

SEGMENTAL DISTRIBUTION OF SPINAL ROOT NUCLEUS OF THE TRIGEMINAL NERVE¹

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For the *spinal nerves* it is believed by many that:

1. Tactile and pressure sensations are conducted through the posterior roots, along the posterior columns of the spinal cord to the *nuclei gracilis* and *cuneatus* of the same side. Thence the fibers form the internal arcuate bundles, decussate and enter the lemniscus of the opposite side.

2. Painful and thermic sensations after entering the cord through the posterior root travel through the posterior horn of gray substance to a column of cells at the base of the posterior horn. New axones arising from these cells cross the median line through the anterior commissure and ascend in the antero-lateral tract of the cord (associated with Gowers' tract).

3. The skin areas corresponding to each spinal segment are now fairly well outlined; while the areas corresponding to each peripheral nerve are still more clearly known. It is also well known that no constant relationship obtains between the two, since the area corresponding to any spinal segment may include parts of several peripheral nerve areas. The areas corresponding to spinal segments take the form of bands, like zebra stripes. In the limbs these zones are in the adult longitudinally distorted from the simpler bands of the embryonal limb-buds.

Passing from the trunk to the head, the interesting question is now suggested: What relation obtains between the segments of the nuclei of the *trigeminal nerves* and the skin areas of the face supplied by them?

There is much reason to believe that the trigeminal "spinal root" and nucleus have to do only, or chiefly, with temperature and pain perception. Müller (1) described a case in which a

¹ From the Department of Neurology and Laboratory of Neuropathology, University of Pennsylvania. Read before the Philadelphia Neurological Society, November 24, 1911.

syphilitic lesion destroyed the "spinal root," and the only consequence was loss of pain and temperature perception in the face. In Hun's patient (2) a gross lesion wiped out the "spinal root" and its nucleus, with the result that pain and temperature anesthesia without loss of tactile sense occurred on the same side of the face as the lesion. In this patient the bulbar continuation of the antero-lateral tract (Gowers') was destroyed; thermesthesia and analgesia (3) of the opposite side of trunk and limbs resulting.

A number of writers have recently maintained that the proximal end of the nucleus of the "spinal root" receives the pain and temperature fibers of the whole mandibular branch of the trigeminus; the middle portion of the nucleus, the fibers coming from the maxillary branch; while the caudad end of the nucleus is the destination of the fibers bearing painful and thermic sensations from the ophthalmic branch of the nerve. Thus Müller interpreted the case above referred to, as did Spiller (4), a syringomyelic case exhibited before the Philadelphia Neurological Society.

The careful study by Spiller of the course and destination of the fibers of the three branches of the fifth nerve (6) led him to conclude that the bundles composing each branch remain distinct certainly through the Gasserian ganglion. As to their ultimate passage through the "spinal root" and their termination in its nucleus he feels that the arrangement just referred to must be inferred.

The two patients whose symptoms I am about to describe showed sensory disturbances of the face which could not be thus explained; but, on the other hand, strongly suggest a complete analogy of segmental distribution between the *trigemini* and the spinal nerves, so far as pain and temperature conduction is concerned.

Elizabeth E.,² a very alert, intelligent and willing subject. Tactile and pressure perception normal over entire body. Pain and temperature perception normal in lower extremities, absent in trunk, except lower abdomen, absent in upper limbs, neck, scalp and parts of the face. On the face pain was felt on the left side anterior to line 4 (see Fig. 1); on the right face anterior to

² The two patients here described were in the Philadelphia Hospital. For the opportunity of studying the former I am indebted to Drs. Burr and Lloyd; for the other patient, to Dr. Charles Potts.

line 3. Cold was perceived on the left only in front of line 4, but several months later this area had shrunk so as to be circumscribed within line 2. On the right cold was felt at the

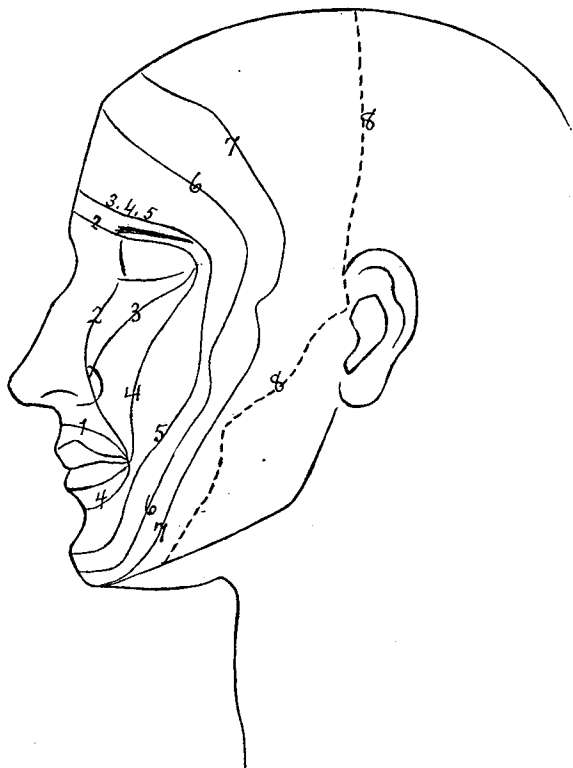


FIG. 1. Temperature and Pain Sensation in Eliz. E— and Chas. B—. Chas. B—. 8, right side: Pain felt in front of this line; 7, right side: Cold felt in front of this line; 6, left side: Pain felt in front of this line; 5, left side: Cold felt in front of this line. Eliz. E—. 4, left side: Cold felt (early) in front of this line; pain felt in front of this line; 3, right side: Cold felt (early) in front of this line; pain felt in front of this line; 2, left side: Cold felt (late) in front of this line; 1, right side: Cold felt (late) in front of this line. Heat was felt over slightly narrower zone than cold. Touch and pressure unaffected. (To facilitate comparison, right and left sides are both drawn upon the one diagram.)

early examinations within line 3; later,—line 1. Hot bodies were felt regularly within slightly narrower areas. The patient was examined repeatedly through four months. Her spinal cord at autopsy showed a syringomyelic cavity in each posterior horn, running from end to end, virtually dividing the structure into two

columns, the smaller being composed chiefly of the posterior white columns. The cavities extended into the medulla oblongata, through the gelatinous substance of Rolando almost to the lower limit of the pons. The cavity on the right side extended slightly further cephalad than that on the left. This

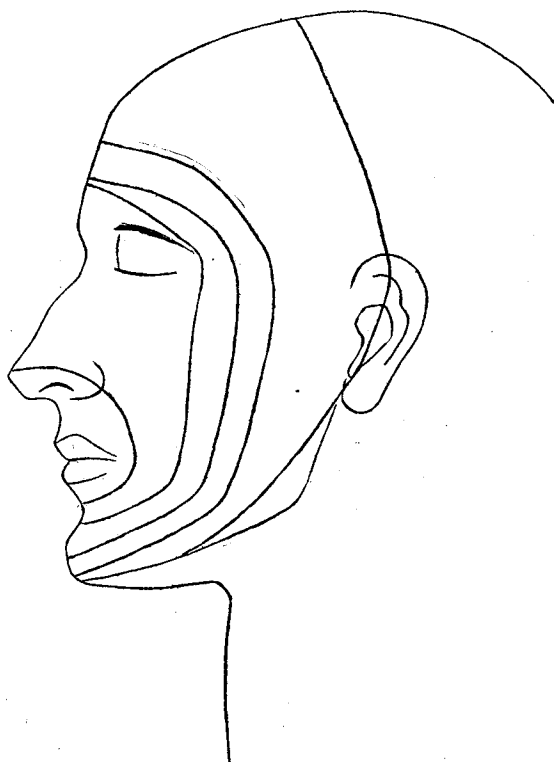


FIG. 2. Kutner and Kramer. Segmentales Fortschreiten der Sensibilitätsstörung am Kopfe. (Lewandowsky, *Handb. der Neurologie*, Vol. I, p. 787.) See also Schlesinger, *Rindfleisch and v. Solder in H. Haenel's article*. (Ib., Vol. II, p. 607.)

explains the smaller areas of preserved temperature and pain perception on the right side.

Stained sections from the lower bulbar region show that each cavity starts dorsally from the bottom of the median sulcus, extends laterally and somewhat ventrally to terminate near the periphery of the section. On the right side the cavity is bridged across by normal structures. At the level of the upper quarter

of the olives the cavities extend on each side from the nucleus of ninth and tenth nerves ventrolaterally ventral to and parallel with the intra-bulbar fibers of those nerves to within a short distance of the periphery of the section. The cavities here are more interrupted by bridges of normal tissue. In sections taken from this block a little nearer the junction of pons and medulla oblongata the cavity on the left side has disappeared. In all sections the spinal tract and its nucleus are normal. The cavities extend in such a way as to affect them probably by cutting off their central connections (see Fig. 5). Wallenburg (5) in discussing the central fibers of this nucleus tells of a degenerated tract secondary to lesions of the upper cervical substantia gelatinosa which passed ventral to the twelfth nucleus, decussated and passed upward and somewhat laterally within the formatio reticularis (3). Inasmuch as the cavities in our patient extend ventral to the "spinal roots" of the trigemini and their nuclei, and cut those structures off from the formatio reticularis, it seems certain that the only pathway between the nuclei and the lemnisci is severed. This suffices to account for the sensory impairment in the patient.

The second patient, Charles B., showed no defect in tactile perception. Pain and temperature were perceived above the abdomen in only a few spots, and were not perceived at all on the neck and scalp. But on the right face anterior to line 8 (Fig. 1) pain was felt; while on the left, pain was felt only anterior to line 6. Distinctions of temperature were correctly made on the right anterior to line 7; on the left anterior to line 5. As in the other patient, hot bodies were felt over a slightly narrower area than cold bodies.

Mucous membranes in Elizabeth E.: Corneæ and conjunctivæ very faulty temperature perception; left more often correct than right. Pain was perceived in these membranes poorly; here again the left side showed better perceptive power than the right.

In this woman the oral membranes distinguished painful stimuli and extremes of temperature, but towards the last these perceptions were limited to the tongue and areas near the front of the cavity. The same was true of the nasal membranes, though in them no tests were made of the deep portions.

In Charles B. pain and temperature perceptions were well preserved on cornea and conjunctiva on the right side; but were

faulty on the left. In the oral cavity perception of both forms of stimuli was well preserved near the front and on the tongue. Farther back in the mouth, particularly on the cheeks, the various forms of stimuli were confused.

Lewandowsky's "Handbuch der Neurologie" gives diagrams of observations of Kutner and Kramer, and shows the combined

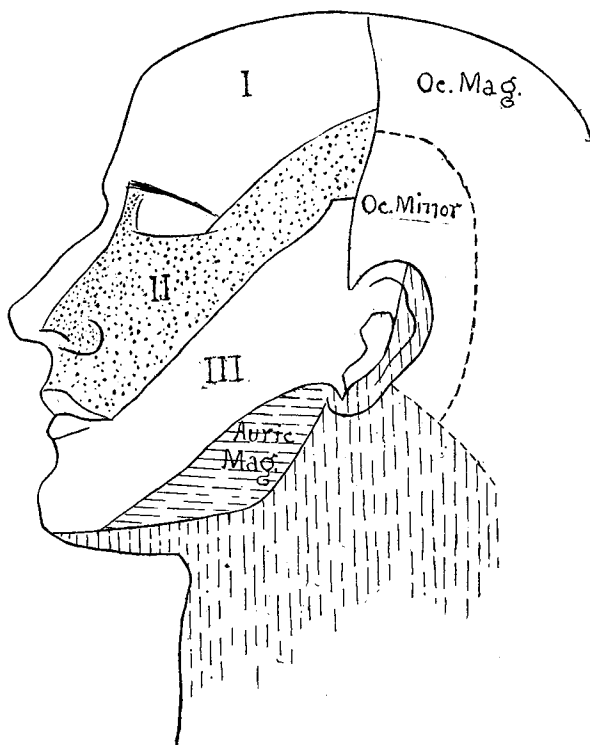


FIG. 3. Sensory skin areas supplied by the three peripheral branches of the V. nerve. After Bing: Gehirn u. Rückenmarks Diagnostik.

results of examinations of the trigeminal sensory areas made by Schlesinger and others (Fig. 2).

The skin areas supplied by the three branches of the fifth nerve are represented in Fig. 3. It is evident that the areas of thermanesthesia and analgesia in our two patients do not conform to the areas to which the peripheral branches are distributed (7). If the fibers of the three branches remain distinct

as three separate bundles through the Gasserian ganglion and "spinal root," and terminate in three distinct levels of the "spinal root" nucleus, then no lesion can be imagined which could produce the sensory disturbance here pictured. It is probable that a reassembling of the fibers occurs before they reach the nucleus.

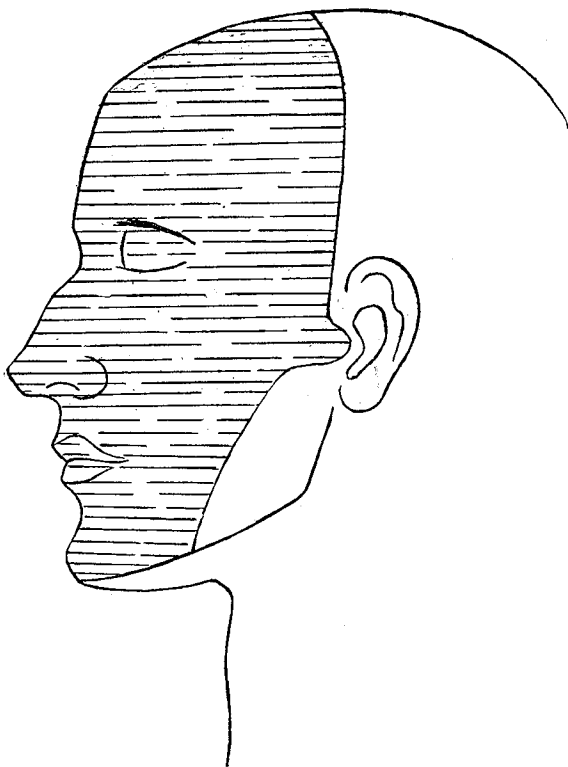


FIG. 4. Average trigeminal sensory area. Cushing. (Howell, Text-book on Physiology, 1909.)

In order to explain the findings in the two patients herein presented I suggest the following as a tentative hypothesis, awaiting confirmation from the study of other cases.

The caudad end of the "spinal root" nucleus receives pain and temperature fibers from a band of skin just anterior to the line shown in Fig. 4, passing from the vertex down to the meatus of the ear, thence to the chin (line δ in Fig. 1). Some of these fibers come through the first, some through the second, and

others through the third, of the peripheral branches of the trigeminal nerve.

Each level of the nucleus (passing cephalad) receives pain and temperature fibers from a concentric band of skin nearer the mouth. Finally the cephalad end of the nucleus receives pain and temperature fibers from the lips and perhaps the tip of the nose.

For the mucous membranes some similar arrangement may exist. Examination of these two patients, however, does not warrant more precise statement.

If a syringomyelic cavity commence in the base of the pos-

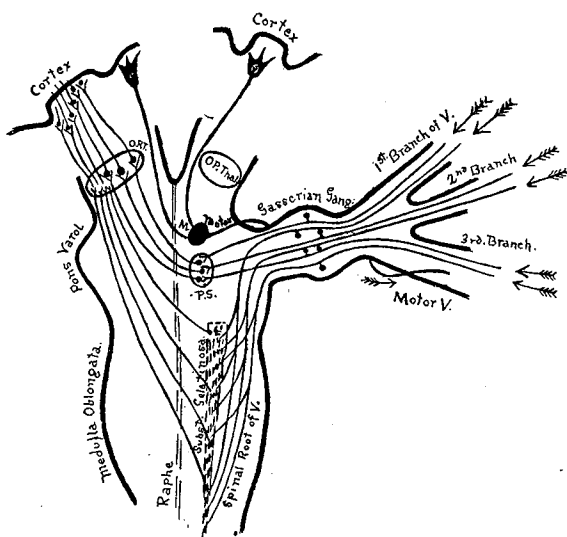


FIG. 5. Schema of fibers and nuclei of trigeminus. Modified from Bing. Tactile and pressure stimuli pass to principal sensory nucleus (PS) from all three branches. Pain and temperature stimuli reach each level of "spinal root" nucleus through all three branches. Cavity in Eliz. E—cut off, central fibers running from substantia gelatinosa toward optic thalamus; cavity extended from caudad point up nearly to head of this nucleus.

terior horn low down in the spinal cord and gradually advance toward the medulla oblongata, it would cut off first the cells already mentioned at the base of the posterior horn which are concerned with thermic and painful sensations. As it reached the upper cervical region in the substantia gelatinosa it would destroy the cells to which these forms of sensation are carried

from the two *occipitales* and the *auricularis major* nerves. The next step would involve the lower point of the *nucleus tractus spinalis trigemini*. Thus the sensory disturbance, which had crept up the trunk and neck, would advance upon the scalp and finally involve the forehead and face.

The forms taken by the zones shown in Fig. 1 are better understood if referred to the heads of the lower vertebrates, such as serpents and frogs, in which the somatic axis from snout to tail is parallel with the cerebrospinal axis. The head in these forms is less differentiated from the other (somatic) segments; so that it is not surprising that a segmental distribution of sensory nerves should be found for the head analogous with that found in the trunk. In these animals the final band of skin, corresponding to the most cephalad point of the long temperature-pain nucleus, is around the mouth.

It would thus appear that the trigeminal "spinal root" nucleus may be but a continuation of the pain-temperature nucleus of the spinal nerves.

An apparent difference would then seem to exist between the tactile-pressure arrangement of the spinal nerves and that of the trigemini in that for the spinal segments tactile-pressure fibers are distributed to the same areas to which the pain-temperature set are distributed, while for the trigemini no segmental arrangement of tactile-pressure fibers has been noted. But it must be observed that the skin area corresponding to a given spinal segment has been mapped out by examining the peripheral results of damage to that segment. Such a lesion may affect indeed the nucleus (in the base of the posterior horn) of the temperature-pain fibers; but it affects no *nucleus* of the tactile-pressure mechanism, but only the *bundle of fibers* entering the cord at that level which conduct tactile-pressure impulses. This shows merely that the fibers for all forms of sensation from a particular skin area enter the cord together, those for temperature and pain running at once to a nearby nucleus (in base of posterior horn), while those for touch and pressure run on upward in the posterior columns to the gracile and cuneate nuclei. Later observations may show that the different levels of the gracile and cuneate nuclei are appropriately connected with successive skin areas, corresponding to those of the spinal segments at which the tactile and pressure fibers enter. In the case of the

trigemini the tactile-pressure bundle of each nerve is so compact, and the principal nucleus to which it extends is so nearly globular, that any subdivision of either would be difficult to demonstrate.

Therefore it can only be said that for the nuclei of the trunk and head that have to do with touch and pressure perception no segmental arrangement is known. For temperature-pain perception, if these two cases have been properly interpreted, a long nucleus extends on each side from the lower border of the pons down to the end of the spinal cord, related to the substantia gelatinosa and base of the posterior horn, and subdivided segmentally so that each level receives the fibers of a corresponding band of skin. The fibers from any one skin-band whether of head or trunk take the nearest convenient peripheral nerve route, and so may be found in several peripheral nerves; but they ultimately come together again at the proper point in the temperature-pain nucleus.

Why these two forms of sensation should be thus differently transmitted, and why the cells that have to do with temperature-pain perception should be stretched out longitudinally while the touch-pressure groups are so condensed, is another and difficult problem.

CONCLUSIONS

1. It is probable that *touch and pressure* sensations are conducted to the Gasserian ganglion, pass to new axones, enter the sensory root and go directly into the chief trigeminal nucleus. Thence new axones conduct them to higher levels, across the raphe and into the lemniscus. And that

2. Pain and temperature sensations pass from the ganglion, also along secondary axones, go through the sensory root down within the "spinal root" to the nucleus of that root. Thence new axones pass cephalad within the formatio reticularis, decussate and finally reach the lemniscus.

3. The two cases here presented suggest that the facial area connected with the caudad point of the "spinal root" nucleus is a band lying along line 8 (Fig. 1), and that each higher level of the nucleus is connected with a band of skin roughly concentric with the first, but nearer the mouth. Finally a zone of skin around the mouth and nostrils is connected with the cephalad end of the nucleus. The fibers extending from any skin zone to

the corresponding point in the nucleus may pass through all three peripheral branches of the nerve.

1. Müller. Deutsch Zeitsch. f. Nerven., XXXI, 5 and 6.
2. H. Hun and Van Gieson. N. Y. Med. Jour., LXV, p. 513.
3. A patient of Spiller (Trans. Phil. Neurolog. Soc., Oct. 22, 1909) showed—right trunk and side of head: thermanesthesia with analgesia. Left face: trigeminal tactile anesthesia, nuclear paralysis of V. nerve (motor) of left side. Spiller accounted for symptoms by inferring a lesion in left *tegmentum pontis* which destroyed the antero-lateral (Gowers) bundle with its temperature-pain fibers from right trunk and limbs; destroyed also the recently decussated central fibers from the "spinal root" nucleus of right V. nerve; also destroyed the principal nucleus (tactile-pressure) of left V. nerve with its nearby motor nucleus. (Fig. 5 will make location of lesion clear.)
4. Spiller. See report of case, JOUR. NERV. AND MENT. DIS., Vol. 38, p. 553.
5. Wallenburg. Anat. auz Jena, Bd. XII, s. 95-110. See Barker, "The Nervous System," 1899, p. 646.
6. Spiller. See Review of Neurology and Psychiatry, Vol. VIII, 1910.
7. Bing (Gehirn u. Rückenmarks Diagnostik, under "The Trigemini") says: "In affections of the most distal part of the substantia gelatinosa in the medulla there follow disturbances of sensation in the frontal region, etc. Thus nuclear trigeminal anesthetics show localizing signs distinguishing them from anesthetics produced by peripheral nerve injuries, just as is true with spinal nerves."