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THE MOTOR, SENSORY AND TROPHIC REFLEXES FROM THE LUNG

AND THE NERVE PATHS THROUGH WHICH THEY ARE EXPRESSED

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PULMONARY REFLEXES SHOWN IN SKELETAL TISSUES

I first noticed an increased tension in the pectoralis muscle on the side in which the lesion was found in a patient suffering from pulmonary tuberculosis in October, 1908. The first description of this was published in March, 1909 (1). At first the fact was somewhat bewildering and I made errors in my explanations (2), in not differentiating the reflex paths from the lung from those from the pleura. This was due to the fact that the path or paths through which such a reflex could take place had not yet been described by physiologists.

When I had satisfied myself beyond doubt that this was a pulmonary motor reflex and that it was constantly present on the side showing activity in the lung, I began to seek for an explanation. With increased experience in its detection I was able to assure myself that the motor reflex from the lung, as it affects the voluntary muscles, was expressed in not only the pectoralis but in all muscles which receive their innervation from the central cervical segments of the cord, particularly the IIId, IVth and Vth, as shown in figure 1, and that it is much less evident in the pectoralis than in others, particularly the sternocleidomastoideus, scaleni, trapezius, levator anguli scapulae, rhomboidei, and central tendon of the diaphragm (3). It is a particularly important fact that the intercostal muscles do not show the pulmonary motor reflex.

Observation convinced me that this motor reflex was an expression of activity and that, after the disease had become chronic or after it had healed, the motor reflex became less evident and finally disappeared, atrophy of the muscles taking the place of the previous spasm (4). In other words, the muscles became atrophied from injury to the neurons caused by the prolonged irritation due to the chronic character of the inflammation; and after the acute stimulation had ceased, the trophic effects alone remained.

Sensory changes previously had been described as affecting certain cervical cutaneous zones (5). In order to understand the sensory reflex from any organ one must know that there are many forms of sensory expression. The sensory reflex is not always a pain. It may be a dull sensation, an aching, a soreness, a feeling of oppression, or changes in perception of heat and cold. The sensory changes from the lung are rarely those of acute pain, but usually those of the deep and protopathic types as described by Head (6). They may be expressed in all deep tissues supplied by sensory nerves which arise from the same cervical segments of the cord as the motor nerves which express the motor reflex from the lung. A sharper pain is occasionally found in the skin, in Head's sensory zones, which take their innervation from the midcervical portion of the cord; but this is rare.

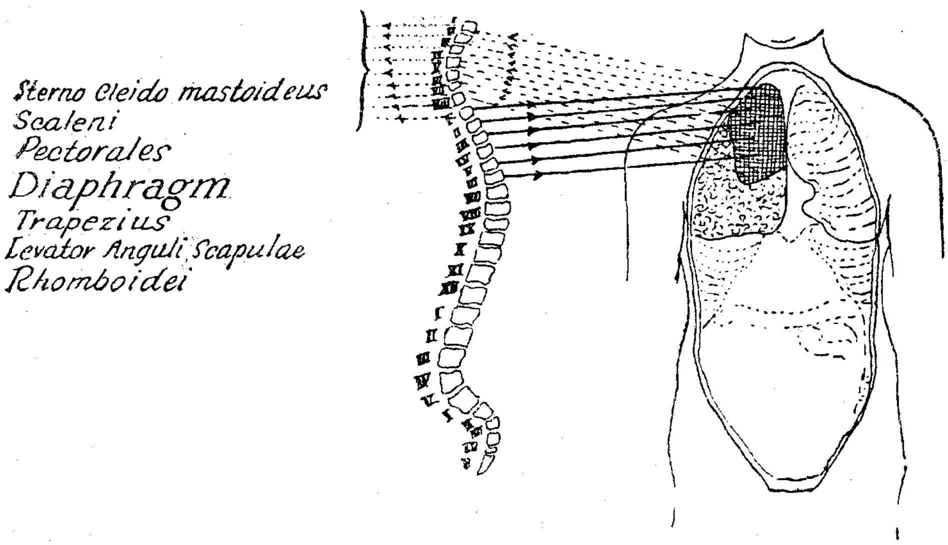

FIG. 1. SCHEMATIC ILLUSTRATION OF PULMONARY VISCEROMOTOR REFLEX

Lines running between the lung and the spinal cord represent sympathetic nerves. Solid lines carry innervation to the lung. Broken lines carry the impulses from the lung to the cord, where they are transmitted in the cervical portion to the spinal motor nerves, which complete the reflex. The muscles involved in this reflex are shown in the illustration. The path of the reflex is not, as shown in the illustration, directly from the lung to the cervical portion of the cord, but back to the upper six thoracic segments, from which it is carried upward to the cervical portion of the cord by intercalated neurons.

The trophic reflex expresses itself in all the tissues that show sensory and motor reflexes from the lung; consequently it is found in all muscles shown in figure 1 and the skin and subcutaneous tissue in the cervical segments III, IV and V, as shown in figures 2A and 2B.

When we were definitely able to recognize these three types of reflexes, (1) motor, (2) trophic and (3) sensory, originating in the lung and expressing themselves in the skeletal structures supplied by nerves from the midcervical segments of the cord, our next step was to determine the

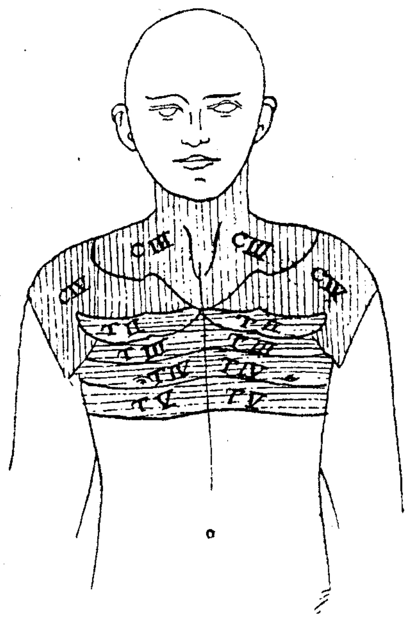

FIG. 2A

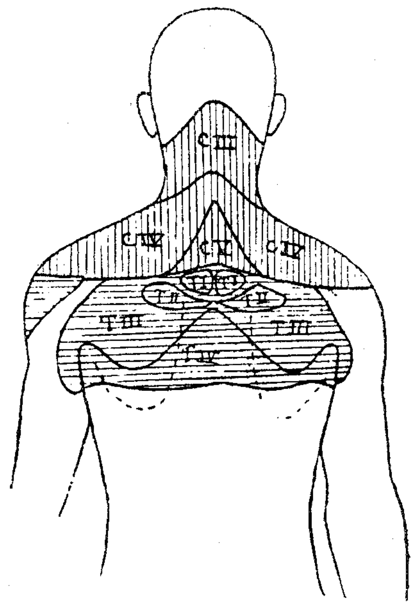

FIG. 2B

FIG. 2A. SHOWING THE CUTANEOUS AND SUBCUTANEOUS AREAS WHICH ARE AFFECTED BY THE PULMONARY VISCEROSENSORY AND VISCEROTROPHIC REFLEXES.
ANTERIOR VIEW

This viscerotrophic reflex is shown particularly as a degeneration of the skin and subcutaneous tissue supplied by the IIId and IVth, and slightly by the Vth, cervical sensory roots. It will be seen that anteriorly this includes the tissues of the neck, shoulders and chest down as far as the second rib.

FIG. 2B. SHOWING THE CUTANEOUS AND SUBCUTANEOUS AREAS WHICH ARE AFFECTED BY THE PULMONARY VISCEROSENSORY AND VISCEROTROPHIC REFLEXES.
POSTERIOR VIEW

This includes the neck, shoulders, and that portion of the chest above the spine of the scapula. The interscapular tissues involving T. I, T. II, T. III, and T. IV show the "hilum saucer of degeneration."

afferent paths. In order to obtain this information I was led deeply into the study of visceral neurology. It was necessary to understand the vegetative nervous system and its relationship to the voluntary nervous system, the laws governing reflexes, factors which influence physio-

TABLE 1
REFLEX SYMPTOMS FROM THE LUNG

	Afferent Nerves	*Symptoms*	*Efferent Nerves*
INFLAMMATION OF LUNG	Afferent through (vagus) parasympathetics	Hoarseness	Laryngeal nerves
		Laryngeal irritation	Superior laryngeal nerve
		Cough	Laryngeal and nerves to all expiratory muscles with inhibition of nerves to inspiratory muscles
		Inhibition of heart	Motor fibres of cardiac vagus
		Increased muscle tonus and glandular secretion in gastrointestinal canal	Motor fibres of gastric and intestinal parasympathetic
		Flushing of face	Sensory fibres of trigeminus
		Spasm of sternocleidomastoideus and trapezius	Spinal accessorius
		Deviation of tongue from median line	Hypoglossus
		Degeneration of facial muscles	Trigeminus and facialis
	Afferent through sympathetics	Flushing of ear	Third sensory cervical
		Dilation of pupil	Motor from Budge's Centre (lower cervical and upper dorsal)
		Spasm of muscles of shoulder girdle and diaphragm	Cervical motor nerves, IId to VIIIth
		Lessened motion of chest-wall, partly due to muscle spasm as above	Cervical motor nerves, IId to VIIIth
		Pain above 2d rib and spine of scapula (superficial)	Cervical sensory nerves, particularly IIId, IVth and Vth
		Pain in muscles of shoulder girdle (deep pain)	Cervical sensory nerves, IId to VIIIth
		Degeneration of skin and subcutaneous tissue above 2d rib anteriorly and spine of scapula	Cervical sensory nerves, IIId, IVth and Vth
		Degeneration of muscles of shoulder girdle	Cervical sensory and motor IId to VIIIth

logical action, and embryology with its developmental and segmental relationships.

There are numerous reflexes possible from the stimulation of any organ or tissue. One must always bear in mind the integrative function of the nervous system if the proper conception of physiological action is to be had. The action of the various tissues of the body are brought into one complete whole by the nervous system. A stimulus entering one segment of the cord may be transmitted to other segments far removed from it before it causes action. For example, inflammation of the bladder will at times produce spasm of the gastric pylorus or cardia. Pain anywhere in the body may produce dilatation of the pupil. The impulses travel over many segments of the cord in order to produce such action.

Table 1 shows some of the common reflexes which arise from the lung. I have classified them according to the afferent path followed as vagus or parasympathetic reflexes and sympathetic reflexes. I have also shown the efferent nerves through which the reflexes are completed.

One of the difficulties which I early encountered was to differentiate pulmonary from pleural reflexes, but I soon found that the pleural reflexes which are mediated through the sympathetics and intercostals with spinal nerves are expressed most regularly over the bony thorax and immediately over the area of involvement. This is true not only of the motor but also of the sensory and trophic reflexes. Only occasionally, when the lower costal pleura and the costal portion of the diaphragmatic pleura are involved, will the reflexes extend to adjacent tissues down over the abdomen (7). Pleural trophic and sensory reflexes, which are mediated through the phrenics, are expressed in the midcervical segments of the cord. I also realize that sympathetic pleural reflexes might occur through the same midcervical spinal nerves that show pulmonary reflexes because the visceral pleura is supplied by the same sympathetic nerves as the underlying lung; yet I have never been able to identify a motor reflex in the muscles of the neck as a result of acute pleural inflammation, nor a trophic reflex in this area as being unquestionably of pleural origin.

NERVE SUPPLY OF LUNG

Both sympathetic and parasympathetic fibres enter the lung at the hilum and follow the bronchi throughout the organ (Müller (8)). The parasympathetics are represented by the vagus and the sympathetics by the fibres taking their origin from the upper five or six thoracic segments of the cord.

It is the particular function of the vagus of the parasympathetic system, when stimulated, to activate the bronchial musculature and the glands of the bronchial mucous membrane. It is the particular function of the sympathetics to oppose the vagus in its action, thus to relax the bronchial musculature and decrease bronchial secretion. The sympathetics also control the action of the blood vessels.

In discussing the innervation of the lungs and the antagonism between the vagus and the sympathetics, Gaskell (9) says:

> In other cases of endodermal musculature we find indications of the reciprocal innervation between the enteral (parasympathetic) and sympathetic systems; thus the motor cells of the endodermal musculature, whether in the lungs (bronchial muscles) or in the liver (muscles of the gall-bladder and duct) have traveled out right into the muscles themselves and their inhibitory nerves come from the nerve cells of the sympathetic system.

Respiration is influenced by both sympathetics and parasympathetics, although the vagus is usually spoken of as the respiratory nerve.

Internal viscera, when compared with skeletal structures, have a relative paucity of sensory neurons, because of the fact that they lie deep in the body and are so shielded that it is not necessary to have the number or the wide variety of receptors for picking up and preparing defensive reflexes against many of the stimuli which affect structures on the surface of the body; for example, they need no nerves which will respond with pain to cutting, pinching or burning, because they are not cut, pinched or burned under normal conditions. But wherever we find efferent neurons belonging to a certain system, we also find afferent neurons of the same system to carry the stimuli, which arise in the structure in question, centralward; consequently, we have both afferent sympathetic and afferent vagal neurons in the pulmonary tissue.

EMBRYOLOGICAL EVIDENCE

Embryologically, the lung belongs to the gastrointestinal system, the same as the liver, pancreas and body of the urinary bladder. This fact is very important in understanding its innervation. It is formed from a diverticulum given off from the anterior portion of the intestinal tract.

Belonging to the intestinal tract the lung carries with it the innervation of the intestinal tract (Gaskell (10)).

In order to understand reflexes, it is necessary to know that the body of man is a segmented organism, having come up from the primitive organisms in which every segment is more or less complete in itself, in that it has a nervous system to care for the body surface and the organs lying within the same segment. This is shown in figure 3, after Ross and Mackenzie.

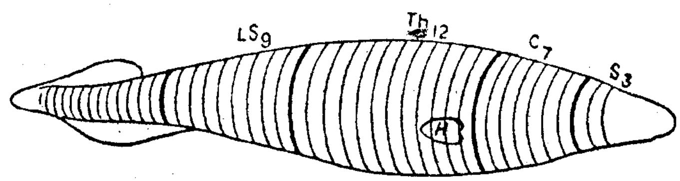

FIG. 3. DIAGRAMMATIC REPRESENTATION OF A PRIMITIVE VERTEBRATE ANIMAL

The Amphioxus, divided for convenience into three segments for the head, seven for the neck, twelve for the thorax, nine for the lumbosacral region, and an indefinite number for the coccygeal region. For clearness of comparison the heart (*H*) is represented as occupying the same position as in man, so that an adequate stimulus from the heart would cause pain in the distribution of the four upper thoracic nerves covering and protecting the heart. (After Ross and Mackenzie.)

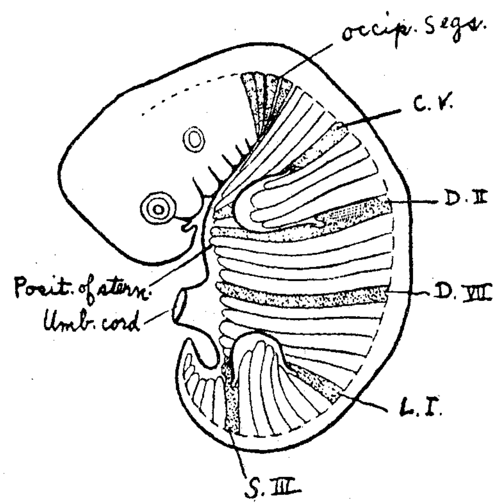

FIG. 4. DIAGRAM OF A HUMAN EMBRYO, FIFTH WEEK, SHOWING THE ARRANGEMENT AND EXTENSION OF THE MESOBLASTIC SEGMENTS

The first and last of each segment entering into the formation of the limbs is stippled (*C. V* and *D. II* and *L. I* and *S. III*). The position is indicated in which the sternum is formed. (A. M. Patterson.)

Man carries the same general plan, which is particularly shown in early embryonic life, as will be noted in figure 4. While, in the differentiation which has taken place, there are variations from the primitive plan, yet the segmental relationship between skeletal tissues and the splanchnic or visceral tissues is preserved. A stimulus on the surface expresses its reflex most readily in that portion of the splanchnic or visceral system, and a splanchnic stimulus likewise expresses itself most readily in that portion of the somatic system with which it is segmentally related.

PHARMACOLOGICAL EVIDENCE

Pharmacological evidence of the innervation of the lungs is furnished by the use of adrenalin and atropine in their relief of the definite vagal syndrome found in asthma. The spasm of bronchial musculature is evidence of a predominating vagal activity. (Pottenger (11).)

This spasm is antagonized pharmacologically by two well-known remedies, namely, atropine, which antagonizes the vagus directly, and in this manner opposes the asthmatic attack; and adrenalin, which reinforces and increases the action of the sympathetics in their antagonism to the vagus, so that the asthmatic attack is relieved. (Meyer and Gottlieb (12), Eppinger and Hess (13), Pottenger (14).)

The affinity of adrenalin for the sympathetic system is manifested throughout the body. Physiologically, its injection produces sympathetic effects in all structures except the sweat glands. (Cannon (15), Gaskell (16).) This close relationship may be inferred from the fact that the medulla of the adrenal gland consists of modified nervous tissue which belongs to the sympathetic system (17).

While both atropine and adrenalin may fail to relieve the asthma completely, yet their action is nevertheless so uniformly inhibiting to the vagal activity found in the attacks as to make the innervation certain.

Another sympathetic effect is met in quite a group of asthmatics whose attacks are relieved by acute toxemia, such as that which accompanies tonsillitis and pneumonia. (Pottenger (18)(19).) This is significant because of the fact that toxemia expresses itself in many tissues as a stimulant of the sympathetics.

THREE IMPORTANT LAWS GOVERNING REFLEXES

Sherrington (20) laid down a law governing sympathetic reflexes which take place between visceral and skeletal structures, as follows:

> Taken generally, for each afferent root there exists in immediate proximity to its own place of entrance in the cord (e.g., in its own segment) a reflex motor path of as low a threshold and of as high potency as any open to it anywhere.

In order to explain the spreading of reflexes in the cord, Pottenger(21) formulated the following law:

The extent of the reflex is influenced by the strength of the stimulus. If the stimulus is slight it may pass over only those efferent neurons which are particularly adapted to it; but if it is stronger, the reflex spreads to other efferent fibres, either upward or downward in the cord over inter- and intrasegmental neurons. (As shown in figure 5.)

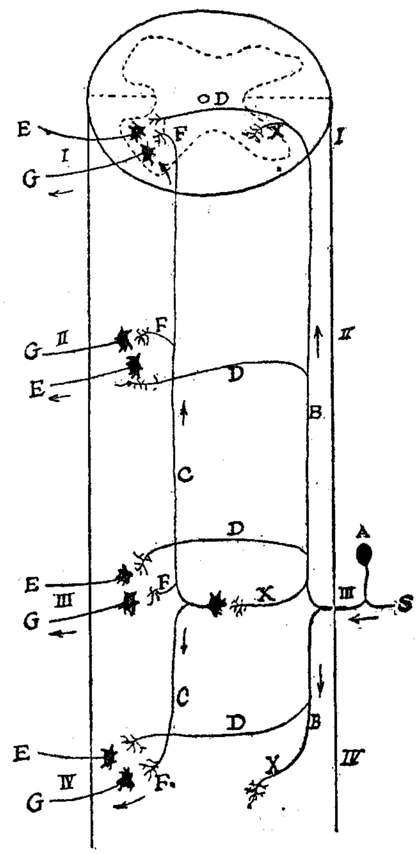

Fig. 5. Showing Schematically the Paths through Which Intrasegmental and Intersegmental Reflexes Are Produced

The impulse is transmitted to the posterior root ganglion A over the sensory fibre S. From the ganglion A root-fibres B enter the cord which divide into ascending and descending branches. From these branches collaterals D are given off, which are transferred to the gray matter in the anterior horn and form synapses with motor nerves E to produce reflexes. Such reflexes occurring in the segment of the cord into which the root fibres enter, as indicated in segment III, are called intrasegmental reflexes. Those occurring in segments I, II and IV are intersegmental reflexes. Other collaterals X are given off from the posterior root fibres, which form synapses with association fibres C, which also divide into ascending and descending branches and give off collaterals F, which form synapses in the anterior-horn gray matter with motor neurons G to produce intersegmental reflexes.

The change in sensation (sensory reflex) from viscera is not a true reflex in the physiological sense, because it does not have a motor component to complete its action.

Visceral pain is usually spoken of as referred pain, although in the clinical sense it may be considered a visceral reflex, for in its localization it follows laws similar to those of the motor reflex, although there is no synapse in which the afferent neuron mediates with a motor neuron. Head (22) has suggested the following law to explain the expression of visceral pain in skeletal sensory nerves:

> When a painful stimulus is applied to a part of low sensibility in close central connection with a part of much greater sensibility, the pain produced is felt in the part of higher sensibility rather than in the part of lower sensibility to which the stimulus was actually applied.

In other words, when a painful stimulus is applied to the visceral tissues of low sensibility, it is transmitted centralward to the cord the same as it would be to produce a motor reflex; but, instead of being transferred to a motor neuron, it irritates adjacent nerve cells which give origin to sensory nerves belonging to the skeletal system in which the pain is expressed.

DISCUSSION

Sherrington's segmental law holds for most of the important organs of the body: for instance, the pleura, heart, liver, pancreas, stomach, intestinal tract, kidneys, and pelvic viscera. It does not hold for the lung, as I have described the reflexes clinically, and it is possible that it may not hold for certain other viscera, the reflexes from which we are not able definitely to describe at this time.

Figure 6 shows the sympathetic connector neurons which furnish the afferent paths from many of the important viscera of the body. With the exception of the lungs, the paths from which may be inferred from figure 1, each organ expresses its reflex motor sensory and trophic changes in the skeletal nerves which arise from the segment of the cord receiving the afferent impulse, according to the law of Sherrington.

After finding that the lung was an exception to Sherrington's rule, in that reflexes, which seem to be due to afferent impulses carried over the sympathetic nerves and which correspond to definitely accepted sympathetic reflexes in other viscera, are expressed in the skeletal tissues which take their innervation from the midcervical portion of the cord; and particularly, bearing in mind the forward position of the lungs in their origin from the gut and also their position in the pharynx in early fetal life; and further, knowing that the central tendon of the diaphragm, which is so closely associated with the lungs, receives its innervation from

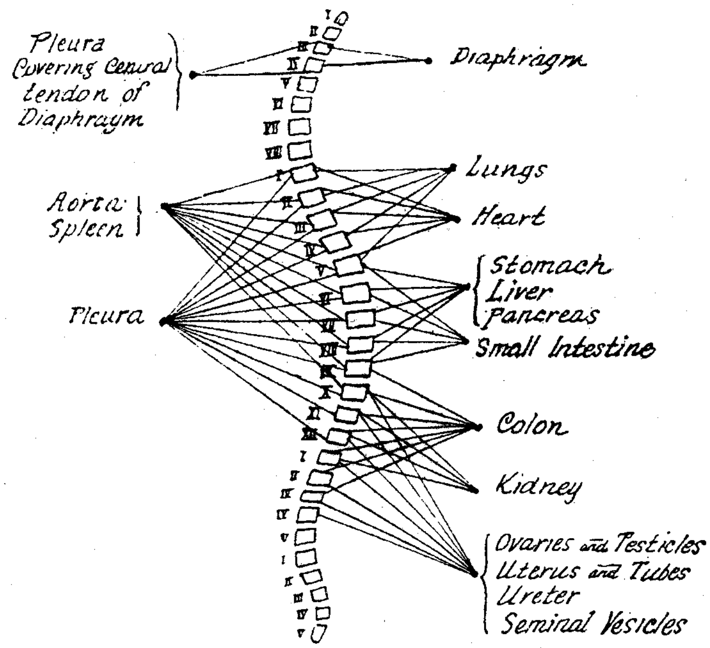

FIG. 6. THE CONNECTOR NEURONS FOR THE IMPORTANT THORACIC, ABDOMINAL AND PELVIC VISCERA

In the figure the connecting neurons are those which belong to the thoracicolumbar outflow, except those going to the diaphragm, which are spinal nerves (phrenics). The motor cells for the viscera are found in the various collateral ganglia.

The figure shows that the innervation of the various viscera may be divided into groups. The heart and lungs are innervated from practically the same segments, the upper Ist to VIth thoracic; the stomach, liver, and pancreas from the same segments, Vth to IXth thoracic; and the colon, kidney, and pelvic viscera from practically the same segments, IXth and Xth thoracic to IIId and IVth lumbar.

In spite of this grouping in innervation, each organ is brought in reflex connection with efferent neurons, both sensory and motor, which are more or less definite, in such a way that the motor and sensory reflexes do not overlap as much as might be indicated.

the cervical portion of the cord and expresses reflexes in skeletal tissues which are innervated by cervical nerves, I (23) suggested, in order to meet the conditions arising in pulmonary reflexes, that Sherrington's law be modified to the effect that impulses from viscera find efferent neurons in segments of the cord *to which they are embryologically related* and with which they form reflexes most readily.

In classifying the pulmonary reflexes I found it a great aid that they could be differentiated from the pleural reflexes. Clinically, the pleura shows four sets of reflexes: through (1) the vagus of the parasympathetics, (2) the sympathetics, (3) the intercostal nerves, and (4) the phrenics. The reflexes mediated through the sympathetics, the phrenics and the intercostals all follow Sherrington's segmental law for visceral reflexes, in that the afferent impulse finds in the segment of the cord which it enters an efferent path through which it expresses its action most readily.

The fact that the upper intercostal muscles, receiving innervation from the upper six thoracic segments of the cord, do not show the pulmonary motor reflex, although the afferent impulses from the lung come back to those segments of the cord, is very suggestive of a transference of the impulse to other segments. The fact that we do find the motor reflex in disease of the lung expressed in the muscles innervated by the midcervical nerves would at least suggest that the impulse may be transmitted from the upper thoracic to the midcervical segments through intrasegmental paths. The further fact that the trophic and sensory reflexes from the lung, which correspond to the sympathetic sensory and trophic reflexes of other organs, are found expressed in the tissues innervated by the nerves arising in the midcervical segment of the cord, while the sympathetic, sensory and trophic reflexes, which arise from the pleura, are mediated through the thoracic nerves from the second to the twelfth, and that the reflex is usually limited to the area over the involvement, seems to indicate that pulmonary impulses are transmitted upward in the cord from the segments which they enter. Thus the localization of sympathetic reflexes from the lung can definitely be differentiated from sympathetic reflexes arising in the pleura.

There are several factors to be considered in determining the pathway of the reflex from the lung. I was guided by the same principle which applies to other viscera. Every internal viscus possessing a double innervation—sympathetic and parasympathetic—shows reflexes in which the afferent impulse is carried over both systems.

Sympathetic motor and sensory reflexes from the appendix, gall-bladder, stomach and duodenum (in case of ulcer), and kidney are quite well known. These all follow Sherrington's law in their distribution. No parasympathetic motor reflexes from any of these organs have been described as occurring regularly in somatic structures in which the afferent impulse is conducted over the vagus. Headaches, however, have been described as parasympathetic sensory reflexes, in which the pain is mediated with the sensory fibres of the trigeminus.

As parasympathetic reflexes from the lung I have described reflex atrophy of the tongue, reflex atrophy of the facial muscles and a motor and trophic reflex in the sternocleidomastoideus and trapezius muscles, the impulses being mediated through the hypoglossus, facialis and accessorius respectively (24).

It will be noted that these reflexes all take place through the cranial nerves with which the vagus is closely associated. Gaskell, in his monumental work on the vegetative nervous system, describes the medulla oblongata as an expanded portion of the cord, and shows that there is the same relationship between the afferent visceral fibres and the motor neurons of the cranial nerves as exists between the sympathetic fibres originating in the thoracic and upper lumbar segments of the cord and the spinal nerves in the same segments. Therefore, we have the two pathways for reflexes: one set of reflexes having the afferent component in the sympathetic, and the efferent in the motor and sensory spinal nerves; the other having the afferent impulse in the vagus, and the efferent in the cranial sensory and motor nerves.

That there are parasympathetic motor and trophic reflexes expressed in the sternocleidomastoideus and trapezius muscles I early recognized; but I had not connected up the reflexes in other muscles of the shoulder girdle and the central tendon of the diaphragm, nor had I explained the pulmonary trophic and sensory reflexes, which express themselves in the tissues supplied by the midcervical segments of the cord as being of vagal origin. I had explained all of these reflexes as being of sympathetic origin, with the exception of the changes in the sternocleidomastoideus and trapezius, which I had considered as being of double origin.

Rasmussen (25), in discussing the reflex paths from the lung in a recent number of the AMERICAN REVIEW OF TUBERCULOSIS, accepts the opinion of Larsell (26)(27)(28)(29), that the chief source of afferent impulses from the lung is the vagus, and he suggests that vagal impulses mediate with the midcervical skeletal nerves to produce most of the pulmonary somatic reflexes. He quotes Larsell's work as showing that cutting the vagus nerve is followed by degeneration of practically all the nerve fibres in the corresponding lung. Larsell believes that the vagus gives us the chief nerve supply to the pulmonary tissue, but he recognizes that certain restricted regions of the pulmonary pleura are supplied by some of the upper thoracic spinal nerves (probably meaning sympathetic). This would indicate that the sympathetic supply to the lung is of very slight importance. He quotes the works of Cajal and of Freeman (30), as showing that the sensory fibres of the vagus, after entering the upper portion of the medulla oblongata, send branches downward into the spinal cord as far as the third and fourth cervical segments, and he discusses the possibility of their mediating reflexes with the spinal nerves.

He also quotes Larsell's work to the effect that the sympathetic trunks are particularly connected with the pleura and that they, passing to the spinal cord over the corresponding dorsal routes, may send ascending fibres to the midcervical region and higher levels, which will mediate reflexes in the midcervical region, but he considers this possibility of comparatively little importance.

Reasoning from analogy in other viscera, as shown above, and also considering the importance of the sympathetic nerves in the relief of asthma, it seems to me that the importance of the sympathetic paths in the production of pulmonary reflexes is underestimated in Larsell's work.

Aside from reflexes which are definitely due to stimuli arising in the lung, we may have reflexes expressed in the neck muscles at times, as a result of severe inflammation of certain other organs. The muscles of the shoulder girdle will at times exhibit a motor reflex in cases of endocarditis, severe attacks of angina, and in acute pancreatitis; so will pain be expressed in the neck areas. While it is possible that the stimuli responsible for this anomalous location of these reflexes and those for the regular reflexes from the lung may course centralward over the vagus, yet the argument is at least equally convincing in favor of their being of sympathetic origin. The law governing the spreading of reflexes, quoted above, is sufficient in either case to explain the unusual location of the motor and sensory reflexes expressed in the nerves from the midcervical region in severe angina pectoris and acute pancreatitis, and also in explaining the vagaries found in the location of pain in diseases of some of the abdominal viscera and the kidney and bladder. Pain in the kidney is usually expressed in the back between the lower dorsal areas and the crest of the ilium, but often above the upper and below the lower limits. The same thing is true in pleurisy. While the regular area for pain is immediately over the point of inflammation, it sometimes extends much higher, and occasionally we find its expression lower, and even over the lower areas of the abdomen. In the lower quadrant (on both the right and left sides) I have seen pain, which resulted from pleurisy involving the lower parietal and the costal portions of the diaphragmatic pleura (7).

Since the sympathetic nerves supplying the lung arise from the upper five or six thoracic segments of the cord, if the lung followed Sherrington's law its motor reflexes would be found in the skeletal muscles receiving innervation from the upper five or six thoracic segments of the cord; but such is not the case. They involve muscles which take their origin from the midcervical segments of the cord.

Since integration of action is one of the chief functions of the nervous system, and realizing that the various tissues and organs throughout the body are brought into harmony of action through the nervous system, and knowing the infinite number of paths in the cord through which this integration takes place through intersegmental as well as intrasegmental paths, and bearing in mind the manner in which reflexes are transmitted upward and downward in the cord when other organs are affected, it requires no stretch of the imagination to believe that the motor reflex from the lung differs in its expression from Sherrington's law only in that it is more complex; the impulses being transmitted to neurons in the segments of the cord which they enter, the same as in case of the other important viscera, which transmit them upward in the cord to mediate with motor neurons arising in the midcervical segments. This suggestion is strengthened by the embryological relationship of the lung coming off, as it does, from the anterior portion of the gut on a level with the pharynx; by its being associated with the pharyngeal structures in early embryonic life; and also by finding that the trophic and sensory reflexes from the lung are expressed in the same skeletal structures, superficial and deep, which receive their nerve supply from the midcervical segments.

Pulmonary trophic reflexes also occur in the same zones of the skin, in the same areas of subcutaneous tissue and in the same muscles which show motor and sensory reflexes. Inasmuch as these trophic reflexes in the tissues supplied by the cervical nerves are constant in chronic or healed pulmonary tuberculosis, the same as motor reflexes are found in both active, chronic and healed tuberculosis, and inasmuch as all of these sympathetic reflexes are found in definite tissues supplied by skeletal nerves from definite segments of the cord, and inasmuch as in the case of all other viscera these are the segments which receive afferent impulses from them through sympathetic nerves, therefore, I feel justified in describing this pulmonary reflex, even though it varies from Sherrington's law as a reflex of sympathetic origin.

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