Physiological Properties of Unmyelinated Fiber Projection to the Spinal Cord

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Sixty per cent of the cells in the spinocervical tract responding monosynaptically to stimulation of peripheral myelinated fibers were found to respond also to stimulation of peripheral unmyelinated fibers. The length of discharge produced by unmyelinated fiber stimulation unlike that produced by myelinated fiber stimulation increased with each subsequent stimulation if the repetition rate was greater than one per 2 to 3 sec. This was called the windup. The discharge produced by unmyelinated fiber stimulation was more susceptible to inhibition by barbiturate and touching the inhibitory receptive fields than was the discharge produced by myelinated fiber stimulation. Volleys in contralateral A fibers inhibited the discharge in units of the spinocervical tract produced by ipsilateral C fiber stimulation. Natural stimulation studies revealed that units with both an A and C fiber input discharged more rapidly as pressure on the receptive field increased. The more intense firing consisted mainly of slower adaptation. These units were said to have a wide dynamic range of response. Units with only an A fiber input gave the same quickly adapting response to both light touch and heavy pressure on skin of their receptive fields. These units were said to have a narrow dynamic range of response. It was suggested that the C fiber input produced the increase in dynamic range and that this accounted for the involvement of unmyelinated fibers in high threshold phenomena (e.g., pain).

Introduction

The object of this study is to examine the effects produced by stimulation of peripheral cutaneous unmyelinated fibers on activity in single cells of the spinal cord. In particular these results are compared with those obtained by stimulating peripheral cutaneous myelinated fibers. There is evidence that stimulation of cutaneous unmyelinated (or C) fibers and stimulation of cutaneous myelinated (or A) fibers produce different central effects. A volley in the large peripheral myelinated fibers results in presynaptic inhibition of neighboring fibers (8, 10, 12), whereas a volley in peripheral unmyelinated fibers results in presynaptic facilitation of neighboring fibers (22). In order

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to describe the central effects of C fibers more completely, one must examine responses of single postsynaptic cells to stimulation of peripheral unmyelinated fibers.

Units of the spinocervical tract whose axons run in the dorsolateral column have been studied. Their cell bodies are in lamina IV of Rexed (28) in association with the incoming afferent fibers and with the cells of the substantia gelatinosa which produce the presynaptic effects (36). Units in this tract have cutaneous receptive fields (18, 30, 34). This tract projects through the lateral cervical nucleus to the thalamus, S1 cortex and S2 cortex (24, 25). Activity in this fasciculus produces the earliest component of the cortical evoked potential due to skin stimulation (19, 27). Preliminary results for electrical stimulation have been reported (23).

Methods

Adult cats weighing at least 2 kg were used for all experiments. While under ether anesthesia the spinal cord was transected at the C1 level; both the carotid and vertebral arteries were occluded for the duration of the experiment. The anesthesia was then discontinued and the animal was artificially ventilated. A laminectomy was performed at the lumbar enlargement. The ipsilateral sural nerve was used for all electrical stimulation of unmyelinated fibers. Other nerves were stimulated for various purposes as described in the text. In some cases the spinal cord was stabilized when recording with microelectrodes although in general this was not found to be necessary. Stability when needed was obtained by the method of Taub (29) which involved insertion of a pin between the cord and the bony canal. The animals were paralyzed by intravenous injection of gallamine triethiodide (Flaxedil).

Recordings were made from single units in the dorsolateral column using 3M KCl filled micropipettes whose resistances were 10-20 megohms; Ag-AgCl electrodes were used to record action potentials from peripheral nerves. These signals were processed in the usual way through a cathode follower and preamplifier and were displayed on an oscilloscope.

One of the interesting findings of this work was the response pattern resulting from C fiber stimulation. For repetition rates greater than one per 2 sec the duration of the response increased with each subsequent stimulation. In order to best display this pattern a different mode of display was used (33).

The object of this display was to present the responses to many subsequent stimuli side by side and thus to reveal any changes in the response from one stimulus to the next. Since the spikes were all of the same height, no information would be lost if they were converted to dots on the oscilloscope. The horizontal sweep was adjusted so that it took about 120 sec to cross the screen. A sawtooth was applied to the vertical deflection plates. Its period was short
The spikes recorded from the single unit were amplified and then used to trigger brightening pulses. These uniform pulses were then fed onto the z axis of the oscilloscope and the intensity of the beam was then turned down so that only the brightening pulses could be seen as dots. The beginning of the sawtooth and the stimulus were made to coincide. The result was a large number of vertical columns of dots. Each column represented one stimulus and its response. The bottom dot was the stimulus artifact and each subsequent dot represented one impulse of the response.

The above mode of display was found very useful for electrical stimulation. When natural stimulation was used, a different method had to be used because the stimulation was continuous (34). It also involved converting spikes to dots but instead of putting a sawtooth of fixed length onto the vertical deflection plates of the oscilloscope, it employed a sawtooth which could be interrupted every time a spike occurred. The heart of this arrangement was a modified Tektronix 162 wave-form generator designed by Dr. J. Y. Lettvin. The resultant display measured interspike intervals with dots far above the baseline representing long interspike intervals (i.e., a long time before the sawtooth was interrupted by the next spike). Brightening pulses were employed in exactly the same manner as before.

The stimulating circuit was the same as described earlier (23). Selective blocking of A fibers was accomplished by anodal polarization (2).

Results

*Electrical Stimulation.* The responses described in this report have been obtained from single axons in the dorsolateral column. This tract of fibers runs lateral to the dorsolateral groove which is the dorsal root entry zone. This fasciculus is not functionally homogeneous rostral to L4 since it contains both the spinocervical tract and the dorsal spino cerebellar tract (17). The cells of origin of the dorsal spino cerebellar tract are in Clarke's column which in the cat does not run caudal to L4. The spinocervical tract originates from cells of lamina IV of Rexed. Thus to record unequivocally from units of the spinocervical tract, one must record at L5 or more caudally. All the results quoted in this study have been made either at caudal L4 or at L5; at both these segments the same properties have been observed. It is doubtful that there is a significant contribution from Clarke's column at L4 since the axons probably run rostrally before joining the dorsolateral column. Thus it appears that these results concern axons of the spino cerebellar tract which originate in cells of lamina IV of lower lumbar segments.

Units in the dorsolateral column which responded monosynaptically to stimulation of large A fibers were selected. The response consisted of a short latency, high frequency burst of impulses (called the early discharge) whose
duration did not change for each subsequent stimulation (33). A 50-100 msec silent period followed the discharge (21). In general this was followed by a period of activity at the same discharge rate as the prestimulus level (Figs. 3, above, and 4), although in some instances it was markedly increased (Fig. 1, top) perhaps due to very low levels of C fiber activation. The number of spikes in the discharge varied from cell to cell for a given intensity of peripheral stimulation; sometimes there were as few as four spikes, while in other units there were long discharges of twenty to thirty spikes.

When the stimulus was increased to stimulate peripheral C fibers, many of the cells also gave a long discharge beginning 150-200 msec after the stimulus (Fig. 1; see also 23). This corresponded to the estimated time of conduction of C fiber impulses to the spinal cord (conduction distance about 175 mm). This long discharge was referred to as the late discharge. In a sample of fifty cells responding monosynaptically to A fiber stimulation, 60% also responded to stimulation of unmyelinated fibers. Often the early and late discharges were not separated by a silent period (Fig. 4). This probably resulted from repetitive firing of the peripheral A fibers when large electrical stimuli were used to stimulate C fibers. Another probable contribution to this activity was the response to stimulation of Aδ fibers (31).

The discharge of dorsolateral column axons resulting from C fiber stimulation (i.e., the late discharge) was very different from the response to A fiber stimulation (i.e., the early discharge). It began with a long burst which was often interrupted by lower frequency discharges or in some cases complete silence (Fig. 2, top). The frequency of discharge of the most intense part of the late discharge was usually much less than that of the early discharge (Figs. 1, 3, 4). Following this long burst there was a much lower frequency discharge, whose duration increased with each subsequent stimulation (Figs. 1, 2). This was called the "windup" of the cell. It continued until the cell fired continuously at a much higher rate than the spontaneous rate.

A long-lasting late discharge was produced in the cell shown at the top of Fig. 2. It demonstrated well the alternation of relatively high and low frequency discharges which appeared as bands with this method of display. This was referred to as the banding pattern. Not every unit responding to the C input displayed the banding pattern (e.g., Fig. 2, bottom) and some units displayed it more prominently than others.

The length of the C fiber initiated late discharge corresponded roughly to the estimated duration of the arrival of the temporally dispersed C volley at the spinal cord (about 300-400 msec). If the stimulus was very close to C threshold so that only the fastest C fibers were excited, only the earliest band of the late discharge was seen.

The windup part of the discharge contained no obvious bands of high frequency firing. It appeared that the incoming C volley produced a long fa-
Fig. 1. Above: Response of single dorsolateral column axon to stimulation of sural A fibers on the left. Note the high frequency early discharge. On the right is the response to sural A and C fiber stimulation. Note that there is both an early and a late discharge. The late discharge on the right lengthens and becomes more intense with each stimulus. This is the windup. Stimulation rate is 1/sec. Vertical time marker 100 msec. Below: Recording of compound action potential on cut end of the sural nerve during activity seen above. The uppermost trace is a recording of the A fiber volley producing one column of the activity seen above on the left. It consists of a stimulus artifact and compound action potential of the large myelinated fibers. The next two traces result from increasing the stimulus intensity so that the C fibers are excited. The middle trace is the action potential corresponding to the first discharge of the dorsolateral column cell to A and C fiber stimulation. The bottom trace is the peripheral volley producing the last discharge to A and C fibers seen above. The size of the C volley remains the same although its central effect increases. The increase in the early discharge seen at this high stimulus strength results from repetitive firing of the A fibers. Time marker represents 10 msec.
Fig. 2. Response of single unit to stimulation of A fibers and C fibers and effect of variation of stimulation rate on the windup. Above: Response of dorsolateral column axon to stimulation of A and C fibers of ipsilateral nerve at stimulation rate of 1/sec (left) and 1/2 sec (right). The first short burst represents the stimulus artifact and response to A fibers (early discharge). Late discharge is response to C fibers. The windup is present only for the faster stimulus repetition rate. Vertical time marker 100 msec. Below: Response of dorsolateral axon (different from a) to stimulation of A and C fibers of ipsilateral sural nerve. Stimulation rate 1/sec (left), 1/2 sec (center) and 1/4 sec (right). Unit "winds up" at stimulation rate of 1/sec and this excitability persists for a long time after cessation of stimulation as seen by high rate of spontaneous activity. As a result initial stimuli at 1/2 sec evoke a very long response. This excitability decreases and the slow repetition rate (1/2 sec) which would normally produce little or no windup here appears to produce a "wind down". Unit shows normal excitability at the beginning of 1/4 sec stimulation and each discharge produced response the length of which is the same as the initial discharge at 1/sec. Vertical time marker 100 msec.
cilitatory phase in addition to the high frequency bursts. Only the initial part of this facilitation was strong enough to express itself as an increase in the firing rate. As a result each subsequent stimulation started off from a higher level of facilitation and therefore produced a longer, more intense discharge.

Fig. 3. Response of single unit in dorsolateral column before (above) and after (below) administration of barbiturate intravenously. The late discharge caused by the C volley was very much reduced by the barbiturate. The early intense firing due to the A fibers was inhibited to a much smaller degree. The stimulus delivered to the ipsilateral sural nerve was repeated once a second. Vertical time marker 100 msec.

To measure the duration of this facilitation the repetition rate was decreased until the windup disappeared (Fig. 2). The minimal repetition rate required for windup varied from unit to unit but it was generally between one per 2 sec and one per 3 sec. This meant that the incoming C volley produced a fa-
The windup might have originated peripherally, i.e., the size of the afferent C volley might have increased at each subsequent stimulation. The results shown in Fig. 1 eliminated this possibility which meant the windup was central in origin. Furthermore a unit which showed a windup to ipsilateral C fiber stimulation did not wind up to contralateral C fiber stimulation (Fig. 5).

Barbiturate eliminated the late discharge, leaving the early one relatively unaffected (Fig. 3). In Fig. 4 the late discharge was more drastically inhibited than the early discharge when that part of the receptive field which inhibited the unit was touched (afferent inhibition; 29, 30).

Zotterman (39) suggested that the effects of peripheral C fibers were in-
hibited by A fibers. It was of interest to examine this now that a clear effect of peripheral C stimulation could be seen. A contralateral A volley was used as a conditioning stimulus to avoid the excitatory postsynaptic effects of an ipsilateral volley. The contralateral medial popliteal nerve was stimulated repetitively at various intervals after the test volley which was elicited by stimulating the A and C fibers of the ipsilateral sural nerve. The ipsilateral and contralateral stimuli each by themselves were controls. The contra-

Fig. 5. Response of single DLC axon to stimulation of ipsilateral and contralateral sural nerve. The stimulation rate was 1/sec. This unit shows the windup response to stimulation of ipsilateral sural nerve fibers (left). Contralateral sural nerve stimulation (right) produces neither early (A) or late (C) discharge and in fact there is some inhibition of the spontaneous activity of the unit. The lowest row of dots for the contralateral stimulation represents the stimulus artifact. Further discussion in text. Vertical time marker is 100 msec.

lateral repetitive stimulation inhibited the late discharge produced by the C fibers and this inhibition lasted about 75 msec (Fig. 6). Since the contralateral volley produced a dorsal root potential of this duration (1, 9, 32) associated with a depolarization of Ib and cutaneous afferent fibers (9), it was considered likely that this inhibition was presynaptic. Not all of the C discharge was eliminated by the contralateral A volley, but only that part immediately following the volley. After the inhibition the remaining part of the C discharge was the same as the corresponding part of the discharge of the control. In other words the reverberatory activity or pacemaker giving rise to the banding was not affected by inhibiting the activity of the cell. Thus the pacemaker was external to the cell. Furthermore even if the first
band was eliminated the subsequent ones appeared at exactly the right time (Fig. 6). This meant that both the onset and subsequent activity of the pacemaker were completely independent of the contralateral volley. It was concluded that the contralateral volley could interfere only with the expression of the pacemaker activity on the postsynaptic cell.

**Fig. 6.** Result of interjecting a contralateral A fiber volley into late discharge of a dorsolateral column axon. This unit "winds up" to ipsilateral C fiber stimulation. Stimulation rate is 1/sec. The contralateral volley is made up of three stimuli at a frequency of 100/sec to the medial popliteal nerve. This stimulus is strong enough to excite only A fibers. Artifact produced by this contralateral multiple stimulation is visible as a line of fused dots at variable intervals from the ipsilateral stimulus. The first artifact is marked by a small arrow at the bottom of the picture and the shifts in test interval form a staircase pattern. Contralateral stimulus by itself produces no discharge. Activity resulting from C fiber stimulation of ipsilateral sural nerve is inhibited 100-75 msec following the contralateral volley. Further discussion in text. Vertical time marker 100 msec.

**Natural Stimulation.** As indicated previously only 60% of the cells which responded monosynaptically to a sural A volley also responded to a sural C volley. This raised the question of whether or not these types of units could be distinguished on the basis of their response to natural stimulation. To study this the sural nerve was dissected free from surrounding tissue in the popliteal fossa but it was not cut peripherally. Units in the dorsolateral column were then classified on the basis of whether or not they were affected by an electrically initiated C volley. The response to natural skin stimulation
of each unit so identified was then examined. It soon became apparent that units with both A and C fiber inputs had a much larger dynamic range of response than units with only an A input. By dynamic range of response was meant the range of natural peripheral stimulation for which the cell of the

![Characteristics of response in units with A and C fiber inputs](image)

**Fig. 7.** Characteristic responses of single units in dorsolateral column with only A fiber input (above) and with A and C fiber inputs (below). Each dot represents a nerve impulse; height above base line represents interval in msec on scale between recorded impulse and preceding one. Vertical time marker 10 msec. Impulses occurring at intervals greater than 100 msec not shown. Above: Two stimuli were delivered; duration of which is marked by horizontal bars. The first was a strong pinch to the skin in the center of receptive field of unit. The second was light touch to the same area. Discharge pattern to both stimuli is similar. This unit has small dynamic range of response characteristic of units with only A fiber input (see text). Below: Two stimuli delivered: left, light touch to skin in center of receptive field; right, strong pinch to same area. Picture shows much more intense response with less adaptation when stimulus strength is increased. This unit has wide dynamic range of response characteristic of units with both A and C fiber input (see text).
dorsolateral column changed its response. A cell with only an A fiber input gave a rapidly adapting response to a light touch stimulus in its receptive field (Fig. 7, above). When the skin was then squeezed, the discharge was about the same or even somewhat inhibited. Units with both an A and C fiber input gave the same light touch response as the A only units. When heavy pressure was applied to the receptive field, there was a quick high frequency burst; however, the unit adapted much less rapidly than it did for light touch so that it fired quite actively for the duration of the stimulus (Fig. 7, below). In other words the units with both A and C inputs gave different firing patterns for light touch and heavy pressure whereas the units with A input only gave essentially the same discharge for light touch and heavy pressure. Thus it was concluded that units with A and C inputs had a larger dynamic range of response than units with A inputs only.

Discussion

One cannot say very much about the synaptology of the pathway from peripheral C fibers to cells of the spinocervical tract since the conduction time in the afferent fibers is much greater than a single synaptic delay. The origin of the late discharge is not clear. It could originate as a result of depolarization of the postsynaptic cell by the temporally dispersed incoming volley in the C fibers. Another possibility is that the C volley produces presynaptic hyperpolarization of myelinated fibers which increases the postsynaptic effect of ongoing activity in these myelinated fibers. Unfortunately the detailed anatomy of C fiber termination in spinal cord is unknown. There is evidence that a pure C volley itself produces no ventral root reflex although it can potentiate the reflex elicited by stimulation of peripheral A fibers (22). It is premature to conclude from this that the afferent C volley acts exclusively by opening a presynaptic gate which potentiates activity in neighboring myelinated fibers.

The mechanism producing the windup is also obscure. It clearly is central as the results of Fig. 1 indicate. It may be presynaptic in origin whereby each succeeding volley passes through a more hyperpolarized terminal arborization. The positive dorsal root potential measured by Mendell and Wall (22) lasts less than 1 sec. However, a long-lasting, low-intensity phase might be hidden in the noise. Another possibility is that the C fibers produce reverberatory activity last 2-3 sec in interneurons which affect the spinocervical cell. If the next input arrives at the cord within 2-3 sec, it sums with the ongoing reverberatory activity to produce a more intense discharge in the interneurons than the one before it. This results in a longer discharge in the cell of the spinocervical tract since the interneuronal bombardment is supraliminal for a longer time. No conclusive evidence exists which would allow the choice of one of these possibilities.

The facilitation produced by the unmyelinated fibers is not restricted to
the unmyelinated fibers which are activated. It has been demonstrated that a conditioning volley in unmyelinated fibers can lengthen the early discharge of a dorsolateral column unit (Mendell, unpublished). This is consistent with a previous result which has shown the potentiation of the ventral root reflex by volleys in unmyelinated fibers (22). Thus, volleys in the unmyelinated fibers produce a facilitation which is not restricted to the stimulated fibers. This differs from post-tetanic potentiation described by Lloyd (16) and Wall and Johnson (37).

Clinical experiments have been performed which are consistent with the results concerning the windup. Collins and Nulsen (5) have stimulated peripheral nerves in man. They find that a single electrical shock to peripheral C fibers alone leads to a diffusely localized, nonpainful sensation. To produce a painful stimulus repetitive stimulation at 3 per sec is required. This must be continued for a few seconds before the subject reports that the stimulus is painful. It is reasonable to assume that some central windup is taking place and it is only after the activity in the central cells has reached a certain level that the stimulus is identified as a painful one.

Noordenbos (26) found that lightly brushing the affected skin area of patients with post herpetic neuralgia produced excruciating pain but only after a delay of a few seconds. Examination of the nerve supply to such pathologic areas indicated a decrease in the number of myelinated fibers supplying the skin. One might conclude that the input balance was shifted so that light touch produced intense activity in the central cells (freed, in large part, from the inhibiting influences of A fibers) but only after a delay to allow for the windup.

Dynamic Range as a Function of Input. The division of units in the dorsolateral column into narrow and wide dynamic range agrees with the classification made by Lundberg and Oscarsson (18). They studied units in the dorsolateral column and they found that units which had a narrow dynamic range could be activated by only the lowest threshold cutaneous afferents whereas units in the wide dynamic range system could be activated by both cutaneous A fibers and high threshold muscle afferents. The present study has extended these results by demonstrating that units with a wide dynamic range have an additional input from cutaneous afferent C fibers. It is not surprising to find a close relationship between unmyelinated fibers and cells with a wide dynamic range. C fibers have long been associated with transmission of intense stimuli and in this tract only cells with a wide dynamic range can process intense stimuli.

It was concluded on the basis of electrical stimulation studies that unmyelinated fibers whose stimulation produced intense central excitatory effects (4, 5) were involved in sensation of intense stimuli. It was also known that unmyelinated fibers had the highest threshold of all peripheral fibers to elec-
trical stimulation (10). It was concluded from these observations that C fibers were involved in processing of intense stimuli by means of a high threshold to natural stimulation. Myelinated fibers which produced much weaker central effects were known to have very low thresholds to natural stimulation (13, 39). More recent investigations on the adequate stimulus for peripheral unmyelinated fibers found that the large majority had very low natural stimulation thresholds comparable to those of myelinated fibers (3, 7, 14). A small number of high threshold unmyelinated fibers were found but it seemed unreasonable to expect this small number of fibers to inform the organism of the presence of intense stimulation. Thus the mechanism by which unmyelinated fibers processed intense stimuli might not reside in a high threshold receptor. Furthermore thresholds to electrical and natural stimulation were not related.

The results of this investigation suggest an alternative: namely, that all the unmyelinated fibers regardless of threshold have the property of extending the dynamic range of central cells to which they project. It is proposed that this extension of dynamic range is related not to a high peripheral threshold but rather to special physiological properties of the central projection of unmyelinated fibers. One must still explain why the central effects of unmyelinated fibers predominate only at high stimulus intensities despite the fact that A and C fibers have roughly the same thresholds.

The discharge produced by C fibers in units of the dorsolateral column can be increased during relatively slow (1 per sec) repetitive stimulation (i.e., the windup). On the other hand the discharge caused by peripheral A fibers is of constant length and it cannot be facilitated even by post-tetanic potentiation (34). Furthermore the central discharge produced by C fibers is much less intense than that produced by A fibers if the frequency of firing is considered as an index of the effect produced. Another manifestation of the relatively weak effect produced by C fibers is that it is much more susceptible to inhibition by barbiturate (Fig. 3) and afferent inhibition (Fig. 4) than the discharge produced by A fibers. Thus stimulation of myelinated fibers produces an intense discharge in the central cell which is maximal at low levels of peripheral stimulation; stimulation of the unmyelinated fibers produces a much weaker discharge in the central cell and this does not reach a maximum until the peripheral stimulation is intense (Fig. 7). It is possible that this difference results in part from the opposite presynaptic effects produced by these two types of peripheral fibers. Presynaptic inhibition (by its negative feedback action) limits the effect produced by myelinated fiber stimulation while presynaptic facilitation (by its positive feedback action) extends the ability of the C fibers to affect central cells at all levels of peripheral stimulation.

During heavy pressure the peripheral fibers tend to fire more frequently
than during light touch (14, 38). The extra impulses in A fibers can do little to increase the central discharge since their central effects saturate at low levels of stimulation. The extra impulses in C fibers, however, can do much to increase the firing rate in the central cell since their central effects do not saturate at low levels of stimulation. Another factor in this regard is that slowly adapting C fibers tend to discharge for a longer time during a long lasting stimulus than rapidly adapting A fibers.

Thus the majority of cells in the spinocervical tract transmit information concerning both light touch and heavy pressure occurring in their receptive fields. In the spinocervical tract the stimulus (e.g., light touch or heavy pressure) is encoded by the patterning of impulses in these cells. The discharge rate in the spinocervical cells is determined peripherally by the balance of activity between the large myelinated fibers and the unmyelinated fibers. This is discussed in more detail by Melzack and Wall (20). It must be emphasized, however, that there are other nuclei in the spinal cord to which a different spectrum of afferent fibers project (e.g., dorsal column nuclei; 2, 31) and the cells of these nuclei respond differently from those of the spinocervical tract (11, 35). Furthermore C fibers project to other central pathways (6) but it is not clear that they produce the same effects there as they do on the spinocervical tract. Normal perception of cutaneous events can occur only from analysis by thalamic and cortical centers of all these inputs of which the spinocervical tract is only one.

The possible special significance of the spinocervical tract in the analysis of intense (and presumably painful) stimuli in cats was reported by Kennard (15). She reported that a bilateral lesion of the dorsal half of the spinal cord eliminates responses to intense stimuli below the level of the lesion. In particular she concluded that the dorsolateral column is of particular importance in the "pain pathway." Thus it is felt that the ideas presented above are relevant in the discussion of the role of unmyelinated fibers in cutaneous sensation.

References


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