Phacodynamics

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Irrigation and aspiration are common techniques employed in ophthalmic surgery. Aspiration uses pumping to remove liquid and debris generated during a surgery. Pumping creates a partial vacuum; the negative pressure forces liquid out.

Three different pumping systems are in use in modern phacoemulsification machines: peristaltic pump, venturi pump and diaphragm pump.

With the peristaltic pump the fluid is removed through flexible tubing using a series of rollers mounted on a rotating wheel. As the wheel rotates, the revolving rollers pinch the tube against the wall (figure 1).

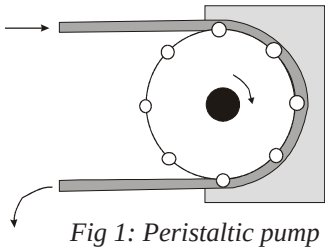

Fig 1: Peristaltic pump

The fluid that gets into the region between the rollers is pushed out in the direction of rotation. At low speeds of rotation a vacuum is not produced unless the aspiration port is occluded. As the speed of rotation is increased, a vacuum is produced in the aspiration line without occlusion.

In the venturi pump Bernoulli's principle is applied. When the speed of flow of a fluid is increased in a region, the pressure there is decreased. Compressed gas, such as air or nitrogen, flowing through pipe A (figure 2) reduces the pressure in the region just above the tube B and creates a partial vacuum in space C. There is no moving part in this pump.

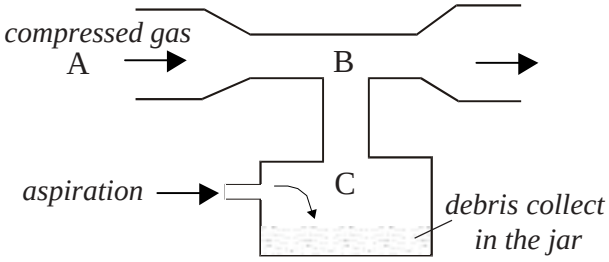

Fig 2: Venturi pump

In the diaphragm pump a flexible metal or rubber diaphragm moves up and down. This movement, along with the vertical motion of two valves, maintains the vacuum (figure 3).

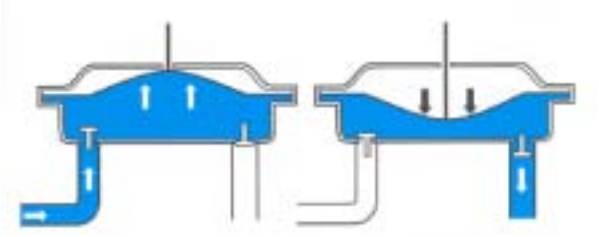

Fig 3: Diaphragm pump

Clinically, diaphragm and venturi pumps are very similar.

Knowledge of rise time and flow rate is important in understanding the mechanics of these pumps. Flow rate measures fluid turnover in the eye and more importantly, indicates how quickly events will progress once the aspiration port is either suddenly occluded or suddenly cleared. Rise time measures how rapidly a vacuum builds up once occlusion has occurred at the aspiration port.

The diaphragm and venturi pumps have rapid flow rates and rise times. The peristaltic pump has a slower rise time, which can be made more rapid by increasing the rotation of the wheel (i.e. at a higher flow rate).

Because venturi and diaphragm pumps have inherently higher flow rates, they build up vacuums in the aspirate line without occlusion of the aspiration port. Once the tip is occluded, a vacuum builds up rapidly.

A peristaltic pump with a slower flow rate is useful for a beginner because it provides the largest safety margin in the event of a sudden capsule occlusion in the aspiration port. The slow rise time allows enough time for the surgeon to come back to position 1 of the foot pedal or even relax. The disadvantage of a peristaltic pump is that it results in a longer procedure. A peristaltic pump at a moderately high

flow rate presents a good compromise between safety and efficiency. The relative performances of the pumps are shown in (figure 4)

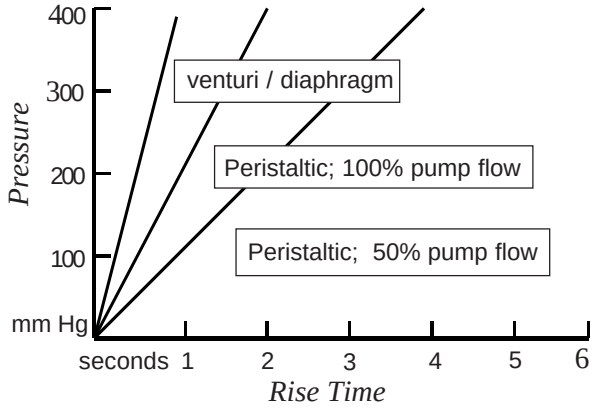

Fig 4: Relative performance of pumps

With regard to maintenance, at the end of the surgery the peristaltic pump should be thoroughly flushed to remove all debris. Debris left behind will stick to the side of the tube and remain there. The debris stuck to the wall blocks the passage and reduces the pumping efficiency. In the diaphragm pump the debris may collect at the side of the valves and block the pumping or reduce the pumping efficiency. A proper flushing of this system is also needed after surgery. The amount of cleaning required for the venturi pump is less severe. The debris will collect at the bottom of the container (figure 2); it is sufficient that the container be emptied and cleaned. This is a much simpler procedure than cleaning tubes and valves. Since there are no moving parts, the life of a venturi pump is longer than the life of the other pumps.

Maintenance tips

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Ophthalmoscopes use a spring loaded steel ball for controlling the motion of the lens disc. In Slit lamps there is a similar arrangement to control the movement and setting of the filters, and at the adjustment lever for the slit height. While servicing those instruments care should be taken not to lose the ball. Because they are spring-loaded (kept in position by a spring) they tend to jump off when the pressure on the spring is released. When the ball jumps off and is not traceable it will be very difficult to get a replacement. A cycle shop may be able to give steel balls of certain sizes. A more useful place to get metal balls of various small sizes will be the welding shops. At the time of welding metals one would notice sparks flying off in all directions. The sparks are metal in molten state that solidify into spherical balls. After welding is done if the floor is swept one can get metal balls of various small sizes which will be very useful as replacement for lost spherical balls of instruments. A visit to a welding shop may give enough balls for a few years for a technician.