

# STUDIES ON PAIN: MEASUREMENTS OF PAIN INTENSITY IN CHILDBIRTH<sup>1</sup>

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It is a common observation that patients differ widely in their reaction to childbirth, some women giving evidence of great distress and others maintaining a high degree of equanimity throughout labor. These variations in reaction have led obstetricians to question the existence of pain in certain patients (1), except for the sensations accompanying the surgical procedures often required for the delivery of the baby. In the absence of a quantitative method for measurement of pain intensity, the reaction of the patient has been the principal index of the severity of labor pains.

The introduction of dolorimetry, a laboratory method of measuring painfulness, by Hardy, Wolff and Goodell (2, 3), has made it possible to obtain reliable estimates of spontaneous and experimentally induced pain intensity. This method provides a scale based on the ability of an individual to discriminate differences in the intensities of pain. The technique consists essentially of comparing the intensity of a spontaneous pain with that induced on the skin of the subject by thermal radiation. No clinical application of this method has yet been made, and in applying it to the study of the pain experienced during labor, it was hoped that the patient could make reproducible comparisons of the labor pains with those evoked by the thermal stimulus on the skin. If this proved possible, the intensity of the painful sensations experienced by a patient in the various stages of labor and by different patients, could be compared on a common basis. This would provide a convenient method for the evaluation of the effectiveness and mode of action of analgesic agents administered for the relief of pain during labor.

It is the object of this report to present experimental data on pain intensity, obtained from a study of 13 women in the various stages of labor

before the administration of any analgesic or anesthetic agent.

## METHOD

Thirteen normal young women without obvious medical or obstetrical complications cooperated as subjects in these experiments. There were ten primiparas and three multiparas. Nine were private patients who had a definite interest in the investigation as they were either former nurses or wives of physicians or professional men. Special urging was unnecessary to persuade these patients to participate in this study, as either curiosity or desire to be of service caused them to volunteer readily. All patients had one motive in common, namely, to withstand any reasonable discomfort if it would help ease the suffering of future patients. The matter was, of course, discussed with the husband and in instances in which the patient was the wife of a physician the husband remained in the room while the study progressed. In two instances the pain studies were discontinued in the latter part of the first stage of labor at the patients' request. At first private patients were deemed most suitable for this study as it was not clear that discriminating differences in intensity of pain would be a simple matter during the course of labor. Since these patients had no difficulty in making the necessary comparisons, four clinic patients were subsequently included in the study.

Prior to hospital admission in labor, all of the private patients had been given preliminary instruction in the thermal radiation technique of pain threshold measurement (4). The operation of the equipment was explained to them, and they were introduced to the several persons involved in the study who would be present during the investigation. As the authors and a technician remained with the patient during the entire period of observation, it was felt desirable that rapport be established between the patient and the experimental team.

During the first laboratory interview the skin of the dorsum of the right hand was blackened with India ink in four areas, and the pain threshold measured on these test surfaces. The pain threshold was measured by first exposing the blackened skin for three seconds to an intensity of thermal radiation slightly above the pain threshold so that a distinct pain was felt. Then, beginning with a stimulus well below the pain threshold, the radiation intensity was increased through successive exposures until the patient reported a barely perceptible prick at the end of the exposure. This intensity was

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taken as the pain threshold. It is of the greatest importance that different areas of skin be stimulated in each exposure, and that as few stimuli as possible be given to locate accurately the threshold. An average of four stimuli was usually sufficient to determine the pain threshold within plus-minus ten millicalories per second per square centimeter. None of the patients studied had the slightest difficulty in recognizing the pain threshold.

During this period of instruction the difference in intensity of two pains was demonstrated by exposing the patient to a stimulus evoking a two-dol<sup>2</sup> pain and then to one evoking a four-dol pain. This was done to impress upon the patient the importance of the intensity aspect of pain as contrasted with its quality and duration, since the experimental pain ostensibly differed from the labor pain in these respects. Most of the patients commented upon the fact that the sensation from the uterus would be different in quality, duration and locale, and, therefore, expressed some doubt as to the possibility of equating the two sensations in terms of intensity. These apprehensions were not borne out by experience as only two of the patients had difficulty in making comparisons, and in these instances the degree of cooperation was not sufficient to continue the observations through the first stage of labor.

The use of the word "pain" in connection with the uterine contraction was avoided in discussing the subject with the patients, and "intensity of contraction" was the descriptive term employed. It was hoped in this way to avoid suggesting to the patient that her labor would be painful.

During labor the technique for measuring pain intensity was as follows: Immediately following a contraction the patient was given a three-second exposure to the thermal stimulus. She made a report as to whether or not the sensation on the back of her hand was more or less intense than that experienced from the uterine contraction. Depending upon this report the intensity of the stimulus was increased or decreased and the test repeated in order to "bracket" the uterine sensation. By having two stimuli, one lower and one higher than the spontaneous sensation, it was possible to find quickly the stimulus which the patient reported to be approximately of the same intensity as her labor pain. Usually three or four stimuli were enough to locate the balance point between the sensation from the uterus and that from the pain apparatus, but if more stimuli were required a rest period of about ten minutes was allowed before resuming tests. Care was taken throughout not to overstimulate any area of blackened skin and thereby produce local hyperalgesia.

It was repeatedly observed that the intensity report was the same whether the comparison of sensations was made at the height of a contraction or in the interval between contractions. As there was more time available between contractions comparisons were usually made then, adjusting the thermal stimulus to produce a sensation equivalent

<sup>2</sup> "Dol" is the term used to denote the unit of painfulness, and has a value of approximately one-tenth the intensity of the maximal pain.

in intensity to that evoked by the previous contraction. Two measurements were made and if the reports agreed within one dol they were averaged and used as the point to be plotted. Single test reports were used only at the highest pain intensities, because of tissue damage resulting from the strong thermal stimuli. Large variations in reports of intensity (three to five dols) occurred when the patient was distracted or not cooperating, and were observed in both patients who requested that the study be discontinued. This possibility had been anticipated since erratic reporting had been observed in a previous study of medical students (3). In spite of the clinical procedures necessarily carried out during the course of the pain study, the fatigue of the patient, and other disturbing circumstances that could not be controlled or eliminated, distraction resulting in erratic estimates was not an important factor. Reproducibility of the measurements within plus-minus one dol was taken to be the criterion of the excellence of the data.

Continued emphasis was placed during labor upon the *intensity* of the sensation as distinct from its quality and duration, because the patients frequently stated that the thermal pain was not "comparable" to the labor pain. The difference between the experimental pain and the labor pain may have caused some difficulty in making accurate comparisons. However, repeated comparisons during labor showed only variations of approximately plus-minus one dol, and as the limit of discrimination is plus-minus one-half dol this shows that the patients were making satisfactory appraisals.

It is important to keep in mind that as the severity of labor pain increases, thermal stimuli of correspondingly higher intensity must be administered and tissue damage will be produced when the comparisons extend beyond eight dols.

Pain threshold measurements were made throughout the entire period of study, in the intervals between contractions. It has been previously shown that an existing pain will cause an elevation of the pain threshold elsewhere in the body (4), and for this reason pain threshold measurements were not made during a contraction.

As soon as the patients were admitted to the hospital they were placed in a private labor room for study. One of the experimental team remained with the patient at all times, and pain tests were made every half hour or when there was any change in the patient's obstetrical status. The majority of the measurements were made in the first stage of labor, although two patients were observed in the second stage, and two in the fourth stage (5). No measurements were made in the third stage. None of the patients had had any analgesic or anesthetic during the time they were studied, although subsequent to the pain studies nine had analgesics and 11 had anesthetics for the delivery. If at any time during the study a patient requested an analgesic it was administered and the pain studies were terminated. This accounts for the fact that most of the patients were studied in the early and middle parts of the first stage of labor.

Measurements were made of the frequency and duration of uterine contractions by manual palpation of the

subject's abdomen. Cervical dilatation was estimated by rectal examination and in some instances confirmed by sterile vaginal examination.

In four patients records were made of the uterine contractions by means of a pneumograph strapped to the abdomen. It was not anticipated that the excursions of the pneumographic needle would be proportional to the intensity of the uterine contraction, but the duration of contraction and the interval between contractions could be more accurately determined in this way than by manual palpation of the abdomen. The patient was given a signal magnet key to press during the time she felt pain, as it was desirable to know whether or not the pain outlasted the contraction. The patient was also asked to give an estimate of the intensity of her pain each five seconds during the contraction. The reports were made in terms of fractions of the intensity of a recently measured uterine pain. This type of procedure for estimating pain intensity had been proved successful in the study of headache and other pains (6, 7).

In the course of all studies careful notes were kept as to the patients' reactions, such as crying, complaining, sweating and degree of alertness and cooperation in the pain studies. Such notes were used to arrive at an estimate of the patient's reaction to her pain.

RESULTS

Figure 1 shows the results obtained on the first patient studied. This individual was a primipara, a professional woman of high intelligence, who wished to experience labor without analgesia, because of her interest in Read's publications on natural childbirth. Studies were begun five hours after onset of the first pains, at which time labor was still mild, and the pain intensity averaged approximately three dols. The cervix was three centimeters dilated; uterine contractions occurred at five-minute intervals and lasted approximately 30 seconds. During the next five hours, as the cervix dilated gradually, the pain increased steadily, reaching an intensity of eight dols, and the contraction interval decreased to one minute.

The subject was calm throughout the course of her labor except for obvious tenseness. However, after the pain had reached eight dols (a severe pain) she asked for an analgesic. This was ad-

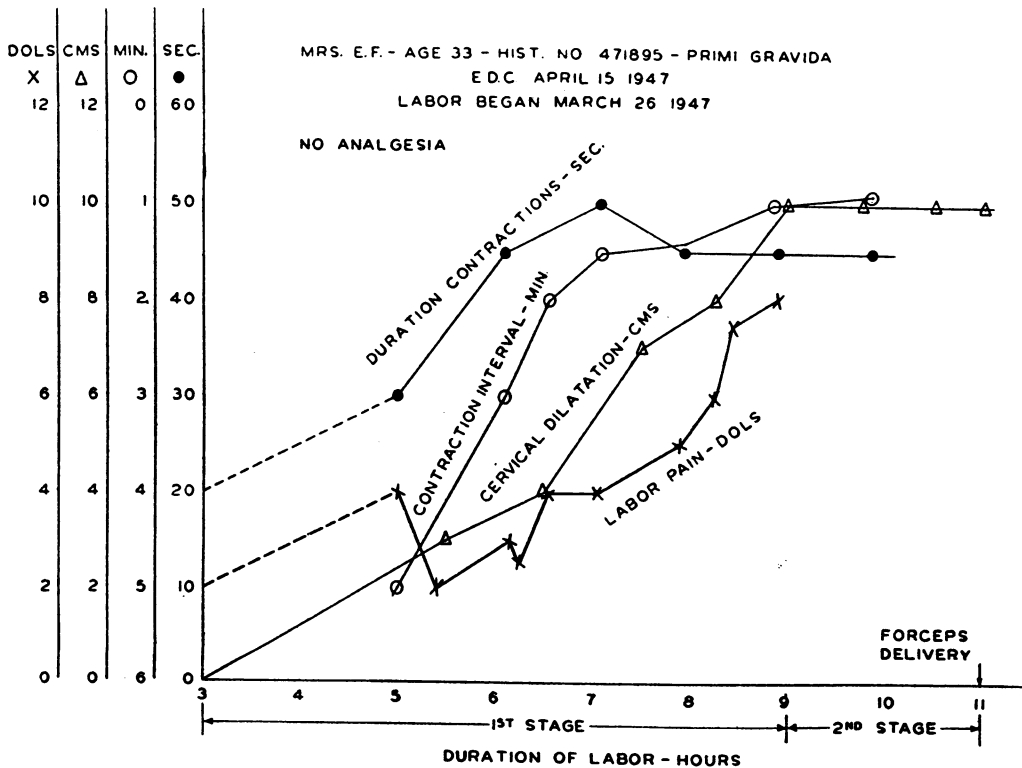


FIG. 1. PAIN CHART OF MRS. F

Abscissa: Duration of labor in hours.

Ordinates: Dots represent duration of contraction in seconds; circles—contraction interval in minutes; triangles—cervical dilatation in centimeters; and crosses—pain intensity in dols.

ministered in the form of nitrous oxide during the second stage.

The second patient was a multipara who had had an unhappy obstetrical history characterized by six spontaneous abortions and only one living child. When the study began her pains were moderately severe, the cervix was closed and the contraction interval was about four minutes. In the next two hours the pain rose very rapidly to the extreme range above nine dols, as shown in Figure 2. The cervix dilated rapidly, and the contraction interval shortened in proportion. Two measurements were made on this patient during the second stage of labor, although the patient had been repeatedly warned of the danger of blistering. Yet she wished to cooperate fully as an expression of her gratitude in having a term pregnancy and insisted on having the tests made. A pain intensity of  $10\frac{1}{2}$  dols was measured. This is the most intense pain which can be experienced. Increasing the intensity of the thermal radiation can cause

no further increase in pain perception (2). Second degree burns were inflicted upon the hands of this patient by the four tests made at levels higher than nine dols. Delivery was accomplished under general anesthesia.

Figure 3 shows a composite study of the 13 patients. As each determination represents not less than eight tests for pain intensity, the 55 measurements are the result of over 400 test readings. These 55 measurements represent an average of about four per patient during the various stages of labor. Since the first stage of labor had a variable duration for each patient, the time scale is expressed in quarters in order to obtain a common basis for comparison. It will be observed that there was a gradual increase in pain intensity as delivery approached, at which time pain reached nine and even  $10\frac{1}{2}$  dols. The dashed line in the figure represents an approximate average of observed values in the first and second stages of labor. In the case of subject H, whose values lie

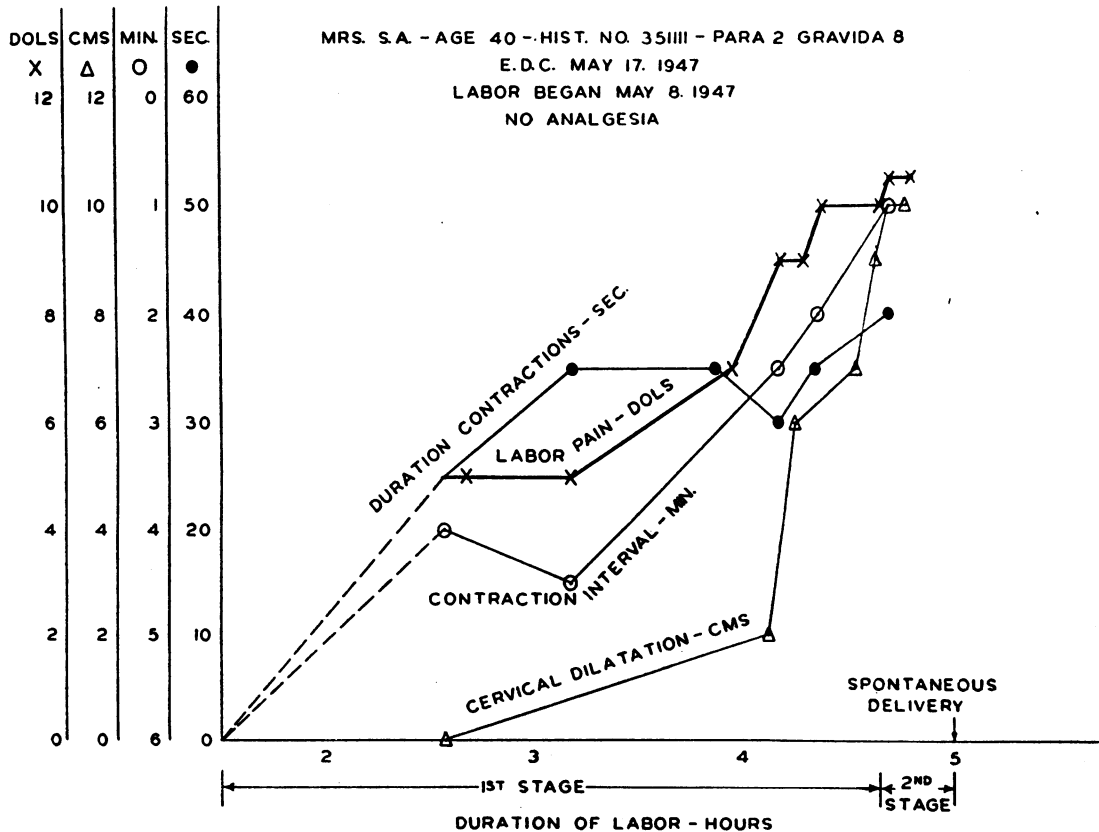


FIG. 2. PAIN CHART OF MRS. A  
 Symbols the same as in Figure 1.

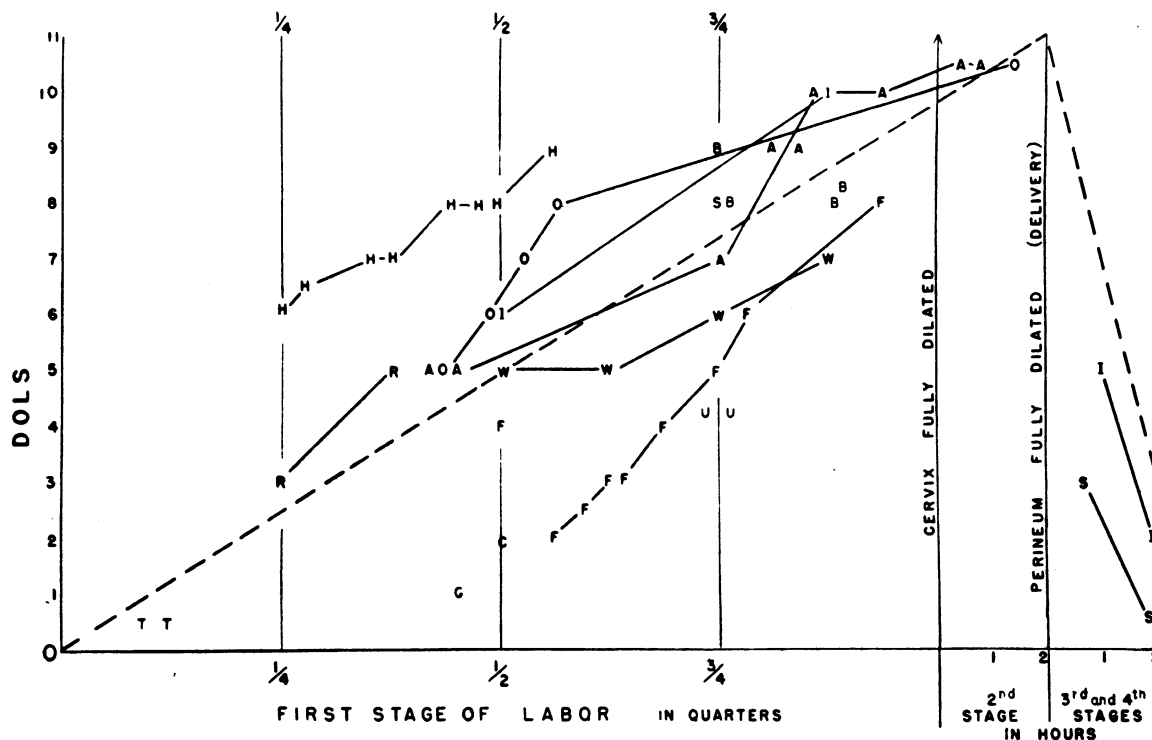


FIG. 3. PLOT OF 55 DETERMINATIONS OF PAIN INTENSITY ON 13 PATIENTS DURING FIRST, SECOND AND FOURTH STAGES OF LABOR

Time scale of first stage expressed in quarters of its total duration.

quite far above the dashed line, it is to be remarked that the progress of her pains was parallel to the average line, but subsequent to the last determination shown she received a considerable amount of an analgesic which may have prolonged her labor.

The intensity of the after pains was measured in only two patients who had received no analgesia in labor and no anesthesia for delivery. These pains were moderate, three to five dols, a half hour after delivery, and decreased to threshold levels two hours later.

Figure 4 shows typical uterine contractions as recorded on the pneumograph. "A" is the recorded curve of contraction; line "B" shows the duration of pain as recorded by the patient when she pressed the key of the signal magnet; and curve "C" is the estimated intensity of pain. The first contraction was recorded in the early part of the first stage of labor, the second during the middle of the first stage, and the third curve during the second stage. It will be seen that the pain in each case was of shorter duration than the contraction, which is in contrast with the findings in

dysmenorrhea. Chassar Moir (8) has reported that in cases of dysmenorrhea the pain outlasts the uterine contraction and from this observation he suggested that the pain of dysmenorrhea might be attributed to hypoxia in the uterine muscle. It will be noted, too, that the stronger pains represent a greater proportion of the time of contraction than do the weaker pains, the range being from 15 per cent to 95 per cent of the total contraction time, depending upon the intensity of the contraction. This indicates that for weak contractions the pain threshold is reached more slowly than for stronger contractions.

The duration of contractions varied considerably from time to time in the same patient in various stages of labor, and showed no tendency to increase as delivery approached. This is in agreement with the observations of Murphy (9) who reports a decrease in average contraction time as labor advances.

#### DISCUSSION

The first questions to be answered were whether or not the method of dolorimetry was applicable to

the measurement of pain intensity in labor, and, if so, what were the limitations of the method.

The more than 400 trial tests resulting in 55 successful measurements of pain intensity on 13 patients establishes the method as a practical one for this type of investigation. However, this study does not attempt to be a complete survey since it does not include examples of the many types of labor and dystocia that may be found in the obstetrician's practice. Measurements can be made easily on any patient who can cooperate. The effects of distraction and lack of cooperation can be recognized by the large and rapid variations in estimates of pain intensity. Although the data are obtained from subjective comparisons of pain intensity, the test instrument affords an evaluation of the patient's report over which the patient has no control.

The most important limitation of the method is the inflicting of burns when high pain intensities are measured. A second limitation is that measurements cannot be made in the face of distraction and lack of cooperation. The patient must be willing and able to make comparisons of her painful sensations with those induced by thermal stimuli.

### 1. Pain intensity

In every patient studied the pain intensity increased as the labor progressed (Figure 3). Although few observations are available during the first quarter of the first stage of labor it can be safely assumed that these pains were of a mild intensity, averaging probably not more than one or two dols. Pain in the second quarter of the first stage was moderate, averaging between three and five dols. During the third quarter the pain of most patients averaged between five and seven dols, which is a severe pain. It was at this point that most patients asked for relief. In the last quarter, the pain was between seven and ten dols. The second stage of labor was characterized by the the most severe pains,  $10\frac{1}{2}$  dols, accompanying the "bearing down." After delivery the pains observed in the fourth stage of labor were again of mild intensity.

An approximate correlation could be made between the intensity of the pain and the extent of the cervical dilatation. Thus, when the patient was experiencing pain of ten dols it was found that the cervix was fully dilated, and if the pain was of one or two dols' intensity the cervix was observed

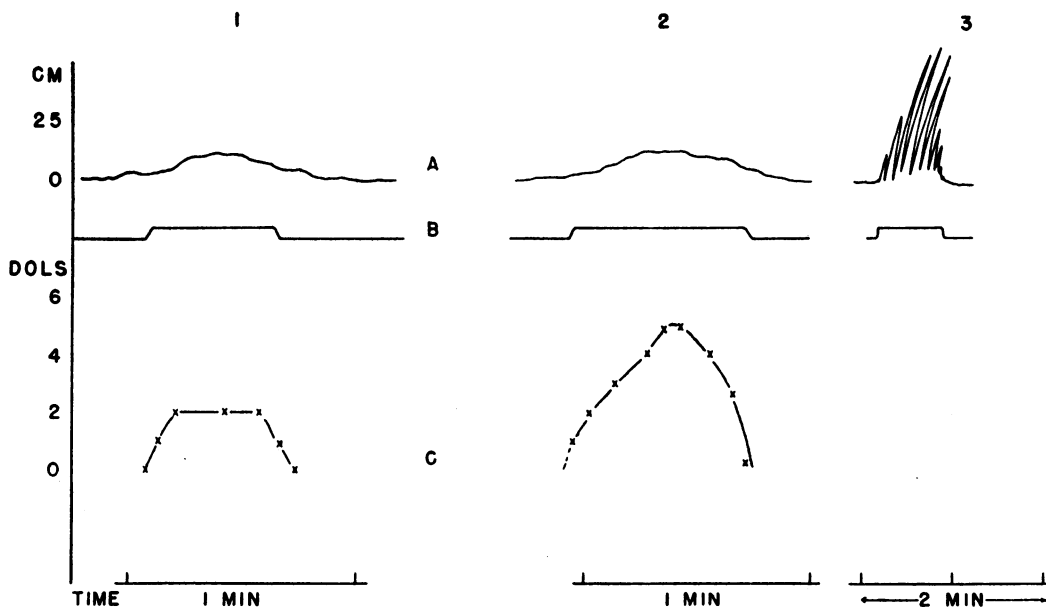


FIG. 4. PNEUMOGRAPH RECORDING AND ESTIMATED INTENSITY OF UTERINE CONTRACTIONS

- A. Typical uterine contractions as recorded by a pneumograph strapped to patient's abdomen.  
 B. Duration of corresponding pain recorded by signal magnet.  
 C. Estimates of corresponding pain intensity.  
 1. Early first stage. 2. Middle of first stage. 3. Early second stage.

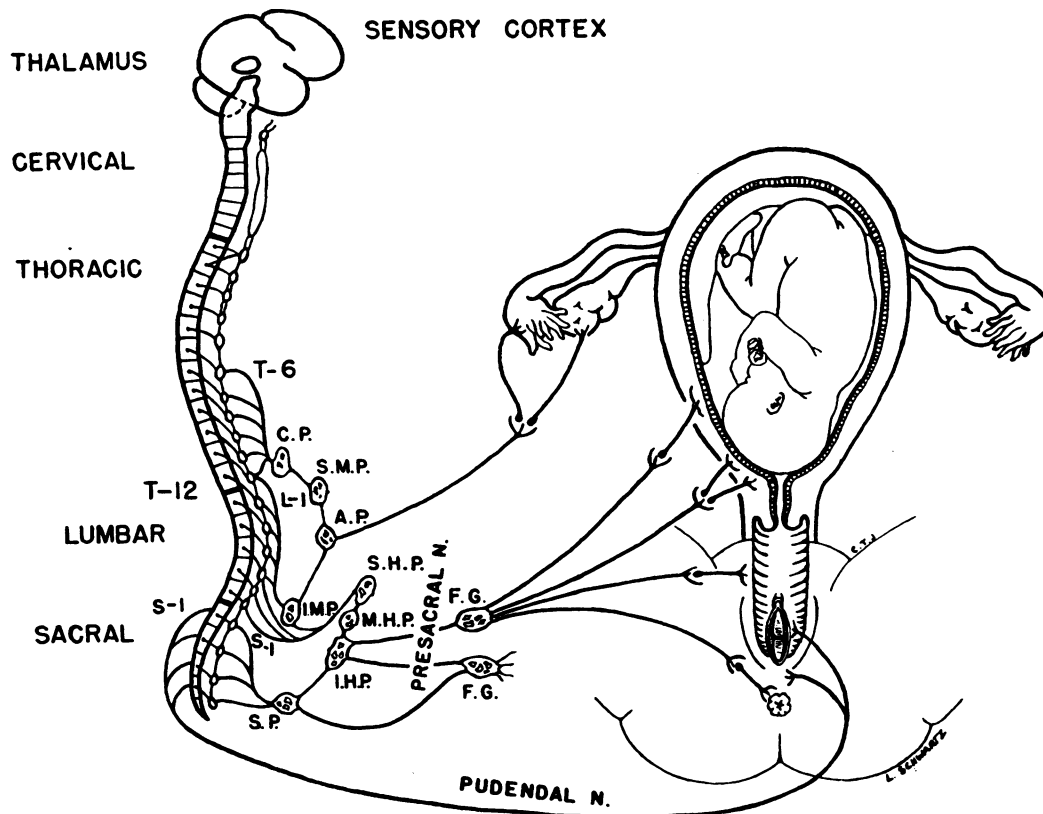


FIG. 5. DIAGRAM OF THE PAIN PATHWAYS OF IMPORTANCE IN CHILDBIRTH

*First stage of labor:* Visceral afferents arising in plexi enervating uterus, cervix and vagina; pathway: Frankenhouser's ganglion (F.G.) into hypogastric plexi (I.H.P., M.H.P., and S.H.P.) thence through the celiac plexus (C.P.), the superior and inferior mesenteric and aortic plexi (S.M.P., I.M.P., and A.P.) and the sacral plexus (S.P.) into spinal outflow from T6 to S4.

*Second stage of labor:* Visceral afferents plus somatic afferents via the pudendal nerve.

to be almost closed. However, a much more quantitative relationship appeared to exist between the pain intensity and the interval between contractions.

The relationship observed between the contraction interval and the intensity of pain provides a simple method for computing the pain from measurements of this interval. Thus,

Dols of pain =  $10.5 - 1.5 \times$  contraction interval in minutes.

This formula may not apply generally, of course, to all cases, although it has been observed to be valid in our series of patients without analgesia.

## 2. Character and origin of pain

During the early part of the first stage of labor the pain was of short duration and of a dull aching

quality, and was associated with a uterine contraction of relatively low intensity (see Figure 4, Curve 1). The visceral structures involved in producing this pain are deep and noxious impulses probably reach the central nervous system via the sympathetic and parasympathetic afferents (10) as diagrammed in Figure 5. As the cervix dilated and the uterine contractions became stronger the pain assumed a sharper quality. It had been noticed in other studies of pain intensity that bright, burning pain and dull, aching pain have a tendency to become similar. That is, a burning pain had an aching quality and an aching pain became sharp (3). This was also true of labor pains.

The ceiling pain was not reached until the beginning of the second stage at which time the somatic perineal structures were involved. These

superficial structures are innervated chiefly by the pudendal nerve (10), as shown in Figure 5, and the most intense pains are caused by the stretching and tearing of these tissues, with accompanying stimulation of the perineal reflex and considerable increase in intrauterine pressure (10). Curve 3, Figure 4, shows a recording of the onset of the reflex which is apparently inhibited periodically, possibly by the intense pain. Superimposed on the low uterine component of the pressure wave were spikes of great pressure from the perineal reflex. The duration of the pain at this time was almost as long as the contraction.

Figure 6 shows a plot of the pain intensity in dols against the uterine contraction in minutes. The connection between the contraction interval and uterine effort has been established by the tocographic measurements of Murphy (9) and others (11), and while it cannot be assumed that the tocographic measurements are necessarily representative of intrauterine pressure, they appar-

ently do represent the uterine hardness and thereby offer a measure of the uterine spasm (12). The uterine pressure in millimeters as estimated from Murphy's work is plotted to the right in Figure 6, and it can be seen that the pain intensity in dols is also proportional to the uterine pressure in millimeters, measured on Murphy's tocograph. This evidence, as well as the clinical observation that dilatation of the cervical canal causes severe pain, supports the conclusion that the pain in the first stage of labor is largely due to the distention of the internal os and the cervical canal as a result of the increased intrauterine pressure caused by uterine contractions.

### 3. Reactions to pain

During the early hours of labor there were generally few complaints and the patients were alert and interested in the study. There was no sweating. Two patients did not fall into this pattern. Mrs. O soon began to show hostility to the entire experimental team in spite of expressing many

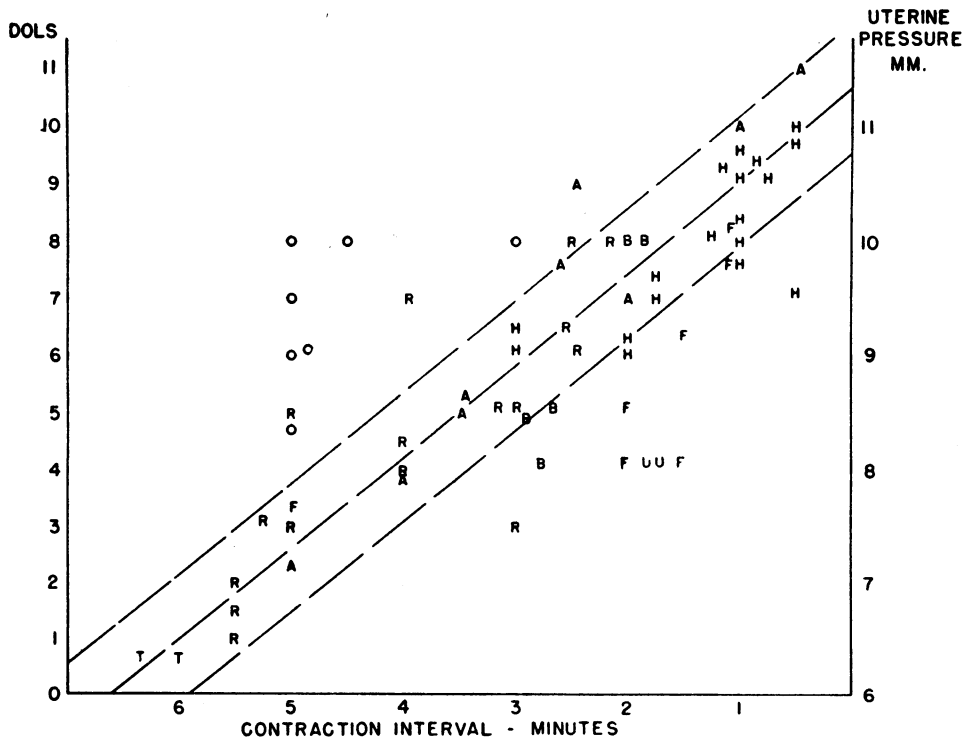


FIG. 6. PLOT OF ESTIMATES OF PAIN INTENSITY (DOLS) AGAINST LENGTH OF INTERVAL BETWEEN CONTRACTIONS (MINUTES)

Ordinate at the right of diagram represents Murphy's tocographic measurements of uterine pressure.



times prior to admission her desire to participate in the study. Cajoling and persistence made it possible to carry on the study and in spite of this difficulty the pain measurements obtained were in the range of those for the more cooperative patients. Mrs. U cried and complained with vigor from the outset although her pain measurements indicated only two to four dols. This patient succeeded in becoming so excited that no further observations could be made in her case.

Late in the first stage 11 of the 13 patients were sweating and crying with each contraction, and were cooperating only with difficulty. Pain was severe at this time, seven to ten dols. One patient, Mrs. A (see Figure 2), gave little evidence of her pain. As a multipara her labor was short and this may account for her restraint in the face of pains measured at eight to ten dols. Fatigue was as important as pain intensity in bringing about a breakdown in the restraint most of the patients maintained over their actions. Thus, in her short labor, Mrs. A gave less visible evidence of pain at eight dols than did the other patients with longer labors at four dols.

The evidence of this study is that the reactions of the patient depended partly on the pain and to a greater extent on fatigue, anxiety, and, in some cases, hostility, whereas the pain intensity as measured was related to the uterine activity and dilatation of the cervical and perineal tissues. It seems important, therefore, to make a clear distinction between the intensity of the pain perceived by the patient and visible evidences of reaction to pain, such as complaining, groaning and crying out. These findings bear out the clinical impression regarding the psychological factors affecting the behavior of patients in labor. However, by measuring the intensity of the pain it is now possible to evaluate more fully the effects of pre-conditioning (as in "natural childbirth") and reassurance, as well as the action of analgesia upon pain sensation in the obstetrical patient. Further studies are planned to include an appraisal of suggestion and hypnosis.

#### SUMMARY AND CONCLUSIONS

1. Four hundred test readings, resulting in 55 measurements of pain intensity, were made on 13 patients during the first, second and fourth stages of labor without analgesia. The measurements

were made by comparison of the labor pains with a pain of standard intensity which was produced by a three-second exposure to thermal radiation on the dorsal surface of the right hand. The pain evoked on the hand had been previously standardized into  $10\frac{1}{2}$  units of painfulness ( $10\frac{1}{2}$  dols) between the threshold pain and the most intense pain which can be experienced (ceiling pain).

2. The pain intensity was observed to change with the progress of labor as follows:

- a. First stage—

First quarter—threshold to two dols

Second quarter—three to five dols

Third quarter—five to seven dols

Fourth quarter—seven to ten dols.

- b. Second stage—Ceiling pain, ten to ten and one-half dols.

- c. Fourth stage—Intensity from three to five dols to near threshold value in about two hours after delivery.

3. The intensity of the pain in the first stage of labor was roughly proportional to the extent of cervical dilatation and inversely proportional to the duration of the interval between uterine contractions. Pain intensity can be estimated approximately by the formula:

$$\text{Dols} = 10.5 - 1.5 \times \text{contraction interval in minutes.}$$

4. The duration of pain was 15 per cent of the contraction time for the weak contractions characteristic of early labor, and 95 per cent of the contraction time at the beginning of the second stage of labor.

5. The pain threshold was measured in the interval between contractions in the first, second and fourth stages of labor. It was within the normal range for all the patients who had received no analgesia or anesthesia.

6. The intensity of the pain experienced by the patient could not always be evaluated on the basis of her reaction, nor correlated with her apparent distress. Distinguishing between the intensity of the pain perceived by the patient and the patient's reaction has been made possible by measurements of pain intensity and pain thresholds.

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