The Measurement of Pain: A New Approach to an Old Problem

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The measurement of pain has eluded accurate appraisal for many years. Assessment of pain is important for three reasons: it is a reflection of the degree of suffering, which is important in clinical medicine; it increases the understanding of human behavior in terms of suffering; and it provides a means for evaluating analgesics. Existing methods of measuring pain, numerous as they are, can be divided into four categories: 1) pain threshold and tolerance studies in humans; 2) animal studies; 3) changes in vital signs associated with pain; and 4) subjective reports of pain.

1. Pain threshold and pain tolerance studies in humans have been used extensively in the evaluation of analgesics, and also clinically to assess the individual meaning of the complaint of pain. The point at which a stimulus, produced mechanically, electrically, chemically or thermally, becomes the sensation of pain can be established within certain ranges of accuracy. However, since it has been amply demonstrated in the literature that the pain threshold is not reliably affected by analgesics, this method has lately lost much of its original meaning.

2. Animal studies have been used extensively for the initial evaluation of analgesics. The effect of an analgesic in changing a certain aspect of animal behavior presumed to indicate stress (the tail flick, for example) can be measured with consistency. They are good screening procedures, but animal distress is not necessarily the equivalent of human pain, especially in its affective aspect. Imagery and fantasy, so important in the pain phenomenon, are purely human capabilities.

3. Studies of changes in vital signs associated with pain, such as blood pressure and galvanic skin conductivity, are distorted by emotionally and pathologically produced changes in these signs. The changes may be only indirectly related to pain, and may even be the result of excitement from the experiment.

4. Studies based on patients' subjective reports of pain have been the mainstay of clinical evaluation of pain and analgesic action. Many methods have been systematized with the aid of statistical and double-blind controls in an attempt to eliminate bias, communication difficulties, and the influence of the environment on the pain experience. The multiplicity of systematizations bespeaks their

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shortcomings. All the ambiguities of a subjective study are involved: the patient's difficulties in remembering and evaluating his own pain and communicating it to the observer, and the effect of the medical environment and the patient's life situation on both the sensing and reporting of pain. In spite of these distortions, this method has brought the most fruitful results and is the most meaningful, probably because the total pain phenomenon, with all its meanings and symbolic representations, is one of the most human experiences we know.

A new method was needed which would overcome all the above sources of error, namely: eliminate bias on the part of the investigator; facilitate communication between investigator and subject; permit accurate measurement; improve the patient's ability to assess his own pain and avoid pain memory; and eliminate bias on the part of the patient due to the medical environment or the life situation. The following describes a new method designed to overcome these errors.

**Method**

The proposed method is based on certain concepts of pain physiology. Two topographically independent, simultaneously occurring pains, of qualitatively similar nature, can be quantitatively compared. Specifically, a pathologic pain can be compared in this way with an experimental pain, as was brought out by this study. An increasing intensity of experimental pain can be measured objectively. We found that an accurate endpoint can be subjectively established for the moment when the experimental pain reaches the intensity of the pathologic pain. By inference, at this point the measure of the experimental pain is the measure of the pathologic pain of unknown intensity (Fig. 1).

Two phenomena, in addition to intuitive perception, make the endpoint clearly known to the patient. A sudden shift of attention from the pathologic pain to the experimental pain may occur, or the two pains may be perceived as one, topographically indistinguishable.

These concepts were implemented by an apparatus (Fig. 2) which consists of a mechanical pain-producing device of two points with a separation of 0.5 mm. Operated pneumatically, it records graphically the air pressure needed to produce a certain pain. The device is operated by the patient himself. The pain-producing element and pressure apparatus are applied to one leg. When the patient presses a but-
Fig. 3. Half-hourly observations on the measurement and subjective reporting of pain without analgesia following abdominal hysterectomies after emergence from spinal anesthesia. Upper graph indicates objective measurement with machine, lower graph indicates subjective reports of pain.
	on with one hand, he initiates air flow into the chamber and, with a constant and controlled gradient, increases the pressure of the pain-producing element on the skin. He is instructed to release the button to terminate the experiment when he feels the pain in his leg to be equal to his pathologic pain. He is not instructed to anticipate attention shift or pain fusion. The graphic recording device faces away from the patient, so that he does not know the degree of pain he is indicating by releasing the button.

This method measures the pain the patient actually feels; therefore it includes aggravation of pain by affective factors. It eliminates, however, pain the patient claims but does not feel. Each test consists of three trials in immediate succession. If the patient understands the test and is comparing the experimental pain to an existing pathologic pain, the three graphic readings will be nearly identical. If the patient fails to understand or attempts to indicate a pain he does not feel, the three readings vary greatly. It is nearly impossible to reproduce readings with accuracy at will. In this study, all readings varying by 15 per cent or more were eliminated.

Because each individual's reaction to the experimental pain stimulus will be
MEASUREMENT OF PAIN

different, this method cannot be used to make quantitative comparisons between single readings for different patients. For example, one cannot say that one patient has twice as much pain as another. Pain in a single patient can be followed, however, and changes in pain can be compared between patients; for example, one can conclude that a certain patient has experienced twice as much pain relief as another.

Thus, a solution of the above requirements for a method of pain measurement has been approached. Bias in the investigator is diminished because he does nothing but give the patient a predetermined instruction, and has nothing to do with the actual pain measurement. The measurement is mechanically accurate, and there is no communication beyond the initial instruction. The patient's assessment of pain involves only perception at the moment of the test, does not involve memory of pain, and cannot be based on deceit or a desire to please or displease the investigator.

This method was used to follow postoperative wound pain, without analgesia. Readings were made at half-hourly intervals for the first postoperative 12 hours. At each reading the patient was asked for a subjective evaluation of the pain, with a choice of four levels: mild, moderate, severe, and very severe. Correlations of machine readings with subjective reports for one patient are shown in Fig. 3.

Machine readings were also compared with the expected effects of a potent analgesic, 100 mg. meperidine hydrochloride, on postoperative wound pain. Fig. 4 shows a graph for one such patient.

A variety of kinds of pain were tested in addition. Accurately reproducible readings were obtained for labor pains (demonstrating both curves for individual contractions and the increment of pain

Fig. 4. Half-hourly observations and subjective reporting of pain following abdominal hysterectomies influenced by meperidine hydrochloride. Upper graph indicates objective pain measurement, lower graph indicates subjective reporting of pain. Arrow indicates administration of 100 mg. meperidine hydrochloride intramuscularly.

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over a series of contractions), phantom limb pains, pain due to gangrenous limbs, and disc syndrome pain. Other pains, especially in the head and face, were felt by the patient to be qualitatively different from the experimental pain and could not be measured. Possibly other types of experimental pain would be more comparable to these very meaningful sensations.

Primarily for purposes of determining the applicability of the technique to different drug types, the narcotic analgesic codeine and the non-narcotic, moderately potent analgesic chlorophenesin were evaluated in comparison with a placebo. The study does not constitute a relative evaluation of the two drugs since this would require at least two dosages for a dose-response measure. The test was not conducted in a double-blind fashion and the placebo was deliberately placed as second drug. We selected 24 patients and did 26 tests consisting of the administration of all drugs on the same day to all patients upon the complaint of pain. The patients were two or three days after an abdominal laparotomy, mostly hysterectomies. They were all women. Their mean age was 51 years and they fell into the socio-economic group of service cases.

Upon the complaint of pain we measured the degree and then administered one of the active medications. We again measured the pain at half-hourly intervals until the pain subsided. Upon subsequent complaints of pain the patient was given a placebo and following that, the other active drug. The same measurements as above were conducted before and at half-hourly intervals after administration of the medicines. The results obtained were subjected to statistical evaluation.

Results

The course of pain in a postoperative patient can be seen in Fig. 3. The course of a postoperative patient as influenced by two administrations of meperidine hydrochloride is seen in Fig. 4. The measurements are compared in these two patients with the subjective degree of pain.

Table 1 presents the average values obtained from 30 mg. codeine phosphate and from 2 Gm. chlorophenesin.

The effect of placebo was most evident between the observation at 0 hour and 30 minutes thereafter. The following observations did not vary much from the 30-minute figure. The relatively low initial pain values of the placebo group may be due to the position of the placebo administration in the middle between the two active drugs. The placebo has been placed there to separate the pharmacologic effect of codeine and chlorophenesin. The low initial value of the placebo possibly may be due to a residual effect of the previously administered active drug.

<table>
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<th>Treatment</th>
<th>Replication</th>
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<td>60</td>
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<td>27.3</td>
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<td>B</td>
<td>77.4</td>
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<td>13.6</td>
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<td>C</td>
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<tr>
<td>Average</td>
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<tr>
<td>Average</td>
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* The letters A, B, C refer to three measurements in immediate succession; measurements represent percentage of control pain immediately after laparotomy.

TABLE I

Average Values of Pain Measurement After Chlorophenesin, Placebo, and Codeine Administration
The relative degree of pain relief in percent of the original degree of pain is represented in Fig. 5. Detailed statistical analysis of the results (analysis of variance) revealed that, while the difference between the postmedication and premedication pain values after placebo treatment was not significant, the differences found following treatment with codeine or chlorophenesthesin were high significant ($P = 0.005$).

**Discussion**

The results of this study indicate that the methodology presented can be used in man for the measurement of degree of pain or of analgesia produced by either a narcotic or a non-narcotic drug. It will be of interest in future studies to determine whether the method lends itself to establishment of dose-response curves with analgesic drugs.

It has long been known that there are many peculiar differences between pathologic and experimental pain. As stated above, the experimental pain threshold probably is not raised by analgesics. This study shows that experimental pain of greater than threshold intensities is considerably less affected by analgesics than pathologic pain, for if it were equally affected, the pain measurement would be identical before and after the analgesic was administered.

Experimental pain fluctuates even when the stimulus is constant (for instance, during the phenomenon of stress and adaptation), while pathologic pain is more or less steady. Experimental pain is not frightening and may even be pleasant (as shown by the glad co-operation of patients in an experimental pain study), while pathologic pain may be frightening. And finally, experimental pain is not interpreted as injurious, while pathologic pain is always considered as such.

Why is there such a gross difference in the interpretation of two more or less identical frequencies of end-organ discharge? And why, as reported, is the degree of analgesia roughly proportional to the degree of pain the patient is in?

The traditional view of pain as a single phenomenon, a certain frequency of end-organ discharge, has led to the view that analgesics act on the central nervous system, hindering in one way or another the perception of these discharges. The differences between pathologic and experimental pain make these views questionable. There is probably something different in the central interpretation of these two end-organ discharges which causes the one to be affected by analgesics and the other only less so.

The question of whether pain is an affect has been debated at length. Most discussion of this matter runs afoul of the fact that pain is a localized phenomenon, while affects, which may be "painful" (such as fear and grief), cannot be localized.
Part of the integrity of an individual is based on the body and the self forming a harmonious unit. This harmony is disturbed, and integrity threatened, whenever part of the body is severed, threatened with severance, or wished away by the self. Affective statements by patients in this study indicated that they wished to distantiante themselves, topographically, from the pain-producing part of the body. This part no longer belongs to the self because, under physiologic circumstances, the body would not hurt itself. The drive to distantiante the ailing part of the body from the self, opposed by the drive to maintain integrity, and the tension arising from this ambivalence can be considered a specific pain affect. Pain sensation, the peripheral phenomenon of end-organ discharge and central reception of the stimulus, contains by itself little or no affect. When pain is produced experimentally, the patient knows that the pain has an external source, not part of himself. He may wish to distantiante himself from the pain-producing machine, but this entails no damage to the body-self unit, and he feels pain sensation without pain affect.

The interpretation of pain sensation in pathologic pain is further complicated by its association with danger. Depending on the individual's history, pain is more or less a sign of threat to life and limb, to bodily integrity. In this aspect, pain is interpreted like any external threat to existence, in spite of the fact that the pain originates within the body. In addition, the pain affect itself creates fear of damage, for the alien part lies within the integrity of the individual; removal of it would damage him bodily. This internal threat contributes to the patient's fear, but is not as available to his consciousness as the more obvious external danger.

In experimental pain, on the other hand, the patient knows that the artificially produced pain sensation bears no ill omen. In addition, the pain-producing agent is explicitly outside the body, and removal of it in no way threatens bodily damage. The experience of pain without its usual danger components is not only acceptable to patients but pleasurable. Their commonly observed willingness to participate in an experimental pain study can be explained by analogy to a roller-coaster ride, where the sensation of falling is produced without the grave consequences of a fall.

Thus, one may divide the pain experience into two functional components: the frequency of end-organ discharge and its conduction to the central nervous system, interpreted as devoid of danger if it is experimentally produced; and the hysterically and psychically based pain affect, an interpretation of the pathologic pain sensation. The pain affect is the tension arising from the desire to distantiante the self from the dangerously disturbing part of the body and, on the other hand, the desire to maintain bodily integrity.

Analgesic action can be understood on the basis of this concept of the pain experience. Narcotics produce a feeling of grandeur and spiritual expansion at the expense of bodily feelings and concerns. Most intoxicating agents are able to produce similar sensations and delusions, and thus can act as analgesics. A feeling of removal of the self from emotional problems is often produced by these agents. Statements of patients in this study indicate just such a removal from the pain experience. They stated, after receiving analgesies, that the pain was just as bad as before, but that it no longer bothered them; it was removed from them.

We suspect that the analgesic facilitates the sense of separation of the self from the painful part by lessening the jealously guarded need for bodily integrity. Thus, integrity is re-established by exclusion of that part, and the pain affect is relieved. The pain sensation, however, is less affected: this is probably what patients
refer to when they say the pain, though no longer troublesome, is still present. This would explain why experimental pain is not affected by analgesics; it consists of pain sensation without pain affect.

Conclusion

1. Two simultaneously occurring pains can be quantitatively compared. The patient's ability to report with accuracy the point at which a pathologic and an experimental pain are equal provides a means for measuring pathologic pain.

2. This pain measurement technique has been shown to yield statistically significant values for analgesia produced by a narcotic (codeine) and a non-narcotic (chlorophenoesin) drug. In the immediate postoperative phase, neither compound shows a significant effect; but in the later postoperative phase, the analgesic response is evident.

3. Just as the pain threshold is not raised by analgesics, the sensitivity to experimental pain of greater than threshold intensity is not altered by analgesics, even when pathologic pain is altered.

4. A speculative theory of the nature of pain is offered on the basis of our experience with patients in this study. Pathologic pain consists of two components, pain sensation and pain affect. The former is the physio-anatomic phenomenon of certain frequencies of end-organ discharge and their conduction to and in the central nervous system. The latter is the affective interpretation of this sensation, consisting of the tension created between the desire to remove or distinuate the painful part of the body from the body-self unit and the opposing desire to maintain bodily integrity. Experimental pain consists of pain sensation without pain affect. A theory of the mechanism of analgesic action is presented, based on this difference between pathologic and experimental pain.

References