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Fluidics in Modern Vitrectomy

Sponsored by Oertli Instruments AG

Highlights from a roundtable meeting

7 November 2009, Movenpick Hotel, Zurich-Airport, Switzerland

Featuring


Arnd Gandorfer, MD, ÄQM, FEBO, Moderator


Shobhit Chalwa, MS, FMRF

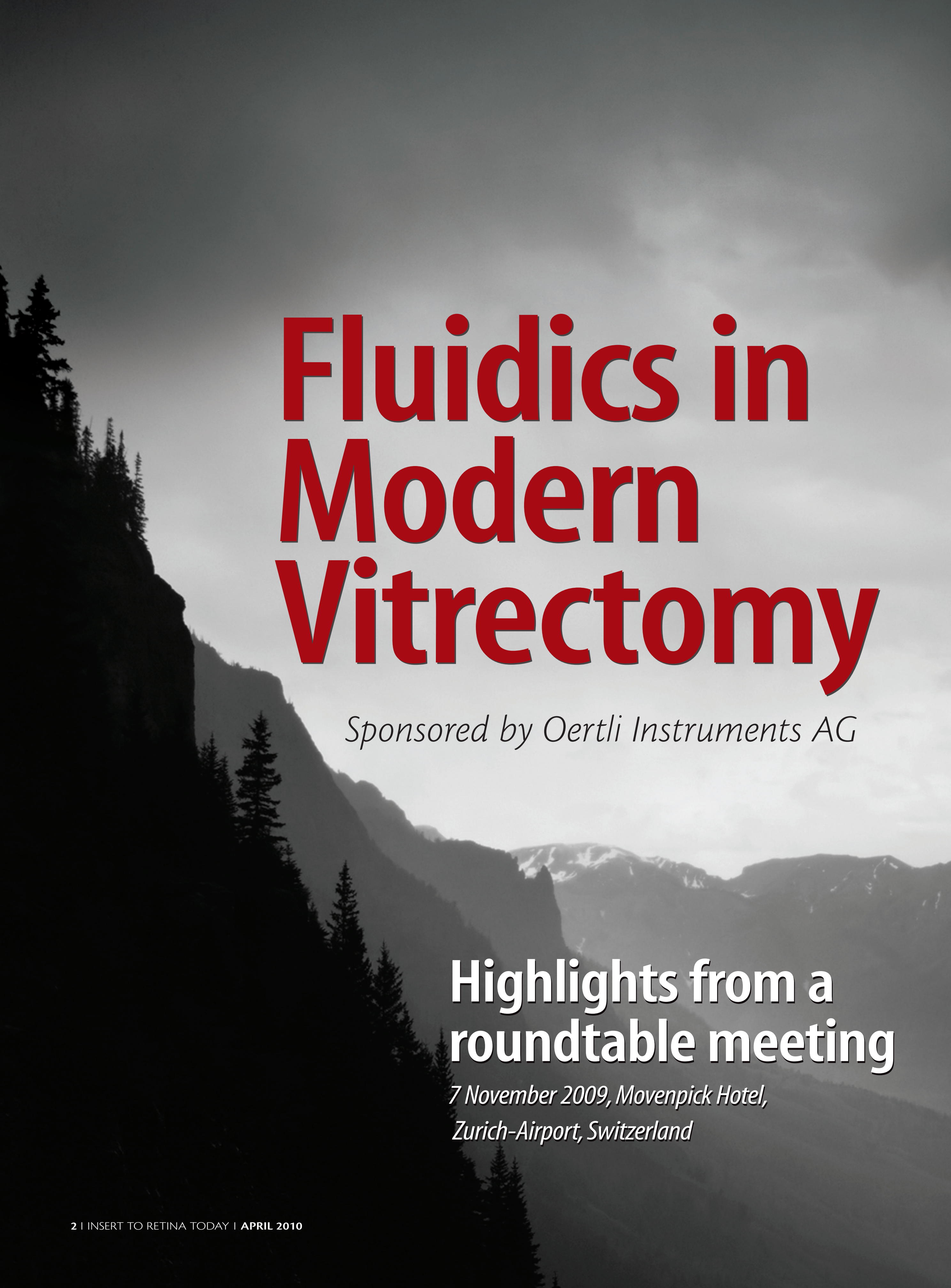

Taraprasad Das, MD


Didier Ducournau, MD


Gregor Jundt, PhD


Andrew Luff, MA, FRCS, FRCOphth


Christian Prünte, MD, PhD



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Panel

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The topic of this roundtable is fluidics in vitreoretinal surgery. Twenty-gauge vitrectomy systems have been the standard in surgery for many years, and we are all accustomed to the three-port vitrectomy procedure. Over time, wide-angle viewing systems became popular, largely replacing contact lenses. More recently, minimally invasive surgery has been widely adopted by many retinal surgeons and 23- and 25-gauge surgeries have largely replaced 20-gauge procedures.

There are little data published on the difference between peristaltic and venturi pump systems on our vitrectomy machines. It is important to understand the concepts of the two systems: flow-controlled peristaltic (Figure 1) and vacuum-controlled venturi (Figure 2). Flow rate control (in an unoccluded state) keeps fluid turnover in the eye exactly at the rate controlled by the pedal while the vacuum adjusts itself to the lowest level required. Vacuum control (in an unoccluded state) keeps the suction-vacuum of the pump exactly at the level controlled by the pedal while the resulting fluid turnover depends on vacuum, size of aspiration path, cut rate and condition of material being aspirated. In the occluded state, there is no difference between the two systems.

How does this information translate to our vitreoretinal surgeries? To answer this question, we have assembled a panel of experts in vitrectomy and combined phaco/vitrectomy to discuss the benefits and limitations of both pump systems in different surgical situations.

- Arnd Gandorfer, MD, ÄQM, FEBO, Moderator

CORE VITRECTOMY

Dr. Gandorfer: Dr. Ducournau, what are the most important considerations when performing a core vitrectomy?

Didier Ducournau, MD: I perform a core vitrectomy only when there is no vitreous pathology such as in epiretinal membrane, macular hole, venous thrombosis, and edema.

Dr. Gandorfer: Which pump and machine settings do you use for core vitrectomy?

Dr. Ducournau: First, I must specify that I no longer use 23- or 25-gauge. Rather, I have returned to using 20-gauge technology because I prefer the shorter surgical time. I use the peristaltic pump for all surgical situations. I always keep the maximum aspiration flow lower (2 cc/min) than my infusion flow, to protect against hypotony. I place the infusion bottle at 70 cm. To reduce the risk of traction in the periphery, I use a slow cutting rate of 800 cpm.

If I were to use 23-gauge technology, I would adjust the maximum aspiration flow to 16 or 15 cc/min with infusion flow at 17 cc/min.

"I perform a core vitrectomy only when there is no vitreous pathology such as in epiretinal membrane, macular hole, venous thrombosis, and edema."

—Didier Ducournau, MD

Andrew Luff, MA, FRCS, FRCOphth: Because I oper-

PERISTALTIC VS VENTURI

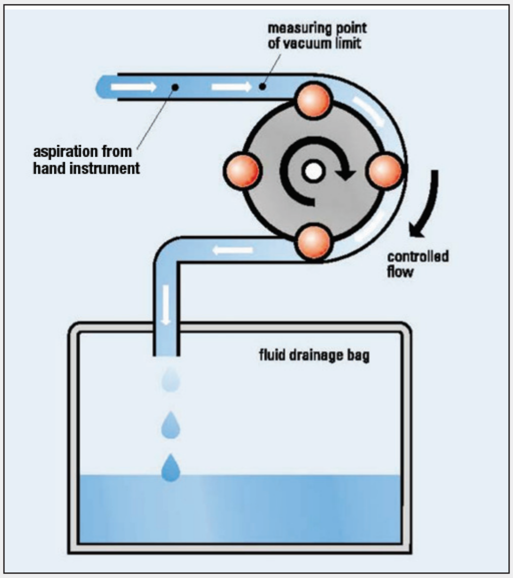

Figure 1. Peristaltic System.

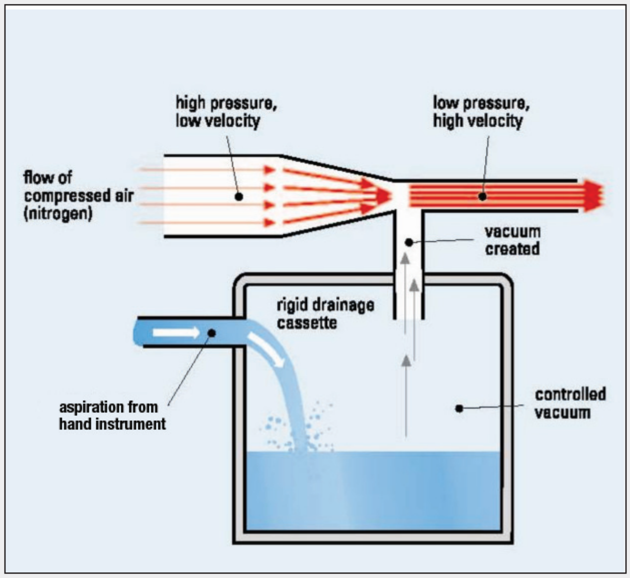

Figure 2. Venturi System.

A peristaltic pump works with flow. By means of roller systems, the peristaltic pump compresses—as the name suggests—the tubing system so as to create flow and vacuum. The compression of the tubes by the rotating movement "milks" the liquid column out of the tubing system. While this is happening, the flow can be directly controlled. The preset vacuum is achieved as soon as the outflow is occluded, ie, at the tip of the cutter. As soon as occlusion occurs and the vacuum continues to rise, the rollers begin to move more slowly, and the outflow decreases. The rollers finally stop when the preset vacuum is achieved.

A venturi pump works with vacuum. The venturi effect means that a vacuum is created by flow. In surgical devices the flow is generated by compressed air or nitrogen; the air nozzle has a connection to a closed drainage bag (Figures 1 and 2).

Peristaltic	Venturi
Direct flow control (vacuum adjusts itself to the minimum required to maintain the flow)	Vacuum based (flow decreases when cutting action starts)
	Vacuum is generated directly through the venturi pump
Flow is constant until occlusion occurs	Only vacuum can be controlled, flow depends on various factors (vacuum, instrument size, type of fluid or tissue aspirated, cutting speed, duty cycle)
Flow and vacuum limit can be set independently from each other	

ate in different surgical centers, I adjust my pump choice and settings depending on the machine that is available. When I am using the Millennium system (Bausch + Lomb, Inc., Rochester, NY), which uses a venturi pump and 20-gauge technology, I set the vacuum at 250 mm Hg to 300 mm Hg. With the Eckardt 23-gauge vitrectomy system (DORC, Zuidland, the Netherlands), I use a vacuum of up to 450 mm Hg.

When I use the OS3 (Oertli Instruments AG, Berneck, Switzerland), which has dual pump capabilities, I favor the peristaltic pump. I use a 40 mL/min flow and raise the infusion bottle to the minimum height required for globe stability.

Taraprasad Das, MD: Two months ago, I switched to using a peristaltic pump. For core vitrectomy, I use vacuum settings similar to the venturi pump—450 mm Hg with 40 mL flow. I see no differences between the two pump systems for core vitrectomy, and both are quick and efficient.

Shobhit Chalwa, MD: For core vitrectomy, I use a peristaltic pump system with the vacuum set at 250 mm Hg. I set my flow slightly higher than Dr. Ducournau.

Christian Prünte, MD, PhD: My primary objective in core vitrectomy is efficiency and for that reason, I use 23-gauge technology for 100% of my cases. I routinely use the venturi pump on the OS3 with the vacuum set at 450 mm Hg and I utilize a high cutting rate of 3000 cpm. My irrigation flow is experimental; I set it as high as possible. My goal is to titrate the irrigation bottle height without cutting, so I adjust height to where I am sure that circulation is continuous, individualizing for each case.

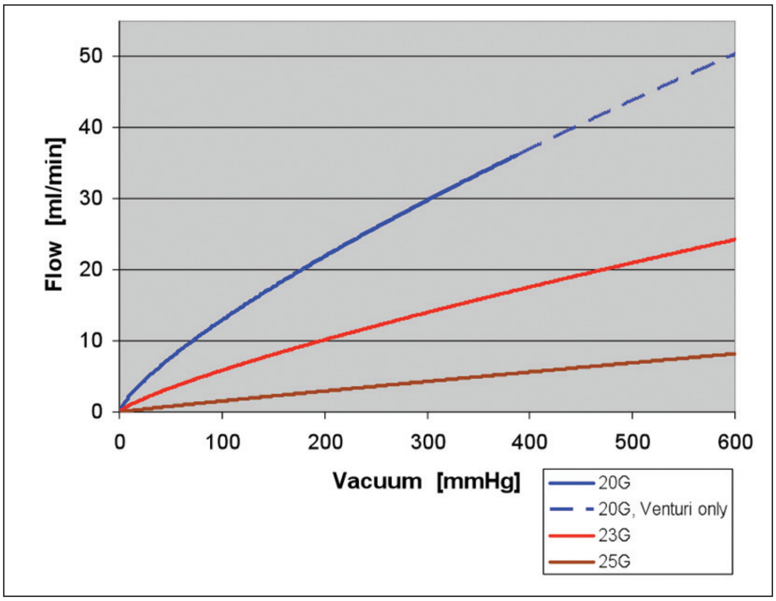

Figure 3. Flow dependence of 20-, 23-, and 25-gauge cutters with peristaltic and venturi using balanced salt solution. All instruments are in an open state.

Data on file, Oertli Instruments.

Dr. Gandorfer: For core vitrectomy, I start with a bottle height of 55 cm, adjusting as necessary depending on the case. One factor that can interfere with circulation is the stiffness of the vitreous. In the case of stiff vitreous, the bottle height can be lowered. I use the 23-gauge Oertli system with the peristaltic pump. I do not use venturi. I use a high cutting rate of 3000 cpm with a vacuum set at a maximum of 600 mm Hg and low flow of 12 cc/min.

“The pump systems in 23- and 25-gauge practically perform in an identical manner, even with high flow and high vacuum.”

—Gregor Jundt, PhD

Dr. Jundt, what is your opinion on these different approaches from a physicist’s point of view?

Gregor Jundt, PhD: We have performed some research on this topic, and Figure 3 shows the dependent relationship of vacuum and flow using 20-, 23-, and 25-gauge peristaltic and venturi pump systems and balanced salt solution when the cutter port is open. The measurements with both pump system are equal up to 400 mm Hg. With 20-gauge instrumentation, once vacuum rises above 400 mm Hg, the peristaltic cannot further increase the flow. It is rare that surgeons work with such high flow rates even with core vitrectomy, because of the increased resistance of real vitreous, so this may not be highly relevant. The pump systems in 23- and 25-gauge practically perform in an identical manner, even with high flow and high vacuum.

Dr. Chalwa: Because the peristaltic pump system is occlusion-based, is there less turbulence at the tip compared to a venturi system?

Dr. Ducournau: The turbulence around the tip has nothing to do with the pump type. The gradient of pressure, which is the difference between the infusion pressure and the depression induced by the machine, is not specific from pump to pump. Turbulence is a matter of flow. If more turbulence is desired, the flow setting on peristaltic must be increased.

POSTERIOR VITREOUS DETACHMENT

Dr. Gandorfer: What is your approach to induce posterior vitreous detachment (PVD)?

Mr. Luff: When inducing a PVD, safety is an important factor. The goal is to grab hold of the vitreous cortex and induce a separation; this will take a variable amount of energy, depending on the age of the patient and the pathology that is being addressed. When operating myself and when training new surgeons, what worries me about using a venturi pump is what will happen when the grip is released.

When I am using the Millennium, I start by turning off the cutter. I then determine the location of aspiration—in my experience, nasal to the disk seems to be a safe area. It then becomes a question of how much aspiration can be introduced on the basis of what will happen if occlusion is broken and some form of surge and collapse occurs. If it happens close to the retina, there is a worry that the retina will be caught by the probe. When attaching the vitreous with venturi, only a moment of patience is required before depressing the pedal. With the peristaltic pump, the surgeon must wait for the pressure to build and the acoustics* to change before the gel can be lifted away. This is much better than the standard venturi approach, for which I teach my students to watch the bag—if a gravity feed is being used and the bag stops dripping while the pedal is fully depressed, the hope is that cortical vitreous has been captured with no other material in the cutter.

Although I feel confident working with a venturi system inducing a PVD, when teaching I would always choose a peristaltic system to minimize the risk of an occlusion break and its consequences.

"Although I feel confident working with a venturi system inducing a PVD, when teaching I would always choose a peristaltic system to minimize the risk of an occlusion break and its consequences."

—Andrew Luff, FRCS, FRCOphth

Dr. Das: Previously I was using the venturi for creating PVD but have switched to the peristaltic pump 2 months ago and have found it safer in terms of inducing PVD. Using the venturi system, I begin cutting and raise the aspiration to approximately 350 mm Hg, and moving close to the optic disc, I hold the vitreous cortex nasal to the optic disc with the vitreous cutter. With the peristaltic pump, once the cutter holds the vitreous cortex, I do not think that there is a difference between venturi and peristaltic pumps.

Dr. Chalwa: I agree that safety remains the major concern with PVD. I think that a vacuum setting of approximately 250 mm Hg to 300 mm Hg one is safe for inducing a Weiss ring on the nasal side of the disk. Once the suction has lifted the vitreous cortex a bit, the fluid tends to stretch through the back of the ring. I prefer to proceed slightly beyond the arcade of the vitreous detachment and then start cutting. Using this technique I can be careful to look for any iatrogenic breaks or any undue traction. I am able to use cutting rates up to 2000 to 2500 cpm safely.

I think that the peristaltic pump allows a better hold once the vitreous is in the port. The peristaltic pump has a forceps effect compared to the venturi pump.

Dr. Gandorfer: It is interesting to hear these comments because there has been a general belief that a venturi pump systems makes it easier to get the vitreous through the port. As we have heard, this is not true.

**In a peristaltic system, the vacuum will increase as soon as the cutter tip attracts vitreous. An acoustic signal indicates this state. Surgeons can "hear" the vitreous.*

Dr. Prünte: After testing the peristaltic pump on the OS3 for core vitrectomy and PVD, I have determined that I still prefer the venturi pump because I think it grasps the posterior vitreous more easily and quickly, enabling it to be lifted out.

I agree that there is a safety advantage when using a peristaltic pump and that it is useful for training new surgeons because it uses an acoustic signal that alerts the surgeon to let up on the pedal upon occlusion. The peristaltic pump is also safer if you use the flow settings to avoid complications. We have all most likely experienced detached retina with attached vitreous; this may be one of the most challenging situations encountered in retinal surgery.

When I start to detach the vitreous close to the mid-periphery and start cutting again, I complete my core vitrectomy and then peel off peripheral vitreous if necessary.

Dr. Ducournau: In cases of core vitrectomy, I do not induce the PVD with my cutter because I do not want to induce traction in the periphery. When performing a complete vitrectomy for retinal detachment, hemorrhage, or other such pathology, I induce PVD with the tip, in which case I will use a peristaltic pump system.

Vitreous traction is the same with a peristaltic or venturi pump system in terms of gradient of pressure. The difference, however, is that you can use 600 mm Hg of pressure to attract the vitreous to the port with a peristaltic pump, which cannot be done with a venturi pump because it would be too risky. The peristaltic pump also provides a higher level of efficiency with a stronger grasping effect.

Dr. Prünte: Can you explain this?

Dr. Gandorfer: The advantage of using a peristaltic pump is that high suction rates (vacuum) and low flow can be applied, and flow can be controlled at the minimum level necessary to engage the vitreous.

Prünte: With the venturi pump, however, you can produce the same high vacuum as with the peristaltic pump.

Ducournau: Of course you can, but in my experience, too high of a flow would be induced making it

> "I think that the peristaltic pump allows a better hold once the vitreous is in the port and the pump has a forceps effect compared to the venturi pump."
>
> —Shobhit Chalwa, MD

dangerous, especially after occlusion break.

Dr. Prünte: But flow is high at the beginning of the procedure, is it not?

Dr. Gandorfer: When venturi and peristaltic pumps are compared for vacuum build up time, and we have the data of actual measurements, it clearly shows that the previously held belief that the venturi system responds more quickly and has a faster vacuum rise time was incorrect.

Dr. Jundt: Figure 3 shows that as the tip opening of an instrument becomes smaller, the pump system generates less outflow.

Using 600 mm Hg of vacuum on venturi with a 25-gauge instrument, a maximum of 8 mL/min of flow can be achieved. With a 23-gauge instrument, 25 mL/min of flow can maximal be achieved. And with a 20-gauge instrument, 50 mL/min of flow can be achieved. Between a vacuum of 400 to 600 mm Hg, the flow can be increased from 35 to 50 mL/min with a 20-gauge cutter. When using 23- and 25-gauge instruments, a flow increase with higher vacuums is almost not achievable.

For 23- and 25-gauge instrumentation, both the peristaltic and the venturi pump achieve the same flow rates.

Mr. Luff: The measurements do not necessarily demonstrate what is happening in actual surgery, particularly when training a young surgeon. Typically, the surgeon will stay away from the cortical gel and the retinal surface. The reason that venturi is faster is because a high flow state to turbu-

lence must be induced that will move material to the tip. This is not required when the tip is manipulated to face the gel, which is difficult as cutter ports are always sideward. I agree that once occlusion occurs, there is no difference.

Dr. Prünte: Much of the data that have been obtained on the physics of the venturi vs peristaltic pump systems are based in the pumps' behaviors in balanced salt solution without irrigation, which is quite different than operating on a human eye with a closed surgical system.

In my experience, the peristaltic pump does not respond as quickly as the venturi in surgery but I do agree that there is a larger margin of safety with the peristaltic pump.

"The previously held belief that the venturi system responds more quickly and has a faster vacuum rise time was incorrect."

—Arnd Gandorfer, MD, ÄQM, FEBO

Dr. Jundt: I think when speaking about response time we must consider settings. For a peristaltic pump to respond as fast as the venturi pump, flow must be set at 40 mL/min. This is the value at which measurements were made because it corresponds to the flow that a venturi system creates at 450 mm Hg with 20-gauge instrumentation. Both systems will build up 450 mm Hg within approximately 0.6 seconds.

The discussion about "speed" of venturi compared to peristaltic in central vitreous and PVD surgery leads to the deciding point: settings. A venturi system can be almost perfectly imitated with a peristaltic pump by increasing the flow rate setting to 35 mL/min or higher and setting the vacuum at 400 mm Hg. This will create the high flow state that moves material to the tip. The opposite, simulating a flow-controlled system with venturi is not possible.

However, the high precision offered by the direct flow control of peristaltic can best be deployed with settings of 10 to 20 mL/min for flow and 200 mm Hg or more for vacuum.

Venturi users do use the term "suction" for suction-vacuum. This is the only parameter that can be controlled with venturi; to increase or decrease suction, vacuum must be adjusted. Venturi users switching to peristaltic should keep vacuum unchanged but change flow to increase or decrease "suction."

Table 1 shows the typical settings that are likely to please venturi users.

SHAVING THE VITREOUS BASE/ADDRESSING THE MOBILE RETINA

Dr. Gandorfer: The next step is vitreous base shaving, and removal of the peripheral vitreous in the case of an attached retina. I think that it is important, of course, that we should differentiate the attached retina from the detached retina.

Dr. Das: When shaving the vitreous base, I use 2000 to 2500 cpm and a very low flow rate, with my vacuum set high. I use 23 gauge because I find that it is safer than 20 gauge. This is the part of the entire vitrectomy procedure that takes the longest amount of time.

In my experience, performing a peripheral vitrectomy between 11 and 1 clock hours is difficult (in 23 gauge) because visibility is poor. I either use my foot pedal or ask my nurse to raise the infusion bottle higher than what I would require for core vitrectomy or PVD.

I have used venturi for a long period of time, but

TABLE 1. SUGGESTED SETTINGS ON THE PERISTALTIC SYSTEM FOR SURGEONS WHO ARE SWITCHING FROM VENTURI

Central vitreous	50 mL/min and 400 mm Hg
Periphery	20 mL/min and 200 mm Hg
Peeling	5 mL/min and 100 mm Hg

for an attached retina, shaving the vitreous base is relatively straightforward so I would feel comfortable switching to a peristaltic system.

Shaving peripheral vitreous when the retina is detached and mobile is tricky. In this situation, switching to peristaltic might be advantageous considering the safety profile of peristaltic system. I have been mostly using low vacuum settings, 50 mm Hg to 70 mm Hg, and cut rates of 2200 to 2500 cpm. With the 23-gauge cutter I set the vacuum much higher than the 20-gauge system.

Surgery in superior peripheral retina is relatively difficult. I usually use the contact lens system (Volk Optical, Mentor, OH) for wide-angle viewing. While doing the superior vitrectomy, I also use a depressor.

As I continue to gain experience using the peristaltic system, I find that I cause fewer peripheral iatrogenic breaks. I am more inclined to use the peristaltic system for peripheral vitrectomy in cases of detached retinas.

Dr. Prünte: Over time, my standard approach has been to use the peristaltic system for peripheral anterior vitrectomy. I do not use different settings for attached vs detached peripheral retina. The anterior vitreous must be addressed as completely as possible, so one option is to perform core vitrectomy in the anterior vitreous.

My settings require high vacuum (400 mm Hg) with very low flow (4 cc/min to 5 cc/min).

Dr. Ducournau: I have the same philosophy as Dr. Prünte. A peripheral vitrectomy must be as complete as possible. I switch my flow to a maximum 6 cc/per min. My foot pedal has the flow settings of 0 cc/min to 6 cc/min preprogrammed, so I can easily select the requested aspiration flow level. I use a low cutting rate of 60 cpm to carefully attract the tissue. For most cases, I operate one pulse at a time and lower my aspiration to 1 cc/min to 4 cc/min.

I then complete a peeling of the posterior hyaloids to the base of the vitreous, depressing the sclera with my left free hand.

Mr. Luff: The way to maintain control with the venturi system, particularly with detached retina, is to decrease the efficiency of the system using a low cut rate to slow the flow. When using the Constellation Vision System (Alcon Laboratories, Inc., Fort Worth, TX), I change the duty cycle to accomplish this.

"Over time, my standard approach has been to use the peristaltic system for peripheral anterior vitrectomy. I do not use different settings for attached vs detached peripheral retina."
—Christian Prünte, MD

The low flow capabilities of the peristaltic pump are excellent in this type of situation. When I am operating with the OS3, I use a fairly high cut rate and I am able to control the flow up to the point where I encounter solid material. When I am trying to dissect solid, fibrotic material in a chronic detached retina, I lower my cut rate to 120 cpm (2 cuts per second), which offers control and efficiency. Using 23-gauge instrumentation, the light port can be moved around. With no blind spots, the surgeon can approach from different angles.

Dr. Gandorfer: In the past, I operated in exactly the same manner, applying a very low cut rate using a peristaltic pump. Several years ago, I switched to the 23-gauge system and began using higher cutting rates. I feel comfortable with higher cutting rates when controlling the flow on a very low level, and I do not change my other settings at all, regardless of the situation. This also applies for the vacuum setting which remains at 600 mm Hg. These settings are only possible by precise controlling the flow on a very low level, set at a maximum of 12 mL/min. The peristaltic pump is perfect for controlling the flow precisely.

Dr. Das: When working with the detached retina, I reduce the suction and the aspiration flow level so that the retina does not get caught in the cutter. I maintain a high cut rate and often depress the retina so that the area becomes convex and easily visible.

Dr. Chalwa: Depression definitely has a stabilizing effect. Many detached retinas have a condensed sheet-like vitreous attaching to the vitreous base or the margins of lattice—flow rates must be low to facilitate removal. The low suction and high cut rates are the key to avoiding iatrogenic breaks.

The 23-gauge cutter offers more controlled removal of the sheet up to the point where it attaches to the detached retina. The 23-gauge cutter offers the advantage to have the port closer to the tip to allow us to work closer to the retina.

Although 20-gauge technology has also improved with respect to the port's proximity to the tip, I still feel that 23 gauge offers better control of the aspiration levels, leading to more stability and fewer iatrogenic breaks.

Dr. Prünte: I routinely use 3000 cpm for shaving the retina, particularly if it is attached. In the detached retina, or in the case of hemorrhaging or PVR, a lower cutting rate is more efficient.

"When working with the detached retina, I reduce the suction and the aspiration flow level so that the retina does not get caught in the cutter."

—Taraprasad Das, MD

When I observe localized attachments of the vitreous, usually in the region of a break, I lower my cut rate to clean this from the retina. In these cases, I find that I use a dual-linear footpedal more frequently because I have more control in switching cutting rates and applying suction safely.

Dr. Ducournau: Would you say that the 3D on the Accurus (Alcon Laboratories, Inc.) is just an extension of the dual-linear foot pedal?

Dr. Prünte: No. The 3D is essentially an automated feature that instructs the surgeon. It does not offer the control of a dual-linear footpedal.

Dr. Das: How do you address lattice breaks in a mobile retina?

Dr. Prünte: I usually address lattice breaks with a medium cut rate, slowly increasing the flow.

Dr. Das: I segment the lattice into two, three, or four sections, depending on the size. I then cut with a medium rate. This method helps me to avoid further iatrogenic breaks.

Dr. Gandorfer: Dr. Ducournau, does your approach to a detached retina differ from how you address an attached retina?

Dr. Ducournau: I approach the highly mobile retina differently. Because there is no attracting force of the retina, I work with a very low flow. Low flow rates offer the surgeon the ability to attract the fiber as slowly as desired and to cut them without catching the retina.

Mr. Luff: When I encounter mobile retina, I consider stabilizing it with heavy liquids. According to the Bernoulli principle, material suddenly moves more quickly when it approaches the port of the cutter, so I try to stabilize the retina.

EPIRETINAL MEMBRANE REMOVAL

Dr. Gandorfer: Have improved cutting rates with 23-gauge technology changed your strategy in epiretinal membrane (ERM) removal for patients with diabetes?

Dr. Das: I am fond of using 23-gauge technology, particularly for my patients with diabetes. I do not have to switch from scissors to forceps to perform dissection and membrane peeling, and I no longer perform en bloc dissection; the 23-gauge helps me to do both. I occasionally use forceps in cases where the membrane is sitting on the optic disc; I lift the membrane with the forceps and remove it with the cutter. I use very high cut rates, which allow me to move across the membrane.

During the surgery, I inject small bubbles of perfluorocarbon liquid to allow better visualization even in presence of small bleeds. I use a good deal of laser for most cases, and finally I use gas or oil as needed. In India, most diabetic patients stay in the

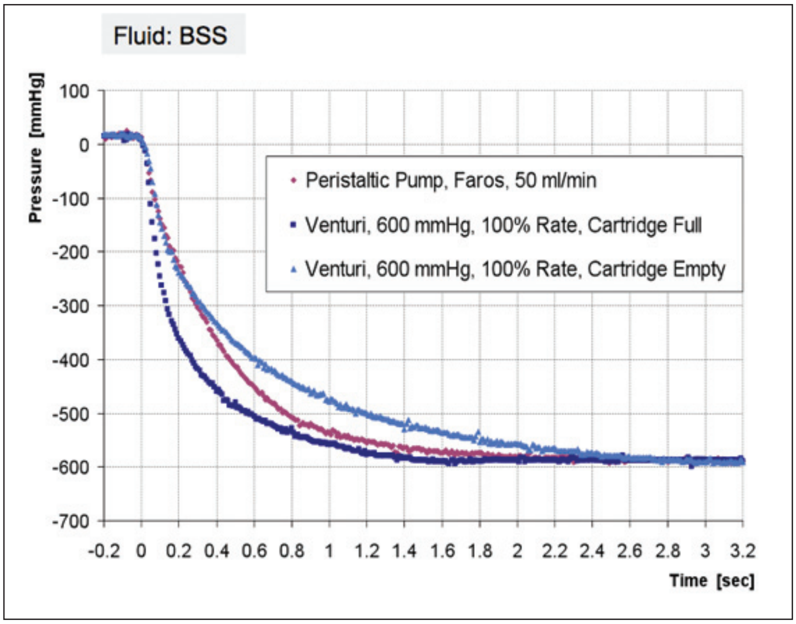

Figure 4. There is no significant difference in the vacuum build-up time between the peristaltic and venturi pumps. Clinically, both systems are equally efficient regarding the vacuum rise time.

Data on file, Oertli Instruments.

hospital overnight; this allows us demonstrate correct postoperative positioning, if any, and also allows a quick look on the first day after surgery.

Recently, we began administering intravitreal bevacizumab (Avastin, Genentech, Inc.) a week or so before the vitreous surgery. This has reduced the incidence of intraoperative bleeding, and the postoperative recovery time has also shortened.

Using 23-gauge technology, I did not initially find a difference between venturi and peristaltic. I have slowly come to realize that 23-gauge peristaltic may be safer because one has a better control of flow levels but still good vacuum, which allows the cutter to be used as a multifunction instrument, obviating the need for scissors.

Dr. Jundt: With correct flow settings, the vacuum rise time during membrane removal is the same between peristaltic and venturi technology (Figure 4).

Dr. Chalwa: Diabetes is a major issue in India. In my clinic, many patients present with taut posterior hyaloid membranes with associated diabetic macular edema in diabetic eye disease. I use a simple 23-gauge vitrectomy with high cutting speeds for posterior hyaloid membrane removal. For more complex cases, such as when I am dealing with a difficult detachment, extra care is required to avoid the possibility of iatrogenic breaks. I still use 23-gauge surgery, but I use a 25-gauge chandelier at the 6 o'clock position with a noncontact viewing system for membrane dissection. During the dissection, I switch to a regular contact-lens viewing system; this gives a better visualization of epicenters and other attachments. I also use bevacizumab prior to surgery, but I have shortened the waiting period to operating on the fourth or fifth day after the injection.

I use silicone oil infrequently, reserving it for difficult tabletop detachments.

Dr. Prünte: The advances that have been made to small-gauge vitrectomy systems in terms of better control, small incision sizes, and cutter designs have changed my approach to epiretinal membranes. I rarely use a bimanual technique for membrane removal because I can accomplish most of the task with my cutter; however, I do require a system that is flexible in regard to flow, vacuum, and cutting rate.

"With correct flow settings, the vacuum rise time during membrane removal is the same between peristaltic and venturi technology."

—Gregor Jundt, PhD

"Based on the economic issues that face physicians and the healthcare system in India, we should be doing combined procedures rather than wait to perform a second procedure."
—Shobhit Chalwa, MD

The dual-linear footpedal on the OS3 offers a significant advantage in allowing flexibility in vacuum and cutting rates throughout the procedure.

Dr. Ducournau: In France, fewer than 5% of the vitrectomies are performed on patients with diabetes. When I perform vitrectomy for a diabetic case, I use extremely low cutting rates and carefully control the aspiration. I use aspirating diathermy to control bleeding during the procedure.

Mr. Luff: Injecting bevacizumab prior to a diabetic vitrectomy has greatly improved my outcomes. In terms of technology, the 23-gauge cutter has become a multi-modal instrument. The 23-gauge cutter can be used to aspirate blood, as a pair of forceps, as a tissue manipulator, and as a cutter. Like Dr. Prünte, I have moved away from bimanual surgery so I do not need my chandelier as often.

COMBINED PHACO/VITRECTOMY

Dr. Chalwa: I first became interested in combined phaco/vitrectomy during my visiting fellowship at the Singapore National Eye Center in 1994. They were performing a large volume of cases; at that time, all the surgeries used 20-gauge technology.

When I began practicing in India, I considered that many of our patients for whom we perform vitrectomy for proliferative or nonproliferative diabetic eye disease often present with 1+ nuclear sclerosis, but the standard practice was to remove a lens and wait 2 months before performing a vitrectomy or vice versa to avoid the incidence of neovascular glaucoma. Based on the economic issues that face physicians and the healthcare system in India, we should be doing combined procedures rather than wait to perform a second procedure.

When we first started doing these combined procedures (pre-bevacizumab), our goal was to make better ablations using both the endolaser and the laser indirect ophthalmoscope. The results were good—we were addressing everything in the same procedure while at the same time improving the visualization for ERM surgery. Bevacizumab, of course, has made the procedure even safer for patients with diabetes.

Dr. Gandorfer: What are the obstacles to performing combined procedures?

Dr. Prünte: I have been an advocate for combined procedures for more than 15 years. We must consider that we induce cataract with our vitrectomy procedures and although at times a cataract does not interfere with the view to the retina, there is never better access to the anterior retina than in an aphakic eye. This is the reason that I always implant the IOL at the end of a combined procedure. In general, I see many advantages to performing a combined procedure.

Dr. Ducournau: This is a complex subject because many factors must be taken into account. First, the quality of the vitrectomy should be considered. In the case of a complete vitrectomy, it is highly likely that cataract will result; a combined procedure makes sense in this scenario. Core vitrectomy, however, is associated with a moderate instance (approximately 60%) of cataract formation, so systematic phaco is essentially condemning 40% of patients to an unnecessary procedure.

Second, in France, most surgeons who are doing combined procedures are those within the university setting. A patient who is referred to the retinal specialist "belongs" to the referring ophthalmologist. It is considered better not to perform a procedure that an ophthalmologist can manage.

There are cases, however, for which I find combined surgery to be necessary. For these, I am using a bimanual technique starting with a 1.4-mm phaco incision. When phaco is complete, I do not implant an IOL; rather, I insert a capsular tension ring to protect the posterior capsule during the vitrectomy time. At the end of the procedure, I enlarge my original incision to 2 mm to inject the IOL.

> "There is nothing that a venturi pump can accomplish that a peristaltic pump cannot."
>
> —Didier Ducournau, MD

ARE TWO PUMP SYSTEMS STILL NEEDED?

Dr. Gandorfer: We have had a large amount of discussion regarding venturi vs peristaltic systems. In your opinion, do we still need two pump systems in one machine?

Dr. Ducournau: There is nothing that a venturi pump can accomplish that a peristaltic pump cannot, so my answer is no.

Mr. Luff: I have no need for a venturi pump—I choose a peristaltic pump for all surgical situations.

Dr. Das: I agree. I find that I am using a peristaltic pump system more frequently.

Dr. Gandorfer: Do you still need to have a venturi pump system available?

Dr. Das: No.

Dr. Chalwa: I still use both; based on my own clinical experience, I believe there is an advantage to using venturi for some procedures. As to whether I need a venturi pump system, I would say no—I agree that all tasks that are performed by a venturi pump can be accomplished with peristaltic. Having one pump system would also cut down on costs, but I admit that I would miss the small advantages of having access to both.

Dr. Das: This is an important point. Currently, there is not one vitrectomy system that is dependable and that is tailored to the needs of the low-income countries around the world. If we had a low-cost but highly dependable machine available, surgeons and patients living in low-income countries would certainly benefit. Eyecare in these regions of the world is currently in evolution, and I think that Sub-Saharan Africa and Southeast Asia will become a major focus in the near future.

Dr. Luff: The peristaltic pump system offers the benefit of its performance not being dependent on the vacuum supply of the hospital in which it is installed, which would be important in these regions of the world.

TRAINING AND EDUCATION

Dr. Gandorfer: When training new surgeons, should we begin with a 23-gauge system?

Mr. Luff: Unfortunately, we have no choice in a National Health Service hospital. I must train surgeons with 20-gauge technology to open the conjunctiva. If I did have the choice, I would start with a 23-gauge system for a number of reasons. It is easy for the experienced surgeon to forget how demanding and tiring vitreoretinal surgery can be when we first begin. Twenty-three–gauge technology allows us to spend more time performing the important tasks in vitrectomy and less time opening and closing the conjunctiva. Additionally, self-sealing 23-gauge surgery lowers the risk of hypotony, retina incarceration, and retinal tears. In summary, I believe that 23-gauge is the safer technology.

Dr. Das: In my opinion, 23-gauge vitrectomy is more difficult to teach and to learn, but in time 20-gauge technology will become obsolete. There will come a time when teaching 20-gauge surgery rather than 23-gauge surgery will be akin to teaching extracapsular cataract extraction rather than phacoemulsification. I would rather take the extra time to teach on a technology that I know will be used by my students in the future. Because wound construction is so important with 23-gauge technology, it would be advantageous to have a teaching model on which students can practice their technique.

Dr. Chawla: In my opinion, 23-gauge technology is best for new surgeons. I agree with the advantages stated by Drs. Luff and Das, but I would also

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>
> —Taraprasad Das, MD

add that 23 gauge offers greater protection against cannula-induced traction on the vitreous space and associated complications.

Dr. Prünte: I also teach with 23 gauge—I think that the closed system and autoseal approach with 23 gauge adds to the safety. It is more difficult for beginners, however, when working with soft tissue.

Dr. Gandorfer: Would you consider training a new surgeon on the 25-gauge transconjunctival approach?

Dr. Ducournau: Whether I would have a new surgeon try 25-gauge transconjunctival surgery depends on the indication.

For retinal detachment surgery, for example, I teach students to use a 360° conjunctival incision for membrane peeling. I am convinced that scleral depression improves peeling because it stabilizes the retina.

In regard to 23-gauge surgery, I would not hesitate to train new surgeons using this technology.

CONCLUSION

Dr. Gandorfer: I would like to thank the faculty for their participation in this roundtable discussion. It is important to understand the options that are available to us as surgeons. Through this discussion, it has become clear that although both venturi and peristaltic have their own distinct advantages, if one were to choose between them, peristaltic technology would come out ahead in terms of directly controlling the flow at the lowest necessary level. We are fortunate to have different options, and as technology advances, our choices become more specifically refined to our needs. ■

TAKE-HOME MESSAGES

- The peristaltic pump is equally well suited for VR surgery as the traditional venturi pump.
- In situations like PVR, shaving of the vitreous base, removal of peripheral vitreous, and mobile retina, the peristaltic pump even offers the following advantages: higher precision and more safety, thanks to direct flow control.
- Dual-linear pedal control, valved trocar systems, and appropriately selected cut rates between 1 and 50 per second further increase safety and precision.
- For learning, peristaltic is preferred.
- There are no obstacles to combined surgery.