

**Title:** Device to Measure Tissue Hydraulic Impedance

**Authors:** Thomas Edrich Ph.D., M.D., James H Philip, M.D., M.Eng

Department of Anesthesiology, Perioperative, and Pain Medicine

Brigham and Women's Hospital, Boston, MA, United States.

**Introduction:**

Tissue Hydraulic Impedance can be defined as the complex resistance that is felt when injecting fluid into biological tissue spaces. Anesthesiologists use this method on a qualitative level when advancing a needle into the epidural space to place an epidural catheter. The sudden “loss of resistance” occurs when the needle tip passes from a ligament with high impedance to the epidural space which has very low impedance. Pitfalls include reaching a “false space” with low impedance to the initial injection. This can be recognized by the increasing hydraulic impedance after subsequent fluid injections.

**Method:**

A device is placed between the syringe and the needle. It consists of a channel with 2 pressure transducer ports as shown in the figure below. As the user tests the hydraulic impedance in the usual fashion by depressing the plunger of the syringe with her thumb, the flow of fluid past a mild stenosis between the ports causes a pressure difference to build up. This is a measure of the instantaneous flow rate. The hydraulic impedance (Z) can be calculated by dividing the distal pressure (P) by the flow rate (I):  $Z=P/I$ .

**Results:**

In-vitro testing was performed using a prototype of the depicted device. The device was placed between an epidural needle (17 Gauge, 3.5 inches) and a 5 mL glass syringe filled with saline. Clinical pressure transducers (Edwards Life Sciences, Inc.) and an Eagle Monitor (Marquette) were used to measure continuous pressures at both ports. Pressure readings were transmitted to a PC using BedMaster software<sup>®</sup> (Excel Medical Electronics, Inc.) and processed using MATLAB<sup>®</sup>. An experienced anesthesiologist tested the setup by inserting the needle and injecting saline into several different Styrofoam blocks. The consistency of these blocks was chosen to simulate different biological tissue types. Variable pressure was applied to the foam to modulate the hydraulic impedance. Certain foam types exhibited the phenomenon of the “false space,” increasing the hydraulic impedance rapidly after subsequent fluid aliquots had been injected.

**Conclusion:**

We have created a new device that is able to identify a simulated tissue plane by quantifying the impedance to fluid injection. It fits between the needle and the syringe and should not significantly disturb the clinician in his usual technique. In-vitro testing using simulated tissue blocks showed this technique to be promising. It augments the clinician’s tactile sense by evaluating the hydraulic impedance in a quantitative fashion. This technique may find application in other clinical settings where needle tips must be guided to tissue planes beneath the surface.

**Summary:**

A new device that measures tissue hydraulic impedance was developed and tested with an in-vitro model. It may assist in identifying the epidural space or other desired tissue planes.

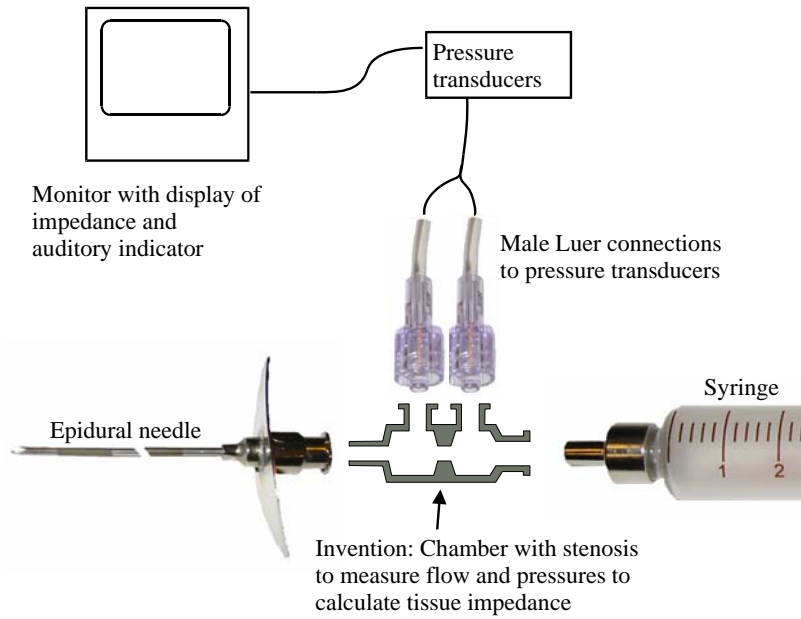


Figure 1. Setup to measure tissue impedance