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PUNCTURE FORCES IN EPIDURAL NEEDLE INSERTION

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Introduction: Epidural anesthesia is commonly administered during childbirth and for pain relief following surgery, but it is not without risks and is difficult to learn. The epidural procedure involves the placement of a needle into the epidural space, via the patient's back. Accurate placement of the needle is critical as there is a risk of damaging the spinal cord. This requires careful monitoring of the variations in force and injection pressure that are felt when penetrating different tissue layers, including a sudden drop in both force and pressure when the needle reaches the epidural space.
Little is known about the needle-tissue interaction forces during epidural needle insertion. To support the development of models and training devices we collected data about tissue resistance during epidural procedures performed on live piglets.
Methods: All insertions were performed by an experienced anesthesiologist using an 18G Tuohy needle. The needle was inserted at 12 levels, ranging from T9-T10 to L5-L6. Per level the needle was inserted in three directions (midline and paramedian left and right). Five piglets were included in the study, resulting in a total of 180 measurements.
A Qualisys motion capture system was used to measure the position of infrared reflective markers that were attached to the needle. The force on the needle and the pressure inside the lumen were measured by means of sensors attached to the hub of the needle. The force and pressure signals were used for initial identification of the epidural space, and correct needle placement was then confirmed by observing saline being injected into the epidural space using doppler ultrasound.
Results: The most notable event during the needle insertions is an initial rise and then a sudden drop, in both force and pressure, that occurs when puncturing the ligamentum flavum and entering the epidural space. The peak forces during puncture of the ligamentum flavum varied between 2N and 18N. The experimental results showed no systematic differences in force peaks, neither between piglets, nor between vertebrae, nor between approach angles. The pooled results are described adequately by a lognormal distribution with geometric mean 7.8*N* and multiplicative standard deviation 1.4*N (n=180)*. Peak pressures could be described by a normal distribution with mean/std 35.8/11.3*kPa (n=180).*
Discussion: In the current study the needle was inserted manually at a variable insertion speed, making it very difficult to identify the transitions between subcutaneous tissue, supraspinous ligament, and interspinous ligament. However, the force and pressure peaks due to the ligamentum flavum could be distinguished clearly. These results can easily be

implemented in simulators in to order make realistic training devices of the epidural anesthesia procedure.