SURGICAL PHACO BASICS:
OPTIMISING MACHINE SETTINGS FOR ALL CASES

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Phacoemulsification accomplishes three simultaneous functions through a closed system: emulsification, aspiration and irrigation. It is important to understand each component to perform safe and effective cataract surgery.

PHACO FLUIDICS: THE BASICS

The term phaco fluidics describes irrigation (inflow) and aspiration (outflow) during phacoemulsification.

The goals of phaco fluidics are to have sufficient power to remove emulsified particles, maintain the stability of the anterior chamber while removing the cataract and minimise heat production by the oscillating phaco needle.

Inflow is determined by the bottle height, which relies on gravity in most phaco machines, the irrigating tube diameter and phaco tip sleeve size. There is no linear control by the machine, which works by the gravity-determined inflow system. We switch it on or off and cannot control it by foot pedal. Newer machines have substituted active inflow systems.

Outflow is determined by the phaco tip diameter, wound leakage, aspiration tube diameter and phaco machine pump.

We must know the difference between the flow rate and vacuum. Flow rate refers to the amount of fluid moved per minute. It helps bring material toward the phaco tip (followability).

Vacuum is determined by the difference between the atmospheric pressure and pressure inside the aspiration line. It is a negative suction pressure created by the pump that helps hold the material to the phaco tip (holdability).

UNDERSTANDING PUMP FUNCTIONS

Two types of pumps are available — the peristaltic pump, which milks fluid along a compressible tube with a series of rigid rollers, and the venturi pump, in which high-velocity, compressed air enters a wider tube, creating vacuum and sucking material from one side to the other.

The peristaltic pump is flow based, with vacuum created on occlusion; the flow rate is constant until occlusion. The venturi pump is vacuum based. Vacuum is created instantly and is continuous with or without occlusion. The flow rate, which cannot be controlled, varies according to the vacuum level.

Post-occlusion surge occurs when there is a sudden increase in outflow (becoming greater than inflow) after occlusion is broken (Figure 1). It results in flattening of the anterior chamber, causing corneal and posterior capsule damage.

There are several strategies to prevent post-occlusion surge, which all focus on maintaining inflow levels at greater levels than the outflow levels.

We can increase inflow with a wider and flexible irrigation tube and decrease outflow with a narrow and thick aspiration tube. We can increase the differential pressure in the inflow side by elevating the irrigation solution bottle or using the Active Fluidics system (Centurion, Alcon) or pressurised infusion system (Stellaris, Bausch + Lomb). On the other hand, we can decrease the outflow differential pressure by lowering the vacuum just before the occlusion break. This can be accomplished with the Chamber Automated Stabilization Environment (CASE mode, WhiteStar Signature Pro, Johnson & Johnson Vision).

CONCLUSION

Outflow fluctuates throughout surgery. It ceases by occlusion and increases suddenly after occlusion break. Inflow must be kept greater than the outflow to compensate for an instant increase in outflow. New phacoemulsification machines with active inflow systems enhance the stability of the anterior chamber during phacoemulsification.

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Figure 1. Post-occlusion surge

New phacoemulsification machines with active inflow systems enhance the stability of the anterior chamber during phacoemulsification

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Principles of Phacoemulsification: Phaco Power Modulation

Technologies offer numerous ways to modulate power during phacoemulsification

By Richard Packard, MD, DO, FRCS, FRCOphth

Ultrasonic power consists of the mechanical impact of the phacoemulsification tip; acoustic shock wave generated by the tip movement; fluid particle wave; cavitation; tip movement; and heat generation. Modulating this power reduces ultrasound power in the eye during phacoemulsification.

**PHACO POWER BASICS**

Changing the power only changes the stroke length; frequency remains the same. Power produces heat and could generate flow resistance, but too much power generates energy dispersion in the eye, releasing free radicals in the anterior chamber, which can be harmful.1 Free radical production is time and power related, so we need to use as little power as we can for the shortest time possible. However, too little power stresses the zonules.

The mechanical impact of the tip is the most important destructive force, such as in longitudinal phacoemulsification, which works like a jackhammer.

Imploding bubbles of cavitation generate significant amounts of energy, so we use low power settings to avoid this. Because we are using smaller incisions, we need to minimise ultrasound power to avoid wound damage.

**MODULATING POWER**

Power is modulated by linear control, setting a maximum level, breaking up the ultrasound stream, and using different tip movements. Currently available machines allow hyper- or micropulsing, where we can vary the power, as well as the duty cycle and space between pulses (Figure 2). When we combine this with burst, we have microburst, which enables surgeons to vary all these parameters.

Modern phacoemulsification devices are designed to maximise efficiency and minimise energy dispersed. The Infiniti and Centurion (Alcon) allow torsional phaco, with torsional cutting left and right in a side-to-side movement, which is more efficient. Nuclear fragments normally remain near the tip rather than being repelled, as with longitudinal phaco.

One problem with a flared tip and harder cataracts is that nuclear fragments may be trapped in the horn of the tip. With Intelligent Phaco software, a bit of longitudinal energy pushes it away gently so the surgeon can reposition it, without clogging.

With the WhiteStar Signature (Johnson & Johnson Vision), we have various combinations with transversal ultrasound or the Ellips FX. Instead of moving backward or forward or rotating, it combines all of these. We can use a straight needle to produce an effect similar to what we would have with torsional phaco.

The Bausch + Lomb Stellaris uses only longitudinal phaco, but there are multiple modulations of micropulsing and it uses a lower frequency, so the heat signature is lower. The tip now moves a little further, so less power is used, resulting in more focused movement of the tip.

**CONCLUSION**

Power modulation reduces ultrasound power in the eye during surgery, reduces free radicals, and engenders less endothelial damage. It can be done with linear control, micropulsing and microbursts, and we can change pulse modes between unoccluded and occluded. Alternative phaco tip movements such as torsional and transversal are also useful.

**REFERENCE**


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**MODERN MODULATED POWER MODES**

- Hyper/micropulse – Linear variable pulse width and variable duty cycle
- Microburst – Linear burst with variable pulse width and maximum frequency pulse at maximum power

Figure 2. Modern modulated power modes
For phacoemulsification during cataract surgery, I prefer to use the WhiteStar Signature Pro system. My preferences are to use the venturi pump for followability and efficiency; the duo-linear foot pedal, which provides a distinct duo-linear separation between irrigation/aspiration and ultrasound for safety; torsional and longitudinal tip movement for safety and efficacy; and the surgical media centre, which provides high-definition documentation for clinical research and education.

**PHACOEMULSIFICATION PARAMETERS**

Today’s pump technologies offer many opportunities to change our fluidics settings, especially with the peristaltic pump, thus supporting safety. Nevertheless, I work mostly with the venturi pump and a maximum vacuum of 160 or 180mmHg, thus increasing efficiency (Figure 3).

With Signature U/S modulations and the Ellipse handpiece, I choose a combination of both modes: longitudinal und elliptical. WhiteStar, variable WhiteStar and pulse-shaping modes can be selected. I always begin with 25% of maximum power. The straight phaco tip is at 30 degrees, and we use a 20-gauge needle.

In preparation, I perform a posterior limbal incision (2.2mm), paracentesis (0.9mm; two for bimanual irrigation/aspiration), capsulorrhesis (5mm, well centred, using digital assistance) and meticulous hydrodelineation and hydrodissection. We must be able to rotate the nucleus at this point in the surgery.

Cortex aspiration is performed with the phaco tip. I use a Sinskey hook because it offers the most opportunities to work in different positions. It is not too sharp or deep and is sufficient for chopping. The nucleus is chopped as usual in quadrants. These quadrants are aspirated in the peripheral softer part, pulled into the centre and emulsified in a pre-occlusion mode supported by automatic rotation of the nucleus quadrant.

**COMPLEX CASES**

In a case with a hard nucleus, there is less cortex and we should not aspirate it. We may increase our power settings up to 100% and change the hyperpulse periods.

The incision should not be too narrow. If necessary, we need to inject more OVD. Using the chopper between the nuclear material and posterior capsule helps a bit, although we should not rely on it too much. We should avoid long periods of occlusion to have enough fluid to pass into the eye, thus cooling the incision.

During emulsification, we work in the centre. We go deep into the nucleus, separate the two parts and go into the periphery and rotate the nucleus.

In a case with a floppy iris, suprarenins help reduce floppy iris problems. We change our preparation slightly. We begin with one smaller paracentesis on the left side for the chopper. Our power setting is 25%, bottle height 106cm and vacuum 180mmHg. I try to reduce U/S power as often as possible and often use prechopping. If necessary, we hydrate the longer and narrower incisions. Incisions also may be more corneal, so they are a little higher and help restrict the pupil. With these preparations, we have had no problems with floppy irises escaping from incisions.

**CONCLUSION**

For my procedures, I prefer the venturi pump, elliptical tip mode and duo-linear foot pedal. Today’s technology with phaco tips and power modulations facilitates surgery in critical situations, so we will have better outcomes than a decade ago.

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The goal of phacoemulsification is to emulsify the crystalline lens while properly maintaining the anterior chamber (AC) for all types of cataracts. Cataracts do not have the same density, and the density of each cataract is not homogeneous.

In this article, I will share how I set my Centurion Vision System (Alcon) for different types of cataracts with the objectives of safety and efficiency.

CENTURION VISION SYSTEM AND ENERGY

Ronquillo et al. found that a ratio of approximately 20% to 25% longitudinal energy and 60% to 80% torsional energy could be used synergistically for better efficiency.1

When performing phacoemulsification with the Centurion, I set the intraocular pressure (IOP) at approximately 40mmHg, vacuum at 500mmHg, and aspiration flow rate (AFR) at 27cc/minute (Figure 4). These preset values are used for all cataracts of varying densities.

I slightly increase the IOP as I remove free material. I avoid high AFRs so the viscoelastic will remain longer in the AC.

I always try to shave material and avoid full occlusion as I am emulsifying. This can help control heating of the phaco tip and avoid surge. Negative rise time (NRT) is helpful for shaving the nuclear material. When the tip gets occluded, adjusting the NRT to -1 slows the pump and alleviates occlusion.

The foot pedal ratio is very important in emulsifying all types of cataracts with one optimised setting. With good ratios, energy will be released as needed and the surgeon can manage fluidics properly. With my preset values, on average, I use one-third of the energy that is set by leveraging the foot pedal at step 3 to emulsify nearly all cataracts.

During cortical irrigation and aspiration, I increase the IOP because we need a taut capsule. A higher IOP and very low vacuum and AFR are set for vacuum polishing. To thoroughly remove viscoelastic, AFR is increased to 50cc/minute.

I recommend that surgeons obtain the best energy and fluidics ratio

Bekir Sitki Aslan, MD

FLUID DELIVERY WITH CENTURION VISION SYSTEM

With active fluid delivery, as more fluid is aspirated from the AC, the system will deliver just enough fluid to maintain it, provided your incision size is compatible with the sleeve and tip and the incisions are not leaking.

The optimum energy and fluidics values appearing on the screen depend on how much you press the foot pedal. These values are within the limits of the preset values but do not exceed them. If more energy is needed, the surgeon can further press the pedal at step 3, whereas the pedal is pressed less for softer cataracts.

Good foot pedal control with the Centurion significantly contributes to using the optimum amount of fluid and energy during surgery with only one set of parameters.

CONCLUSION

I recommend that surgeons obtain the best energy and fluidics ratio. We need one set of parameters that fits our habits and techniques and to use the foot pedal to optimise energy and fluidics to perform phacoemulsification safely and effectively.

REFERENCE


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