow. If surgery is going too fast, lower the flow rate so you in turn lower the speed.

Think of vacuum as akin to grip. If things keep falling off, you need to increase your grip. Flow has a lot to do with distal followability. With epinucleus removal, it’s the flow

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## CME questions (Circle the correct answer)

**1. According to Dr. Henderson, which of the following is a goal of phacoemulsification fluidics?**

- a. To maintain a stable anterior chamber
- b. To remove the cataract with minimal instrumentation
- c. To maximize heat production
- d. To avoid inducing dry eye

**2. With a peristaltic pump, flow and vacuum must work together.**

- a. True
- b. False

**3. Which of these power modulations has more than 100 pulses per second?**

- a. Burst
- b. Hyperburst
- c. Pulse
- d. Hyperpulse

**4. According to Dr. Park, what kind of motion does traditional phacoemulsification use?**

- a. Side to side
- b. Circular
- c. Forward and backward
- d. Pulsating

**5. According to Dr. Cohen, what would be appropriate vacuum for sculpting?**

- a. 30 to 40
- b. 60 to 70
- c. 100 to 120
- d. 150 to 175

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that draws the epinucleus to the phaco tip. On the other hand, the problem with too much vacuum is surge, which is a dangerous possibility. One thing to help prevent this is an anti-surge algorithm. Surge is very much dependent on the level of vacuum immediately before occlusion is broken. You have your tip, and your tip is occluded with the piece. If you have a vacuum of 200 and that piece suddenly goes in, that is where you will want to minimize surge. At different points during the case, such as when you need to impale the nucleus early on with chopping, high vacuum is very safe. You can turn it up to 500 because if you get a little surge, there will not be any issues with the posterior capsule. If you want to work on the epinucleus or the last fragment, you will want to use a much lower vacuum, perhaps 200. At that point, grip

is less important, and it's more about proximal followability when there is partial occlusion of the phaco tip.

### Adjusting flow and vacuum for surgical tasks and lens types

Another time to consider flow and vacuum is with sculpting. When sculpting, you want a fairly low vacuum of 60 or 70, as well as a decent flow rate. Then, to chop or impale a quadrant, switch to your highest vacuum. You can turn the vacuum up, get the fragments, and then turn vacuum down to a point where it will not grip things as much. With epinucleus removal, I turn the vacuum to 200 or so and turn flow up to compensate. In that situation, you want followability, but you also want to minimize a post-occlusion surge. That's a stepwise paradigm I use for safety. I grab a dense

nucleus, but grip is not important for the softer epinucleus.

Let's say you have a new machine and you want to see how high of a vacuum you can use. Take a little fragment and hold it with a phaco tip. Let the vacuum build, then let it clear and see how much surge you get. If you do not get any, turn it up higher until you see jumping in the chamber. This gives you an idea of the high vacuum setting.

For a case such as a soft lens, I will do hydrodelineation to separate the endonucleus from the epinucleus. There is minimal hydrodissection. Using irrigation and aspiration in foot pedal position 2, I will clear out a space, removing the OVD, anterior cortex and the anterior epinucleus. I will go to an epinuclear setting but use linear aspiration as opposed to panel aspiration. Residents find that removing a soft lens

is more challenging than working with harder nuclei. They tend to overuse phaco and can actually phaco right through these soft nuclei. I prefer linear control of aspiration in the epinuclear setting.

Avoiding wound burn is always an issue, and the risk for wound burn can increase with smaller incisions. That said, 2.2 mm incisions are common nowadays. It's critical to make sure there is flow under the OVD on top of the lens and to stay in foot position 2 while removing the anterior cortex and epinucleus. Surgeons should remain in foot position 2 for these tasks before going to foot position 3.

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