

Telemetric Intraocular Pressure (IOP) Monitoring in the Adult Monkey Shows Ocular Pulse Increases with IOP

J. Crawford Downs¹, Claude F. Burgoyne², Yi Liang¹, Verney Sallee³

¹Ocular Biomechanics Laboratory and ²Optic Nerve Head Research Laboratory, Devers Eye Institute, Portland, OR

³RTOP Consulting, Colorado Springs, CO

Purpose

To test the hypothesis that the ocular pulse amplitude (OPA) is higher at high IOP. Collagen-based tissues such as cornea and sclera stiffen significantly as they stretch, and also stiffen with age. We hypothesized that in conditions when the corneoscleral shell is stiffer (e.g. at higher baseline IOPs and/or in older eyes) the eye is less able to absorb transient IOP fluctuations and therefore the ocular pulse amplitude is higher.

Methods

We have adapted a proven implantable telemetric pressure transducer system (T30F, ITS, Dexter, MI) to monitor IOP by integrating the transducer into a custom baseplate fixed to the orbital wall that is connected to the anterior chamber via a silicone tube. An implanted transmitter sends 500 IOP, ECG and body temperature measurements per second to an external antenna in the perch of the cage. Data is acquired with a commercially available system equipped with real-time barometric pressure compensation (ITS).

We tested transducer accuracy from 5-55 mmHg in two implanted monkeys by cannulating the anterior chamber with a 27-G needle connected to an adjustable saline reservoir equipped with an in-line digital manometer. We recorded continuous telemetric IOP and ECG data during IOP calibration tests while the animals were under anesthesia, with steady heart rates of 110 and 130 beats/min and blood pressures of ~110/65 and 105/60, respectively. We calculated ocular pulse amplitudes at IOPs ranging from 3.5 to 54 mmHg.

Results

- The IOP transducer was accurate to within 1 mmHg from 5 to 55 mmHg, with a base noise level ≤ 0.5 mmHg (Figure 1)
- Average ocular pulse amplitude increased nonlinearly with IOP from 10 to 50 mmHg (Figure 2)
- There was no detectable ocular pulse at IOPs below approximately 8 mmHg
- Peak ocular pulse lagged left ventricle contraction by approximately 50% of the cardiac cycle duration
- IOP fluctuated with respiration with an amplitude of ~0.2 mmHg at an IOP of 10 mmHg increasing to ~0.5 mmHg at an IOP of 40 mmHg (Figure 3)

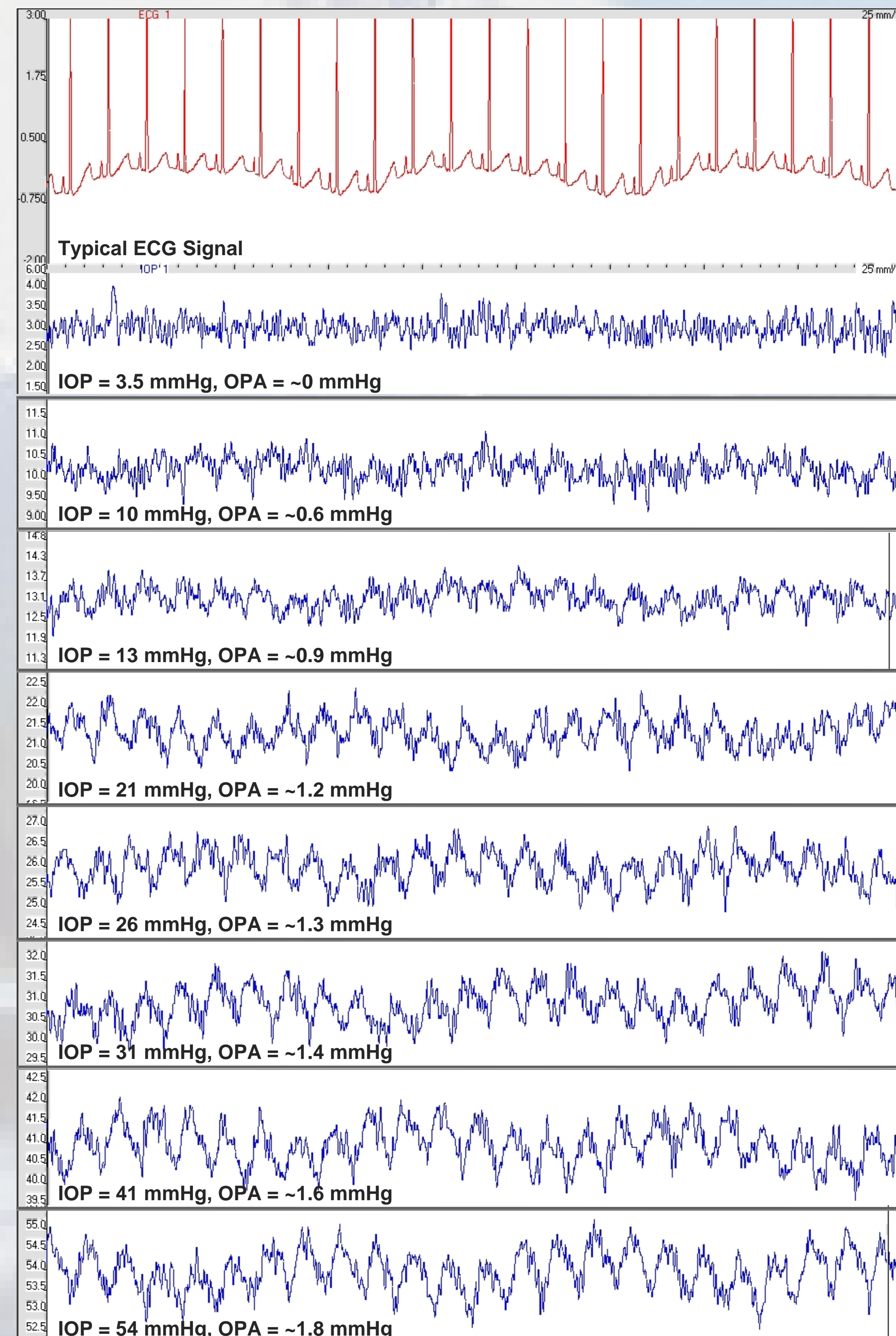


Figure 1. Screen captures of typical telemetric ECG and IOP signals for IOPs of 3.5 up to 54 mmHg in Monkey 2 showing ocular pulse amplitude increasing with IOP

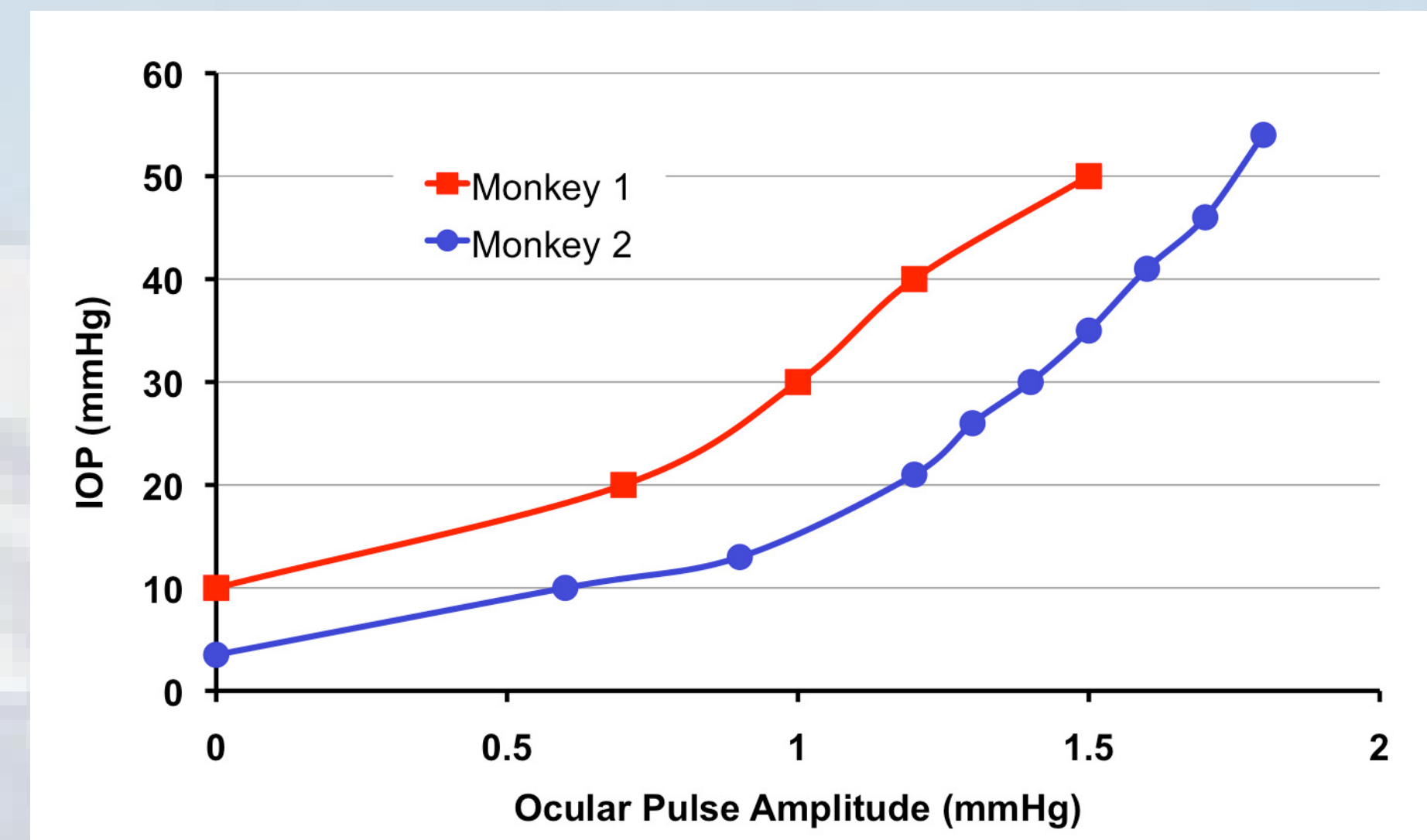


Figure 2. Ocular Pulse Amplitude versus IOP for Monkeys 1 and 2

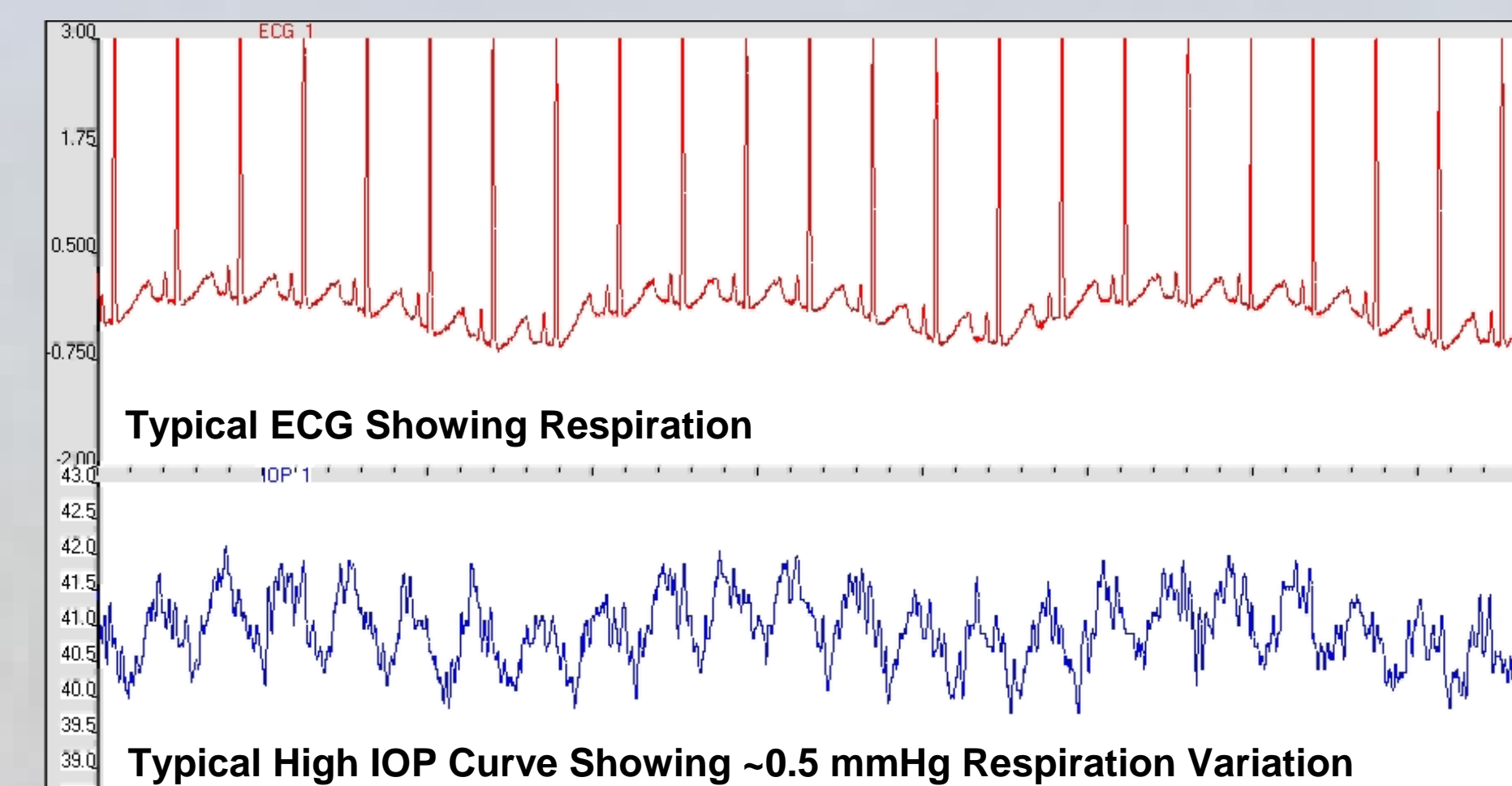


Figure 3. Screen capture of the coupled real time ECG and IOP signals showing respiration in both signals as a slow sinusoidal rhythm

Conclusions

- Ocular pulse amplitude in the adult monkey is ≤ 0.5 mmHg at IOPs below 8 mmHg, but increases nonlinearly with IOP to ~1.5 mmHg at 50 mmHg
- In conditions when the corneoscleral shell is stiffer (e.g. at higher baseline IOPs and/or in older eyes) the eye is less able to absorb transient IOP fluctuations and therefore the ocular pulse amplitude is higher
- Such fluctuations may expose the optic nerve head in eyes with stiffer corneoscleral shells and/or higher baseline IOP to higher magnitude cumulative IOP insult over time