Evaluating Intraoperative IOP Levels During Cataract Surgery

An effort to improve patient safety.

BY JOSÉ RAMÓN HUESO, MD; ENCARNACIÓN MENGUAL, MD; AND JUAN GARCÍA, MD

The risks of extreme fluctuations in IOP during cataract surgery are well known.[1-5] We believe that maintaining a safe IOP profile is important throughout both standard coaxial phacoemulsification and bimanual microincisional phacoemulsification. We therefore conducted a study to determine the intraoperative IOP profile during our cataract procedures and whether we could make adjustments that increased overall safety.

MATERIALS AND METHODS

We operated on 125 eyes with cataracts (80 using standard phacoemulsification through a 2.75-mm incision and 45 using microincisional phacoemulsification through a 1.5-mm incision).

We used the series 20000 Legacy phacoemulsifier (Alcon Laboratories, Inc., Fort Worth, TX) for all procedures. Specifically, we employed an aspiration flow rate of 25 mL/min, a maximum vacuum level of 500 mm Hg, an ultrasound power of between 25% and 40%, a pulse rate of 18 pulses per second, and the Neosonix technology (Alcon Laboratories, Inc.) at 100%.

SURGICAL TECHNIQUE

Our initial technique varied according to the type of cataract. We performed bimanual phacoemulsification

Figure 1. The authors connected the Universal Pressure Meter to the irrigation terminal.

TABLE 1. THE SEVEN STAGES OF PHACOEMULSIFICATION

Irrigation (Stage 1)	Instrument's entry
I/A (Stage 2)	Initial viscoelastic/ epinuclear removal
Occlusion (Stage 3)	Impaling of nucleus
Full Occlusion Break (Stage 4)	Breaking of nucleus
Partial Occlusion Break (Stage 5)	Fragment emulsification
I/A (Stage 6)	Cortical removal
Irrigation (Stage 7)	Instrument's exit

using an appropriate nucleofractis method such as divide and conquer or phaco chop. For every case, we created two paracenteses (1 mm each) and one main incision. The pressure transducer was introduced through the second paracentesis in order to measure IOP.

Incisional leakage was an essential component of the IOP profiles. To approximate the amount of leakage around the instruments' shafts, we estimated the residual space within each incision that was not blocked by the instrument. In standard coaxial phacoemulsification, we estimated the incisional leakage to be through a 0.53-mm space. For bimanual microincisional phacoemulsification, we estimated a 0.15-mm space.

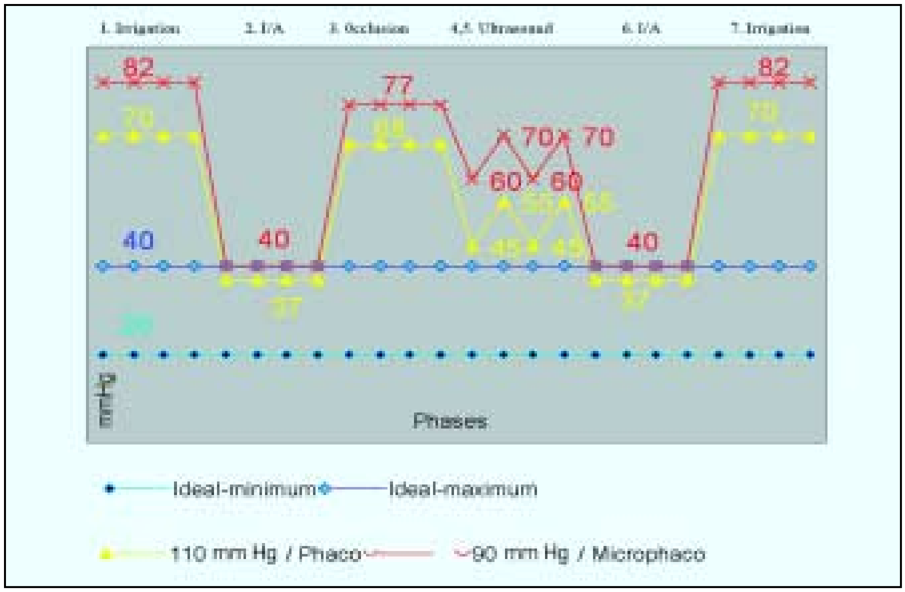

Figure 2. The authors' initial profile evaluation is depicted.

SURGICAL MONITORING

We divided the fluid dynamics occurring during phacoemulsification into seven arbitrary stages (Table 1). We recorded the IOP during each stage. We defined *hydrostatic infusion pressure* as that obtained through gravity according to the height of the BSS irrigating bottle and *forced infusion pressure* as that obtained using a positive-pressure air pump (Grieshaber Air System; AlconCUSÍ, Barcelona, Spain) connected to the bottle at the patient's head level.

To measure IOP values, we used the Universal Pressure Meter (Bio-Tek Instruments, Inc., Winooski, VT) (Figure 1) connected to the irrigation terminal through a millipore filter and a unidirectional safety valve. After introducing the irrigation tip into the anterior chamber, we carefully recorded IOPs during each of the aforementioned seven stages. For each stage, we compared

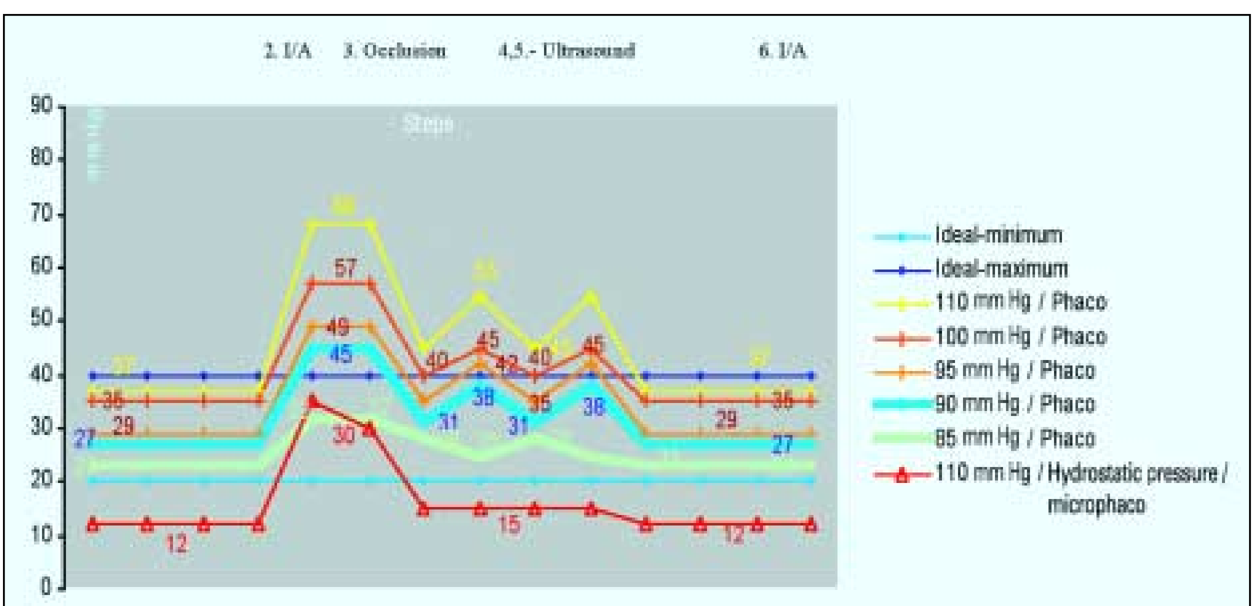

Figure 3. The authors improved their profiles.

the infusion pressures generated by the two irrigation systems: hydrostatic versus forced infusion. We also compared the IOP profiles between the standard coaxial and bimanual microincisional phaco techniques.

RESULTS

Our preliminary findings (Figure 2) showed that the gravity-fed system (hydrostatic infusion pressure) yielded higher intraoperative IOP levels than the positive pressure system (forced infusion pressure; 110 vs 90 mm Hg, respectively). We were impressed by how high an IOP level was reached during stages 1, 3, and 7. These levels were on the order of 70 to 80 mm Hg.

We reduced these IOP spikes (Figure 3) by first eliminating stages 1 and 7; we simultaneously commenced aspiration as we introduced the instruments through the viscoelastic-filled anterior chamber. To reduce the high IOP levels occurring during stage 3 (occlusion), we substituted manual chopping and fracturing maneuvers for ultrasound and impaling. This technique also re-

DISCUSSION

By Mark Packer, MD

The stability of the volume and anatomic conformation of the anterior and posterior chambers is critical to the safety of phacoemulsification. Maintaining a constant volume within the anterior segment of the eye facilitates intraocular maneuvers such as the creation of the capsulorhexis, hydrodissection, and the aspiration of tissue. The loss of chamber stability threatens the integrity of the capsular bag and corneal endothelium, thereby increasing the likelihood of posterior capsular rupture and corneal edema.

During surgical steps when aspiration is not required, such as the creation of the capsulorhexis and IOL insertion, modern surgical technique relies upon viscoelastic devices to maintain volume. When aspiration is necessary, however, as during the phacoemulsification of lenticular material, surgical technique requires intraocular irrigation to maintain volume and prevent chamber collapse. The rate of inflow of irrigation fluid must equal or exceed that of aspiration outflow and incisional leakage in order to maintain chamber stability. Phaco equipment relies on gravitational flow (irrigation bottle height) or forced infusion (pressurization of the irrigation bottle) to produce inflow. Pressure drives irrigation fluid into the eye to maintain the stability of the anterior segment during surgery.

Although physiologic IOP rests between 10 and 20 mm Hg, physiologic conditions are not necessarily optimal for surgery. In their article, José Hueso, MD; Encarción Mengual, MD; and Juan García, MD, suggest that an ideal pressure profile lies between 20 and 40 mm Hg throughout the surgical process. They base their idea on published reports documenting the risks of extreme fluctuations in pressure and hypothetical considerations concerning the Scylla and Charybdis of excessive pressure and chamber collapse. Nevertheless, the optimal pressure profile for phacoemulsification remains to be determined.

Hueso et al describe a relationship between infusion pressure and IOP for standard coaxial phacoemulsification and for bimanual microincisional phacoemulsification. Notably, they have explored avenues to alter surgical technique to maintain IOP in the range they deem optimal. Optimal surgical technique, however, should not be determined by hypothetically derived values of IOP (or any other intraoperative parameter, for that matter). Rather, surgical methods should be evaluated in terms of outcome variables in order to determine optimal parameters. Surgeons exploring the intraoperative control of IOP therefore could help advance the science of phacoemulsification by studying the relationship of pressure and outcomes such as immediate postoperative UCVA, postoperative IOP, postoperative endothelial cell loss, and postoperative anterior chamber reaction.

IOP represents a surgical tool for maintaining a stable anterior segment during surgery. Although studies of IOP and surgical technique may help guide us to decreased morbidity and improved outcomes, we should not presume to know in advance the ideal range for IOP. Higher pressures may, in fact, represent a benefit by permitting the more rapid completion of surgery and the reduced use of ultrasound energy in phacoemulsification. Only prospective, randomized investigations of technique will permit us to determine the "ideal profile."

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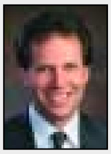

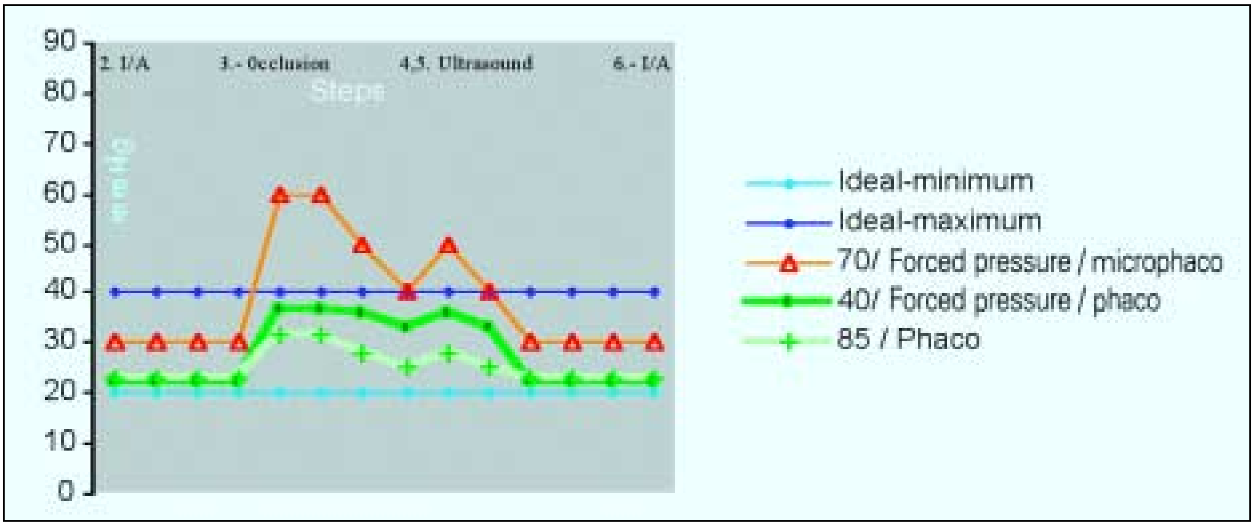

Figure 4. The authors' ideal profiles are shown.

duced the total ultrasound time needed.

Because our IOP levels were still high during stages 3 through 5 (occlusion, full and partial occlusion break), we reduced the infusion pressures during both phacoemulsification and microincisional phacoemulsification. We tried both the gravity infusion and the positive-pressure infusion systems, and we obtained our ideal profiles. We feel that the safest IOP profiles resulted when we used the positive-pressure infusion system, which produced IOP levels of 40 mm Hg (Figure 4).

CONCLUSIONS

With this study, we obtained IOP profiles that have practical implications for our surgical techniques. A hydrostatic infusion pressure (bottle-gravity infusion) of 85 mm Hg (110-cm bottle height) is enough in standard coaxial phacoemulsification, because it situates the profile between 20 and 40 mm Hg. In bimanual microincisional phacoemulsification, an infusion pressure of 135 mm Hg (135-cm bottle height) is inadequate; the profile during the I/A stage is less than 20 mm Hg, because the inner diameter of the irrigation terminal offers resistance to the fluid, reduces irrigation flow speed,[6,7] and thus provokes anterior chamber instability.

A forced-infusion pressure (air infusion pump) of between 40 and 50 mm Hg is acceptable in standard coaxial phacoemulsification, and 70 mm Hg is sufficient in bimanual microincisional phacoemulsification.

Our improved profiles in standard coaxial phacoemulsification are obtained with an 85-mm Hg hydrostatic-infusion pressure and a 40-mm Hg forced-infusion pressure, whereas, in microincisional phacoemulsification, the forced-infusion pressure required is 70 mm Hg. We achieved our ideal profile with standard coaxial phacoemulsification and a forced-infusion pressure of 40 mm Hg. ■

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