The Dynamic Flexometer: An Instrument for the Objective Evaluation of Spasticity

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Anesthesiologists may care for patients who have spasticity in the operating room or pain clinic. A number of therapeutic modalities for treatment of spasticity exist, but there are few simple objective methods for evaluating their effect. We describe one instrument, the Dynamic Flexometer, that measures the force required to move the limb passively through its maximum range of motion. The data presented validate the instrument's reliability. Two clinical cases presented here demonstrate the instrument's utility. This device may be of value to anesthesiologists involved in the care of patients with spasticity. (Key words: Anesthetic techniques, spinal: opioids; fentanyl; alcohol. Spasticity: evaluation.)

SPASTICITY as a result of injury to the central nervous system may interfere with patient movement or positioning and contribute to pain and discomfort. Anesthesiologists may care for these patients in the postoperative period or be consulted regarding options to decrease spasms. In general, therapeutic alternatives for these disorders can be divided into pharmacologic and neurodestructive options. Pharmacologic therapies include orally administered antispasmodics such as diazepam or baclofen; neurodestructive modalities include dorsal root entry zone lesions, dorsal rhizotomies, and subarachnoid alcohol or phenol injections. Recently, alternative oral antispasmodic drugs such as tizanidine and clonidine have been introduced, and invasive modalities such as central nervous system stimulation and continuous infusions of neuraxial morphine or baclofen have been used to treat spasticity.

With the advent of multiple treatment options, it has become imperative that both the initial and sustained effect of these therapies be accurately assessed. Existing evaluation methods often rely on subjective clinical rating systems or complex electrical or orthokinetic devices. This report briefly reviews existing evaluation modalities, describes a new instrument for the objective evaluation of spasticity, and demonstrates several clinical applications of the device.

Materials and Methods

The device consists of two pairs of 0.75-inch-diameter, 18-inch-long stainless steel tubes threaded into a machined two-piece steel block (fig. 1). Different lengths of stainless steel tubes can be interchanged to accommodate a variety of joints and patient sizes. The blocks are joined together at the fulcrum with a bearing. Within the bearing is fixed a zero-to-five–turn potentiometer. At one end of the tube is an eye bolt to which a force transducer (0–50 kg) is connected by a J-hook. A strap is attached to the transducer, allowing it to be manually pulled. Power to both the transducer and potentiometer is supplied by two 9-V batteries. With appropriate padding and tube length selection, the device can be placed across nearly any joint. Once placed across a joint, i.e., the knee, the device is fixed to the extremity with adjustable straps; the proximal end of the device and the limb are stabilized; and the distal limb is moved through a range of motion by pulling on the transducer. With the use of a timing clock, the distal limb is manually extended at a constant velocity of 30 deg/s to standardize the rate of joint movement. The potentiometer serves as an electrical goniometer, producing a voltage proportional to the angle of the joint, and the force transducer produces a voltage proportional to the effort required to straighten the joint.

Prior to data collection, both the transducer and potentiometer undergo two-point calibration. During the measurement, the voltages from the potentiometer and force transducer are amplified and recorded digitally on a personal computer and an analog-to-digital converter with a sampling rate of 25 samples per s. The data are stored in a file and can be plotted later using a standard commercially available graphics package. Alternatively, the signals from the potentiometer and force transducer can be graphed using an x–y plotter. Digitization of the signals provides the ability to display data simultaneously from measurements obtained at different times, even days or weeks apart. Since the data are sampled over a constant interval, the velocity of joint movement can then be determined.
In an effort to determine the reliability of the device, ten subjects with spasticity from spinal cord injuries were evaluated. Measurements were obtained by passively extending the knee from 90 to 150 deg at the rate of 30 deg/s. One week later a second trial was performed, and the same measurements were obtained. Data were collected by several teams of investigators. Analysis of the data by paired t test was done to compare the results of both trials.

Results

Case One

A patient with a complete T8 spinal cord injury from a motor vehicle accident was treated with an intrathecal injection of alcohol in an attempt to relieve hip and knee flexor spasms. After a baseline evaluation of lower extremity spasticity with the device (fig. 2), 0.75 ml absolute alcohol was injected at the L1–L2 level in 0.25-ml increments. Thirty minutes after the injection, the clinical impression was that most of the spasticity had been relieved. This was confirmed by reevaluation with the device. Twenty-four hours later, spasticity was again present, though at a reduced level (fig. 2). A repeat block was believed necessary and resulted in a total relief of spasticity.

Case Two

An elderly patient with severe lower extremity spasticity from a closed head injury was to undergo repeated neural axis local anesthetic blockade to facilitate splinting and physical therapy of his lower extremities. Due to potential cardiovascular instability associated with the use of intrathecal local anesthetics, a diagnostic block was done with 85 μg intrathecal fentanyl. Both the clinical impression and objective analysis (fig. 3) confirmed that fentanyl provided good relaxation, comparable to the improvement produced by a previous injection of intrathecal lidocaine. The patient continued to obtain good results from repeated intrathecal fentanyl injections without the potential hypotension associated with local anesthetics.

The results of the reliability trials are displayed in table.
1. There was no statistical difference between the results obtained in the two trials.

Discussion

In 1964, Ashworth described a clinical scale as a method of spasticity assessment. This scale rates the clinical impression of the resistance encountered to passive movement of the limb through a range of zero (no increase in tone) to four (limb rigidity in flexion or extension). Since then, a number of other studies have used this scale to document changes in spasticity. Although the Ashworth scale is suitable when therapy is evaluated by the same observer over a short period of time, variations may be encountered when the observer is changed or the period between observations is lengthened.

Other assessments of spasticity have included clinical evaluation scales, the opinion of the treating physician, or the assessment of the patients themselves. These methods, like previous classification systems, all suffer from observer bias and all lack a standard reference point over time.

In an attempt to better standardize and define disability, technical evaluations such as motography have been used to document ambulatory patterns. Motography records complex gait and ambulatory movement using a type of time-lapse photography. This method provides objective analysis criteria, but it is limited to patients who are ambulatory, and thus in many patients is unsatisfactory for exploring spasticity.

Direct recording of muscular electrical activity by electromyography has been used to evaluate spasticity. A further refinement of this technique uses the Hoffman reflex (H reflex), which is an electrically evoked muscle twitch involving a monosynaptic spinal reflex pathway. The ratio of the H reflex to the response obtained by direct muscle stimulation (M response) represented an attempt to better define spasticity using electromyography. Difficulties associated with the use of the H response/M response ratio include the need for precise electrode placement and the inconsistent correlation between the H response/M response ratio and clinical exam. Integrated electromyography also has been used to document spasticity and the effectiveness of therapy. The integrated electromyograph records the underlying activity of the affected muscles using surface electrode. The area under the electromyograph is believed to be representative of the amount of underlying muscle activity and possibly to reflect the degree of spasticity. Variations of this method have included simultaneous recording of the degree of flexion or extension and rate of limb movement. Potential problems associated with the use of electromyograph recordings include the need to standardize electrode placement over long periods of time and the time-consuming nature of the testing procedure. In addition, the method of electrical stimulation uses a monosynaptic neural reflex pathway that may not reflect the complex, diverse mechanisms comprising clinical spasticity.

Devices that measure overall muscle tone, though useful for evaluating muscle strength during a local anesthetic block, require voluntary muscle control and are not useful for measuring spasticity. Finally, commercial orthokinetic devices are available but are largely designed to measure voluntary effort, are not portable, and are very expensive.

Analysis of data obtained from ten different subjects using the assistance of several investigators has shown that the results obtained with this device are reproducible. However, it is very important that the limb is extended at a constant and controlled rate of speed since rapid extensions of the limb may precipitate additional spasms and confound the reliability of the instrument. Therefore, during all measurements the rate of extension was controlled by a timing device.

The instrument described in this report is portable and is inexpensive to build; it simplifies data collection, storage and analysis; and it objectively quantitates the overall tone and spasticity of the affected limb. This device has proved useful in documenting response to clinical therapy as well as evaluating new medications. Anesthesiologists who treat patients with spasticity by means of neurolytic blocks or implanted devices that deliver medications to the neuraxis may find this instrument useful to objectively document the effect of treatment. With the advent of numerous new spasmyotic agents and therapies, this instrument has the potential to provide an objective, quantitative evaluation of both acute and long-term treatment modalities.
References