Sliding pressure algometer, a development in eliciting pressure pain thresholds at the boundaries of surface markings of abnormally tender regions

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ABSTRACT
The pressure algometer probe tip is usually held stationary and pressure is steadily increased from zero until a pressure pain threshold (PPT) is elicited. In order to explore the extent of surface markings of abnormally tender regions in more detail an improved method is proposed whereby the pressure algometer is not kept still. It is slid over the tissues at a predetermined downhill pressure and velocity to produce compressive, tensile and shear stress within underlying tissues. It is moved over surrounding non-tender regions until it reaches the surface overlying an abnormally tender region where a PPT is evoked. The probe is removed immediately and the skin marked. When this is repeated from different directions, the boundary of the surface markings of a tender region will appear in corresponding detail. Provided that this ‘sliding pressure algometer’ produces sufficiently similar amounts of stress when applied on separate occasions, it can be used to monitor the progress of a condition or the effects of treatment. To reduce cost and increase availability, this pressure algometer may be made of a plastic syringe converted into a gas-tight chamber.

TENDerness
Following injury or the development of various pathological conditions, an abnormal degree of tenderness may develop as a result of a resetting of the pain threshold in favour of allodynia and hyperalgesia. The pathophysiology of persistent tenderness is not fully understood, particularly in regions containing skeletal muscle. However, Mense studied muscle nociceptors which in good health have too high a threshold to respond to physiological muscle movements or stretch. After injury, the balance of central responses tips towards persistent pain as a result of substance P release and a reduction in nitrous oxide synthesis and also because the efficacy of inhibitory neurons is diminished by excitotoxicity. New terminals sprout and increase synaptic contacts outside the injured region’s original innervation, producing referred pain. Furthermore, the effect of Aβ traffic is changed by spinal cord processing to the extent that presynaptic inhibition of Aδ and C-fibre input is prevented and allodynia arises when nociceptive second-order neurons become stimulated by Aβ input.

Winkelstein describes the release of proinflammatory cytokines from glial cell neuroimmune responses. Microdialysis reveals proinflammatory substances in tender muscle fibres (particularly the smaller type 1 fibres). In addition, processes that maintain a low threshold in one region may alter it in others.

Whatever the cause of tender regions, the patient’s reactions to mechanical stimulation provided by palpation are an important clinical palpation. When the pressure of the examiner’s hand, fingers or thumb exceeds the pressure pain threshold (PPT), sensation changes from pressure alone to a combination of pressure and pain.

To avoid being limited to any particular aetiology, when a region presents a PPT less than a clinician would expect in good health, it will be called an abnormally tender region.

SIZE OF ABNORMALLY TENDER REGIONS
Thirty years ago a question about the size of abnormally tender myofascial regions arose in the relief of myofascial pain workshop of the 1981 Edinburgh meeting of the International Association of the Study of Pain, where David Simons examined a deltoid muscle of a delegate with shoulder pain. He directed our attention to a region of surface area <1 cm² which he described as a taut band containing a myofascial trigger point (MTrP). When he moved this rapidly in a direction perpendicular to the muscle fibres, a brief muscle contraction could be seen. He declared this was a ‘local twitch response’. The chairman of that meeting, Peter Nathan, wanted to know why his experience of examining patients had been so different. He found much larger abnormally tender regions, whose surface areas may be ≥50 cm² and are capable of crossing muscle boundaries.

The idea that the seat of tenderness is small is by no means new. For centuries, Chinese practitioners describe small regions of extreme tenderness to palpation as ah shi points according to the way the patient cries out during palpation. As Dung points out, they were the first to systematically map the surface markings of these regions.

In 1977, Mann and Melzack realised that many commonly described acupuncture points share the same location as the tender points described by Western doctors. On body outline charts, the locations of many acupuncture points overlap those of MTrPs.

Nowadays the location of a MTrP may be confirmed during electromyography by the presence of abnormal end-plate potentials. Meanwhile vibration sonoelastography of a region containing a MTrP shows increased stiffness in an elliptical hypoechoic nodule that occupies an area of 0.16±0.11 cm² when observed on a two-dimensional ultrasound display. Even in such a large animal as a horse, a MTrP is believed to be of similar size.

But in clinical practice where such equipment is not usually available we resort to finding abnormally tender regions by palpation.

We know a patient’s reaction to palpation is far from entirely objective. In an attempt to reduce bias, pressure threshold metres or pressure algometers have been introduced.

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BIRTH OF THE SLIDING PRESSURE ALGOMETER

The usual procedure with a pressure algometer is to make sure its probe tip does not slip sideways and pressure is steadily increased from zero in a direction perpendicular to the skin until a PPT is elicited. As a typical example, Fischer employed a probe tip whose surface area was 1 cm² and increased the pressure at a rate of 100 g/s. The average pressure in kg/cm² is recorded as the PPT of the region immediately below the probe tip, which usually has a surface area of 1 cm². In tissues directly under the probe tip, compressive stress arises. However, in those tissues that are stretched by indentation of the probe tip, tensile stress also develops.

How mechanoreceptors and mechanonociceptors transduce mechanical stimuli into action potentials is at an early stage of exploration; however, nociceptors have been shown to be sensitive to compressive and, also, tensile stress. Furthermore, mechanonociceptor activity is increased when tensile and shear components of stress are added to a region already exposed to compression. Sliding a probe across the tissue at a given downward pressure produces compressive, tensile and shear stress, whereas holding the probe stationary exerting the same downward pressure produces only compressive and tensile stress. Thus at any given downward pressure sliding the algometer as opposed to keeping it stationary will bring more stress to bear in underlying tissues and therefore tend to evoke a PPT more readily.

LARGE REGIONS OF TENDERNESS

Lange illustrated surface markings of a variety of abnormally tender regions he found by firm palpation in every region of the body. Almost all of these have a considerably greater area than those shown as points in maps of MTrPs provided by Travell, Rinzler and Simons. Although it was usually considered that only a small number of MTrPs populated an affected muscle region, it is now realised that they can be more numerous. In a study of patients with shoulder pain, a stationary algometer was applied vertically at each contiguous spot over the entire surface markings of the infraspinatus muscle. This muscle revealed multiple markedly tender regions surrounded by those that were less so: the former were called ‘active MTrPs’ while the latter, ‘latent MTrPs’.

Although latent MTrPs may be less tender than active ones, nevertheless they also exhibit nociceptive hypersensitivity. As pain can arise from both active and latent MTrPs and there may be many of each within the same muscle, the large abnormally tender regions described by Lange and Nathan may have come to light by a sufficiently firm palpation that elicited a PPT in a region that contained both.

This lends an urgency to the development of a clinical technique that can explore the surface markings of large tender regions. However, such exploration requires caution, as the perception of pain caused by palpating an abnormally tender region increases out of all proportion to any increment in applied pressure.

SLIDING THE ALGOMETER

To avoid distress, the clinician starts the operation by sliding the algometer over non-tender tissues at a predetermined downward force in a painless manner at a steady pace until it reaches the boundary of the region that is sufficiently tender to produce a PPT under these circumstances. At this moment the stimulus is immediately removed and the location is marked on the skin.

To make this probe available to every practitioner, the sliding pressure algometer over non-tender tissues is a 5 or 10 ml disposable plastic syringe. This forms a compressible air algometer that has been tested and described before by Shafer, Alban and Johnson and Watson, who succeeded in avoiding the cost of spring and strain gauges that most algometers employ. But in this new concept the probe is not held stationary. It is slid across the skin surface.

The procedure for making the gas-tight sliding pressure algometer (figure 1) is as follows: obtain three disposable, plastic syringes of the same volume preferably 5 or 10 ml, a sterile surgical glove, one cable (zip) tie and a rubber band. Remove the pistons from all three syringes and remove the rubber seals from two syringe pistons.

If 5 ml syringes are employed, each rubber seal is 1.12 cm in diameter and therefore presents an area of 1 cm². To prevent air escaping from the syringe, push one of these rubber seals into:

Figure 1 Diagram of the sliding pressure algometer. It comprises a 5 or 10 ml syringe rendered gas tight by inserting a second seal inside it to prevent air escape (1). The thumb and second finger are pressed vertically downwards in the direction of arrows (3) on the flanges (4) with sufficient force to align the seal on the piston head with the cable (zip) tie (2). Through the seal attached to the base of the piston by the sterile material (6), this produces the downward pressure required to produce compressive and tensile stress in the skin and underlying tissues. Meanwhile the third finger advances the probe horizontally across the tissues at a known velocity in the direction of horizontal arrow (5) thereby exerting additional shear stress.
seals down the barrel of the syringe to its furthest extent. Reinsert an intact piston into this syringe. Air is now trapped in the barrel of the syringe between the two seals: the volume of air is progressively reduced by compression when the piston is pushed forcibly into the syringe.

A cable (zip) tie is used to form a loop around the external surface of the syringe cylinder. The geared surface of the tie is passed through its ratchet to form a loop around the syringe. Ensure the loop is tight enough to stay in one place when left alone but can still be slid manually up or down the cylinder when required. Remove excess tie material.

The base of the syringe piston is now pressed against a weighing scale to provide a given force of, for example, 1.5 kg.

While this force is being provided, the cable tie is slid over the outside of the cylinder to a position that overlaps the piston head.

If the cable (zip) tie is brightly coloured it can easily be seen from almost any angle while the probe is dragged over the skin.

During this procedure, the practitioner makes sure the rubber seal on the head of the piston is kept in line with the tie.

To avoid cross-infection, sterile material is interposed between the probe tip and the skin. In this example, a ‘finger’ is cut off a sterile surgical glove.

The remaining rubber seal is dropped into this finger. The base of the syringe piston is now inserted. The sterile glove material is pulled upwards around the base of the piston until the rubber seal is held tightly against it. A rubber band is twisted around the glove material to keep it in place. The sterile material attaches the rubber seal to the base of the piston sufficiently firmly to allow it to be slid over the patient’s skin.

If the downward force is 1.5 kg and the area of the rubber seal forming the probe tip happens to be 1 cm², the probe produces a downward pressure of 1.5 kg/cm².

Provided that the sterile glove material or any other sterile, durable material used to attach the rubber seal to the base of the piston is disposed of and replaced on each occasion, the possibility of cross-infection is reduced accordingly.

The surface marking of an abnormally tender region is established by sliding the algometer at a given downward force.

While maintaining the same downward pressure, the probe is now moved by the practitioner from the non-tender region to the tender area at a velocity of, for example, 1 cm/s, the procedure being practised with a tape measure, the second hand of a watch or a light-emitting diode set to flash on/off at 1 Hz by an electronic metronome.

As one approaches the tender region from different directions with, for example, a downward pressure of 1.5 kg/cm² at a velocity of 1 cm/s over the tissues from non-tender towards the tender, mark each spot where a PPT is elicited with a biro and soon the boundary of the surface markings of this region will appear in corresponding detail (see figure 2).

The location, length, breadth and area within the boundary are estimated by viewing it through a transparent acetate sheet marked out in square centimetres.

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**PROPOSALS**

Development of this sliding pressure algometer is at an early stage as the following three proposals are yet to be investigated.

**First proposal.** As it adds shear stress, at any given downward pressure, a sliding pressure algometer is more likely to elicit a PPT in an abnormally tender region than a stationary one. To investigate this, the effect of the sliding is compared with the stationary pressure algometer as follows: sliding—proceed along a particular path towards the tender region with the sliding pressure algometer at a given downward pressure and mark the skin when a PPT is elicited; stationary—proceed along the same path again employing the same pressure algometer but in a stationary fashion from zero to the same downward pressure as used while sliding at regular intervals until a PPT is elicited and mark the skin. Record the distance between the two marks. If significant differences appear between the two marks in patients who are not trying to dissemble, then this knowledge may become useful both clinically and medicolegally when someone who is not in pain is pretending to be so but does not know whether a sliding pressure algometer is more likely to detect

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*Figure 2* A sliding pressure algometer is moved at a steady pace—for example, 1 cm/s, at a predetermined downward force (typically 1.5 kg/cm²) over non-tender tissues by the practitioner’s hand until a pressure pain threshold is elicited. This occurs at the border of an abnormally tender region, which in this hypothetical example is sizeable (see hatched area) in the medial aspect of the thigh.
tenderness at a given down pressure than a stationary one. Second proposal. Provided that the downward pressure and the velocity of its progress across the tissues are kept as constant as possible and the position of the patient's body is maintained, whenever the manoeuvre is repeated the sliding pressure algometer will deliver a sufficiently similar amount of compressive, tensile and shear stress in the tissues on each occasion to become a reliable test of changes in the surface markings of an abnormally tender region that might occur during the progress of a disease or its treatment. To see if this is so, the manoeuvre is repeated when no change in treatment has been applied. One could then observe how fixed or variable the surface markings of these regions are, and also one could answer the question whether the manoeuvre itself 'sensitises' its innervation and increases its size if repeated too often. Third proposal. If the abnormally tender region happens to be sizeable and the pressure algometer is slid towards its boundaries from the non-tender region, the extent of its surface markings is established not only with less discomfort to the patient but also more conveniently and in less time than if it is kept stationary on each occasion and applied with sufficient downward pressure to evoke a PPT over several areas within it. To look at this, one could examine the region by both methods, note the time taken, and ask a patient to rate the discomfort produced.

Provided that some or all of these proposals stand up to investigation, sliding the probe rather than holding it still provides an advance in pressure algometry that will help us obtain more information than previously possible about the surface markings of large abnormally tender regions and how they may change as a result of disease or treatment.

**References**

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