to avoid spilling of saline (figure-4). Now epidural needle is advance slowly in, using both the hands (figure-5). The constant uniform force on the plunger by elastic band automatically pushes the piston when the epidural needle enters the epidural space which is noticed visually.

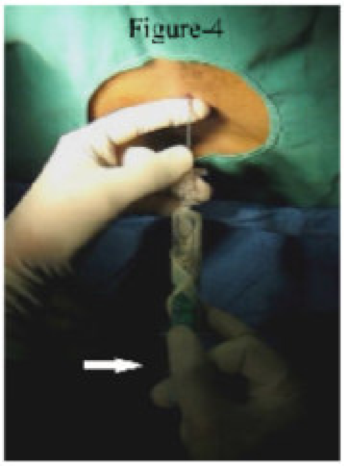


**Figure 4**

**ADVANTAGES**

1) Elimination of need to apply pressure on the plunger allowing the operator to use both hands while continuously advancing the epidural needle. When the needle enters the epidural space, plunger of the syringe automatically depresses which is noticeable visually.
2) By using both hands one can advance epidural needle with better precision, great control, stability and confidence.
3) Modification of LOR syringe allows reliable, quicker and safer identification of the epidural space.


**Figure 5**

4) Constant force on the plunger that automatically depresses when the epidural needle enters the epidural space eliminates the subjective “feel” required with standard LOR syringes.
5) Air Vs Saline: As no subjective feel is required, technically saline is as good as air. Thus by avoiding air complications related to it like, patchy block, risk of venous air embolism can be avoided.
6) Cost effective: by replacing regular syringe instead of LOR syringe cost can reduced.

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# The Role of Bulk Modulus in Epidural Placement

**Glen Atlas**

Anesthesiologists frequently use the loss of resistance to air technique (LORTA) to identify the epidural space. Initially, the ligamentum flavum is identified by its unique tactile characteristic during placement of the Tuohy needle. Following this, the LORTA process involves filling a glass syringe, with room air, and affixing it to the Tuohy needle. A pressure then develops, in the syringe, as the plunger is depressed. This pressure is a consequence, of the resistance to air flow, from the ligamentum flavum.

This pressure change, which occurs from a change in relative volume, can be characterized using the physical property of bulk modulus. Bulk modulus, B, is defined as the change in pressure *(dP)* divided by the associated change in relative volume $(dV/V_i)$:

$$B = -\frac{dP}{\left(\frac{dV}{V_i}\right)} \quad (1)$$

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Note that B has units of pressure. Furthermore, the negative sign is necessary as a pressure increase occurs following a decrease in relative volume (See figure 1).

Eventually, as the Tuohy needle is ultimately advanced into the epidural space, an "absence of pressure" results with depression of the plunger. This occurs as the air, which was contained within the syringe, flows into the epidural space. Thus, this loss of pressure occurs from the loss of resistance.

Rearrangement of (1) documents the relationship between change in pressure and change in volume with respect to a given initial volume:

$$dP = -B\cdot\left(\frac{dV}{V_i}\right) \qquad (2)$$

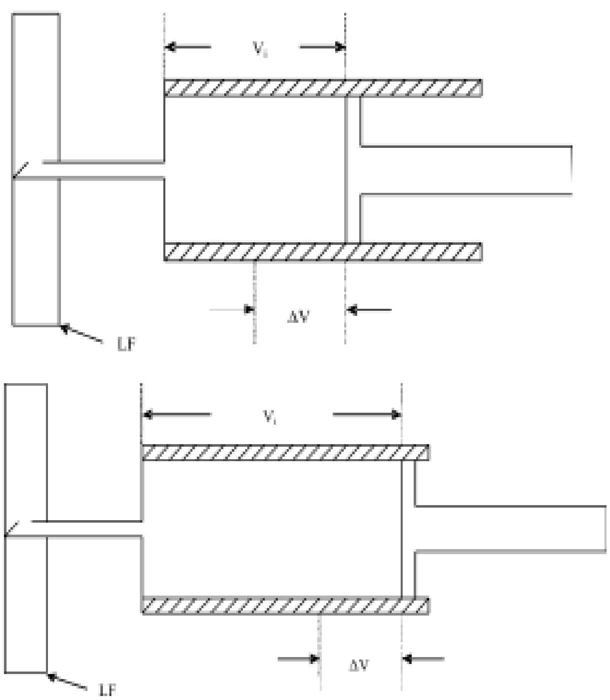


**Figure 1**

*With the tip of the Tuohy needle located in the ligamentum flavum (LF), the plunger, of the air-filled syringe, is then depressed a given distance resulting in compression of the air. This yields a change in volume ($\Delta V$). The change in relative volume is defined as $\Delta V$ divided by the initial volume ($V_i$). Note: The syringe in the upper panel, with a smaller $V_i$, will generate a greater pressure with the same $\Delta V$. This is in contradistinction to the syringe depicted in the lower panel which will generate less pressure for the same $\Delta V$.*

The bulk modulus, for air, is 14.5 pounds per square inch (PSI) which is equivalent to approximately 100 kilopascals (kPA). The measurable change in pressure, $\Delta P$, for a measurable change in volume, $\Delta V$, can then be computed for various initial volumes, $V_i$, within an air-filled syringe.

Elastance, E, or stiffness, of an air-filled syringe can also be examined using bulk modulus:

$$E = \frac{dP}{dV} = -\frac{B}{V_i} \qquad (3)$$

Note that elastance is inversely proportional to initial volume. It should be appreciated that the bulk modulus of normal saline (NS) is much greater than that of air. This results in NS being virtually "incompressible" with respect to air. Thus, when using NS during the loss of resistance technique, changes in the pressure generated, with respect to different initial volumes, will not be noticeable.

Studies examining loss of resistance techniques, comparing air to NS, have shown that the use of air is associated with a greater incidence of "patchy" or suboptimal blocks.[1] Nonetheless, many anesthesiologists prefer the LORTA technique. The reasons for this include familiarity of the use of air over NS and the ability to rapidly identify CSF in the event of a "wet tap."[2] Thus, it is conceivable that a reduction in $V_i$, when using the LORTA technique, would yield a possible reduction in the detrimental effects of air within the epidural space.

In conclusion, anesthesiologists should be cognizant of the role of bulk modulus when using the LORTA technique during epidural placement. Particular attention should be paid to the greater generation of pressure, associated with a smaller initial volume of air, for a given depression of the syringe plunger.

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