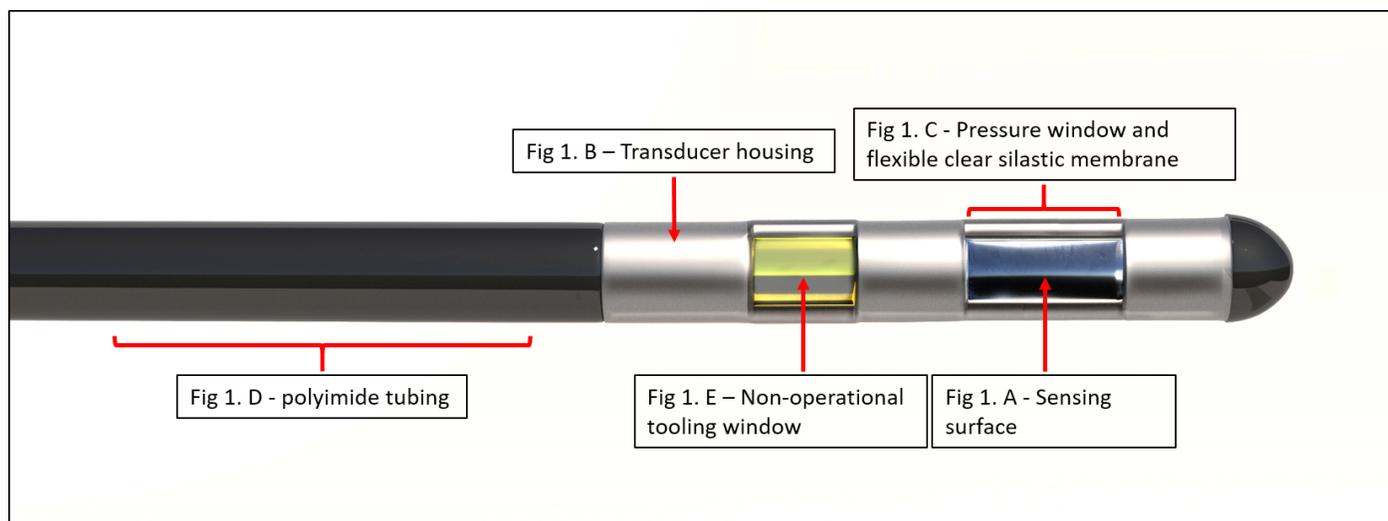# Anatomy of a Pressure Sensor

Pascal's law states that for a fluid in a closed container, a pressure change in one part is transmitted without loss to every portion of the fluid and to the walls of the container.

When inside a ventricle, the catheter's "sensing surface" (Fig 1. A) will experience the pressure of the fluid within the chamber regardless of where the sensor is inside the chamber. This sensing surface is a small portion on one side of the "transducer housing" (fig 1. B) and is able to sense pressure through a small opening in this housing. The opening is referred to as the "pressure window" (Fig 1. C). The pressure window is located directly above the transducer sensing surface. The pressure window is filled with a "flexible clear silastic membrane" (Fig 1. C) that is in simultaneous contact with the transducer sensing surface and the blood. The flexible membrane is responsible for separating the transducer electronics inside the housing from moisture and also for transferring the force of the blood pressure to the transducer sensing surface inside the sensor housing. This along with the external "polyimide tubing" (Fig 1. D), and delicate internal wires that transmit the recorded data, constitute a **solid-state pressure catheter** (Fig 1).

Fig 1. B – Transducer housing

Fig 1. C - Pressure window and flexible clear silastic membrane

Fig 1. D - polyimide tubing

Fig 1. E – Non-operational tooling window

Fig 1. A - Sensing surface

Things to be aware of when using micro pressure sensor catheters:

PRESSURE SENSOR ORIENTATION

In order for the transducer to work, the pressure window must be exposed to the body of fluid being observed. Keep in mind that the sensor window is on the side of the sensor. When the pressure window interacts with tissue rather than fluid, the result will be the sensor reporting the force of tissue interaction, and not the fluid pressure of interest. Situations where the transducer is reporting tissue force is when the transducer is in a small diameter blood vessel and interacts with the vessel wall or in a ventricle and the sensor window interacts with trabeculae or ventricular walls.

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THE MEASURE OF   BETTER RESULTS.

Anatomy of a Pressure Sensor Cont.

SHORT TERM FLEXIBLE MEMBRANE CHANGES

The flexible silastic membrane that separates the sensing surface from fluid must be largely impermeable to fluid. In reality all silastic materials have some degree of permeability, meaning that the flexible membrane absorbs some amount of fluid and swells when exposed to water. The swelling will change the dimensions of the flexible membrane and exert force on the sensing surface. The changing output from the sensor during this event is called "Hydration drift". Hydration drift will continue until the silastic has absorbed as much water as it can; typically half an hour in a saline solution. This is why we hydrate our catheters prior to use.

LONG TERM FLEXIBLE MEMBRANE CHANGES

Inevitably, the mechanical properties of the silastic sensing membrane are going to change with time and use. A small part is due to age and ambient environment when the catheter is stored. A larger influence is care and maintenance of the sensor post-use. Dissolved proteins entering the silastic membrane during use and any tissue left to dry on the flexible membrane can alter its mechanical properties over time. Much can be done to lessen any degradation if the catheter is not allowed to dry with any bio-material on the membrane. Careful adherence to the cleaning steps as outlined in our care and use documents will prolong catheter life and accuracy.

BALANCING THE TRANSDUCER

Before using a pressure catheter, the sensing surface needs to be balanced or "Zeroed". This is an electronic method to compensate for any system changes in the sensor or its electronics; either as it ages or undergoes thermal or re-hydration driven forces. Transducer balancing must be done before every experiment. This process is covered in our Quick Start Guides and user manuals.

MECHANICAL COMPONENTS INSIDE THE CATHETER

In order to prolong the life of a micro catheter, it is important that the user have some appreciation of the mechanism. The sensing surfaces, tube wall and conducting wires are measured on the order of microns. It is not unrealistic for an untrained user to unknowingly apply damaging forces to the catheter.

1. A common form of damage to micro tip catheters is catheter shaft damage from excess force applied to the shaft. Similar to an eggshell, the polyimide shaft material will collapse if it is deformed past a certain point either by bending or crushing. Shaft strength will not return once it has gone past the yield point. The catheter shaft will also be weakened by any micro cuts or abrasion. Collapsed shaft tubing is often responsible for damaging the very small wires inside the shaft.

2. The transducer sensing surface is only microns thick and resides directly under the flexible membrane in the pressure window. It is important that any non-fluid forces be minimized in this area. Tissue, bending and abrasion from overly tight sutures are examples of forces that can rupture the sensing surface.

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Anatomy of a Pressure Sensor Cont.

CATHETER CONNECTOR AND STRAIN RELIEF

To this point we have talked largely about the catheter's distal tip, but consideration must also be given to the catheter's connector and strain relief. Located at the proximal end of our catheter is a connector or "handle board" (Fig 2. A), which allows for interface with our pressure hardware via an "HDMI connection" (Fig 3.). This area should be kept dry and free of dust/debris at all times to ensure proper functionality. Directly attached to the handle board is a white rubberized "strain relief" (Fig 2. B) that is designed to reduce stress on the polyimide tubing that can be caused by articulation of the tubing relative to the handle board. We suggest minimizing the necessity of the strain relief and this can be accomplished by positioning the handle board close to your subject and taping it down. This will prevent unexpected movement of the connector that can happen during a complex surgery. With the above fundamental information in mind, a careful review our handling and care documentation will go a long way to prepare you for successful and safe data collection.

Fig 2. B – Strain relief

Fig 2. A – Catheter Connector or "Handle Board"

Fig 3. – Catheter's HDMI Connection

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